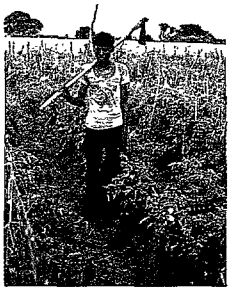
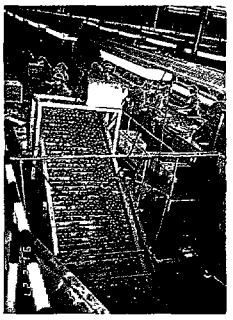
PN-ACJ-643

Dynamics of vegetable production, distribution and consumption in Asia





Edited by
Mubarik Ali

Asian Vegetable Research and Development Center

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Dr. Hans Jansen, an Economist at AVRDC in 1990–94, initiated the exercise in late 1993. The editor would like to acknowledge Dr. Jansen's editorial advice and his efforts in raising funds for this project.

I deeply appreciate the continuous support, interest, and persuasion of Dr. Samson C.S. Tsou, Director General of AVRDC. His critiques and suggestions were invaluable. And, without the personal interest and constant encouragement of Drs. David Midmore and Richard Morris, both former directors of the Production Systems Program at AVRDC, this book would not have reached the printing press.

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It must also be noted that many national institutes supported this project by furnishing published and unpublished data. These contributions were critical to the success of this project and publication.

Preface

A meeting was sponsored by GTZ about five years ago to set a course for exploring the economic data available in the vegetable sector. The main idea was to evaluate the current status of the vegetable sector in different countries and regions in Asia, to identify the gaps in research, and to suggest future research directions in a comprehensive way. Prominent agricultural economists from 13 major vegetable-growing countries in Asia attended the meeting.

The amount of data available on almost all issues in the vegetable sector came as a surprise to the workshop participants. Time series data on vegetable area, production, and yield, cost of production, prices, and details of marketing structure and behavior, international trade, and consumption patterns were available. These data, however, had rarely been analyzed to determine changes in vegetable production, distribution, and consumption. Participants at the 1994 meeting decided to organize these data and to do some basic analysis in order to gain a picture of the vegetable sector in their respective countries. They wanted to learn how the sector has changed over time, and how it can be changed to better serve vegetable producers and consumers.

When the participants committed to this task, perhaps they did not realize the amount of work that would be required. For this was a monumental undertaking. Many different vegetables are grown in each country, and each could be considered a sector on its own.

It was decided to not analyze each commodity, but rather treat each as part of the vegetable sector, and then limit the discussion to the contrasts, if any. This saved the authors from lengthy discussion about individual commodities. Yet data on each vegetable species were collected, analyzed, and interpreted in the context of the larger vegetable sector.

Now, finally complete, it is the most comprehensive country-by-country analysis of the vegetable sector in Asia.

As much as possible, the structure of each country report is the same. This makes the book particularly useful because it allows easy comparisons across countries. Uniformity in content and layout, for example, allows the reader to compare how seasonality varies across countries, or to compare production costs or even policy issues. Perhaps most important is the book's heuristic value: it presents many researchable international and country-specific problems.

I admire and appreciate the patience of the authors, editors, typists, and formatters, and the many people who worked quietly and industriously behind the scenes on this mammoth task. You have contributed to the advancement of the vegetable sector in Asia.

Samson C.S. Tsou
Director General
Asian Vegetable Research and Development Center

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Dynamics of Vegetables in Asia: A Synthesis

Mubarik Ali

Introduction

The economic, political, and social environments in Asia are fast changing. These changes include continuous increase in population and urbanization, increase in incomes, changes in agricultural input and output prices, development of physical infrastructure, such as roads, markets, and communication systems, and social infrastructure, such as education and training. On the food demand side, emphasis is now shifting from basic nutrients (i.e., calories and protein) to balanced diets (i.e., calories, protein, and micronutrients). This book enumerates these changes in the context of vegetable production, consumption, and distribution in 13 major vegetable growing countries of Asia. This chapter aggregates the individual country trends and draws conclusions at the regional level. Before proceeding, it is recommended to read Appendix 1 for explanations of the estimation procedures and terminology used in this book.

Supply of Vegetables

Production

Vegetable production in Asia grew at an annual average rate of 3.4% in the 1980s and early 1990s, from 144 million t in 1980 to 218 million t in 1993. Most of the increase was concentrated in East Asia and South Asia (Fig. 1). In South Asia, the highest growth was recorded in India, Pakistan, and Nepal, where vegetable production more than doubled. In East Asia, China showed the highest growth, posting a 50% increase over the period. In Southeast Asia, vegetable production doubled. It is worth noting that most of the increase in India and China, major contributors to vegetable production and its growth, occurred during 1982-85. Since then, the increase has slowed or stopped.

The area under vegetables in Asia increased at an annual average rate of 2.1%, from 12.0 million ha in 1980 to 16.3 million ha in 1993. Most of this increase came from China (from 5.2 million ha in 1980 to 8.1 million ha in 1993). In South Asia, vegetable area increased from 4.3 million ha in 1980 to 5.5 million ha in 1985, but remained at that level thereafter. The area fluctuated around 1.3-2.2 million ha in Southeast Asia during 1980-93 (Fig. 2).

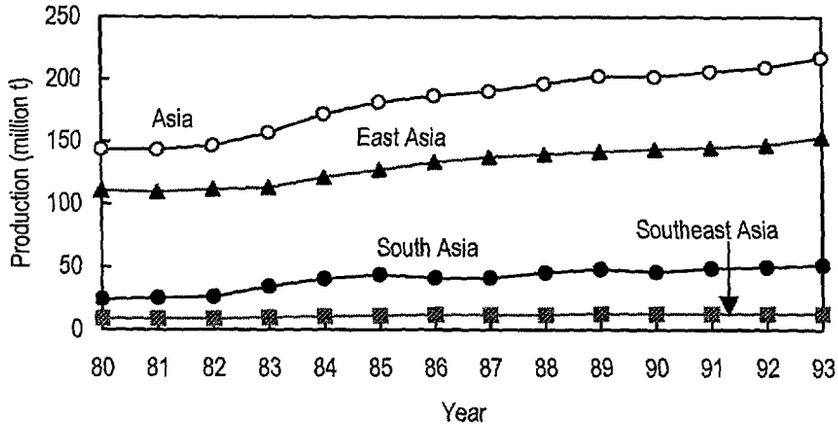


Fig. 1. Regional trends in production in Asia

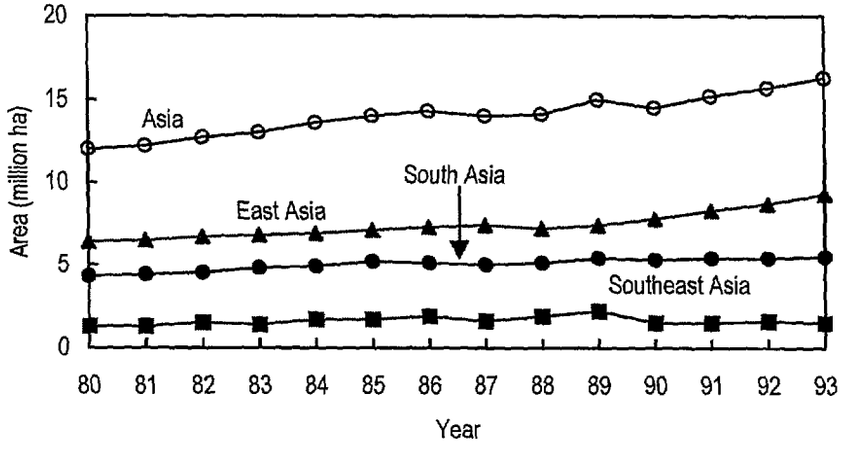


Fig. 2. Regional trends in area in Asia

There is regional variation in the level and growth in productivity. East Asia has the highest per hectare yield, followed by South Asia. Productivity is lowest in Southeast Asia. Some of this variation is due to differences in the mix of vegetables grown in each region. For example, Chinese cabbage is a major vegetable in East Asia, while eggplant ranks high in Southeast Asia. Some difference can be attributed to the ecoregional environment. For example, East Asia is mainly temperate and sub-temperate, while Southeast Asia lies mainly in the tropics. Vegetables are more difficult to grow in hot, humid lowland conditions; therefore, their productivity is expected to be low in Southeast Asia.

Average per hectare yield of vegetables increased marginally in Asia, from 11.9 t in 1980 to 13.3 t in 1993. Growth in productivity was highest in South Asia, where per hectare yield increased at an annual average rate of 4%, from 5.6 t in 1980 to 9.3 t in 1993. In East Asia, productivity declined, mainly because of a change in the vegetable mix from high volume crops, such as Chinese cabbage, to low volume crops, such as onion and mushrooms. Although Southeast Asia achieved a respectable annual productivity growth rate of 3%, yields remained low compared to other regions (Fig. 3).

However, the higher growth in productivity in Southeast Asia compared to overall Asia narrowed the vegetable yield gap between the two regions.

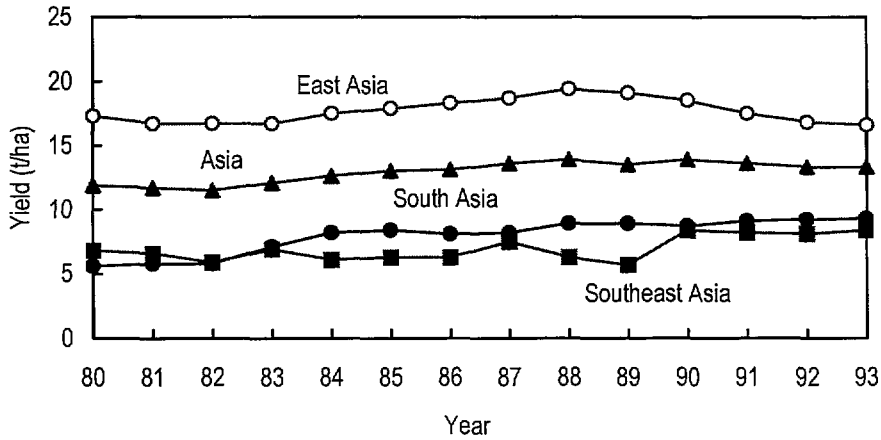


Fig. 3. Regional trends in yield in Asia

Availability

Since 1987, vegetable production in Asia has been at a level sufficient to provide a minimum-required per capita annual availability of 73 kg (or 200 g/day) (Fig. 4). But there is no reason for complacency; 73 kg is a minimum requirement. For better quality of life, availability should be higher. Consider Korea with per capita annual availability of 229 kg. In fact, Asia reached the minimum target due to high per capita availability in East Asian countries (110 kg/year). Vegetable availability in other Asian countries remains very low—about 60% of the required minimum in South Asia and just 40% in Southeast Asia (Fig. 4).

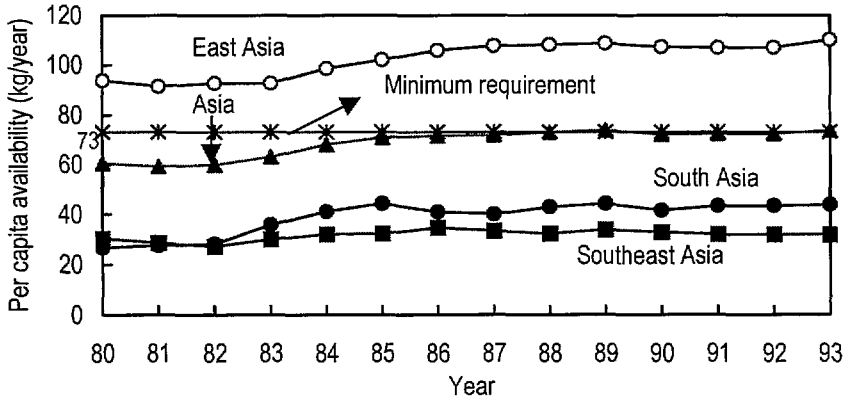


Fig. 4. Regional trends in per capita availability in Asia, 1981-93

Irregularity in Supply

Availability is not only stagnant and at a low level in most of Asia, yearly supply of vegetables is quite irregular as well. In each country report, the detrended coefficients of variation in individual as well as total vegetable area, production, and yield are compared with rice, a dominant crop in Asia. In this chapter, these coefficients are presented at the regional level. The conclusion is the same as in the individual reports: Vegetables, even as a group, have higher yearly variations than cereals in all regions (Table 1). At the regional level, the instability in vegetable area and yield is almost equal in most cases. However, the country reports do point out the relative importance of these two sources of instability in vegetable production.

There has been a significant decrease in the variability of vegetable production in different regions when compared over 1980-86 and 1987-93. Although this is a small span over which to compare variability, a positive development is evident. Despite this improvement, variability in vegetable production has remained far higher than production variability in cereals. Therefore, more needs to be done to stabilize vegetable production through yield stabilizing technologies, such as stress tolerant varieties, protected cultivation, and government policies, such as ensured vegetable prices.

Table 1. Detrended coefficient of variation (CV) in area, production, and yield of vegetables and cereals during 1980-93

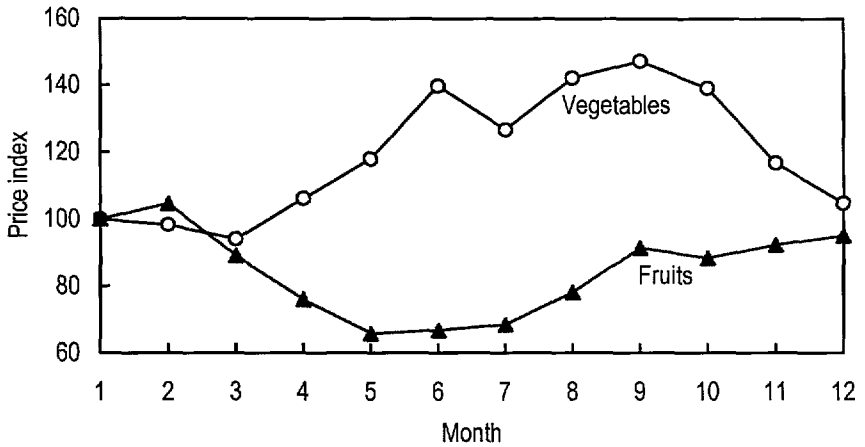
Region	Detrended CV in vegetables (%)			Detrended CV in cereals (%)		
	Area	Yield	Production	Area	Yield	Production
South Asia	9.69	10.40	8.17	2.08	3.73	3.82
Southeast Asia	14.51	11.09	5.37	2.35	2.46	2.86
East Asia	4.05	5.37	4.43	1.89	3.90	4.17
Asia	2.83	2.35	3.05	1.46	1.59	2.85

Seasonality in Supply

Vegetable production not only varies from year to year, but also from season to season. In the tropics, high temperature, excessive humidity, frequent and intensive flooding, and poor field drainage induce insect-pest development and reduce vegetable supplies during the wet summer. However, this pattern does not prevail everywhere. In temperate areas, in countries such as China, Japan, and Korea, and in northern Pakistan and India, supplies in winter are significantly reduced because of heavy frost and cold temperatures.

It is normally perceived that seasonality in individual vegetables can be counterbalanced by the seasonality in others. Evidence in this book refutes this. Even taken as a group, vegetables do show seasonality, both in price and availability.

It was also perceived that short supply of vegetables is compensated by abundant supply of fruits, another cheap source of micronutrients. This is not true either. In Taiwan, for example, vegetables and fruits are both in short supply in September-October and their prices are high (Fig. 5). A similar situation is discussed in the Indonesia and Nepal reports.



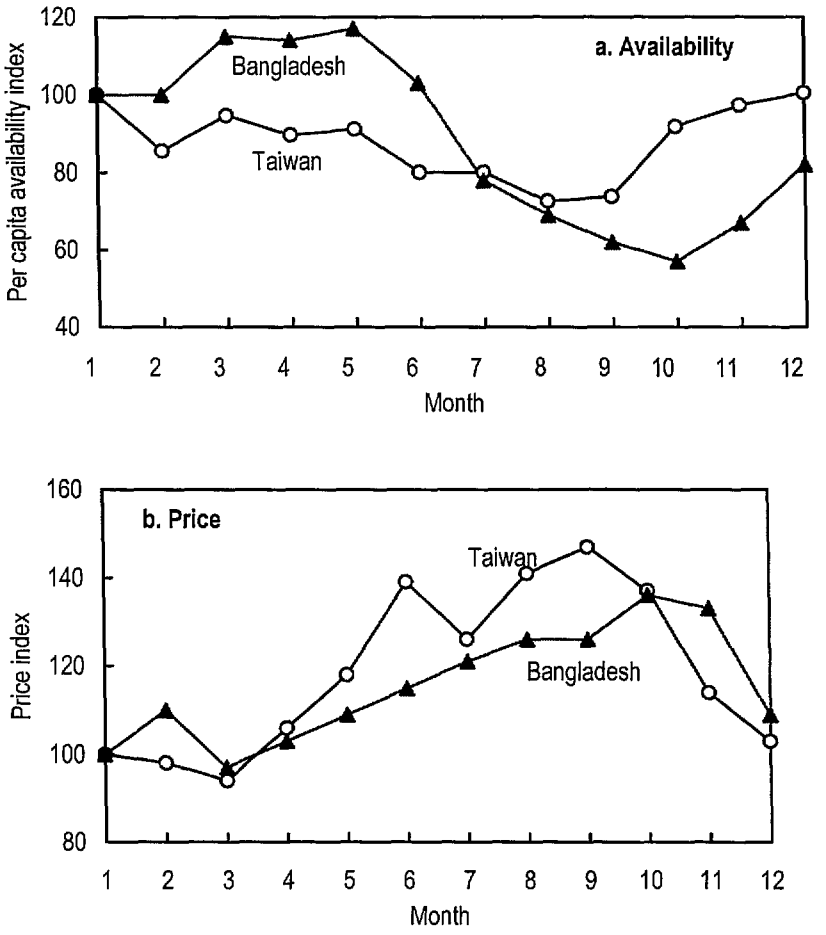
Source: Official data from Taipei Municipal Government

Fig. 5. Seasonality in fruit and vegetable prices in Taiwan, average of 1974-92

Seasonality in vegetable prices is usually high where consumers' preference for vegetables is high, which suggests that consumers are willing to pay high prices to maintain their vegetable consumption level during the lean supply period. This induces producers to grow more vegetables in the off season, reducing seasonality in availability. In countries where vegetables are less preferred, the opposite is true—consumers reduce their consumption rather than pay high prices, which eventually results in a serious shortfall in supply. Comparing seasonality in Bangladesh and Taiwan, while total vegetable supply in October in Bangladesh is 50% that of March-May, and in Taiwan supply in August-September is 73% that of December-January, seasonality in vegetable prices is high in Taiwan and modest in Bangladesh (Fig. 6).

Because preference for vegetables is normally related to income level, the above analysis implies that income-induced demand is concentrated during the off season. Vegetable production during the peak summer months is more difficult than during the peak winter months. This, combined with the fact that most Asian cities are located in the lowland tropics, creates a high demand for summer production technologies.

Most Asian countries, however, have highland areas where environmental conditions are favorable for vegetable cultivation when it is very hot and humid in the lowlands. For example, the summer season supply for Bangkok mainly comes from Chiang Mai, for Manila from Bagiuo, for Kuala Lumpur from the Cameron Highlands, etc. So, maintaining good trade and transportation links with these areas within a country can reduce seasonality. However, despite recent improvements in the supply from these areas, such sites can meet only a small portion of the potential summer vegetable demand of urban and rural areas in the lowlands, and seasonality in vegetable supply remains a big issue.



Source: Elias and Hussain (2000) for Bangladesh, and Wann et al. (2000) for Taiwan.

Fig. 6. Seasonality in vegetable availability and prices in Dhaka (Bangladesh) and Taipei (Taiwan) markets

In this book, seasonal patterns in vegetable prices (and in some cases their supply) of major vegetable producing countries in Asia are presented. These patterns reveal that peak and low price periods do not overlap in different countries of Asia. For example, overall vegetable prices are highest in September-October in Taiwan, the peak is reached in May-July in Indonesia. Similarly, the market arrivals of vegetables are lowest in July-August in India, and in January-February in Pakistan. And evidence is provided in this book on regional differences (within a country) in seasonal patterns of individual vegetables. For example, in India, eggplant prices are highest in October in Calcutta while they are around their lowest in New Delhi. This provides an opportunity to reduce seasonality by strengthening regional and cross-country trade. However, as quality traits in vegetables are site-specific and consumers prefer fresh vegetables, regional trade has scope to remedy seasonality only in those vegetables having long shelf life and where quality attributes are uniform across regions.

Introduction of modern vegetable technologies along with government policy support for summer vegetable production has proven to be a sustainable way to reduce seasonally in most vegetables. A pertinent example is Taiwan where such policy has improved summer vegetable supply (Wann et al. 2000). A more particular example is tomato in Taiwan, where introduction of summer tomato

varieties from the Asian Vegetable Research and Development Center (AVRDC) has reduced seasonality in prices, especially during the months of August-November (Fig. 7).

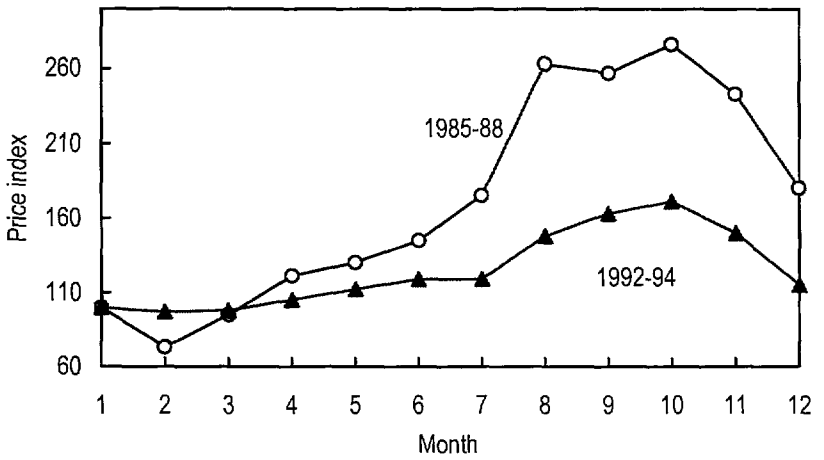


Fig. 7. Reduction in seasonal tomato prices at the retail level in Taiwan

Vegetable Demand

Consumption

Household consumption data for certain years in some Asian countries are available. These data help to determine the importance of vegetables in the diet, and help to compare vegetable demand across income groups and regions. The contribution of vegetables in the diet ranges from 5 to 28% (weight basis) (Table 2). The consumers' budget share for vegetables has generally increased, mainly because of a higher rate of increase in vegetable prices than prices of other foods. However, the contribution of processed vegetables has remained small.

Table 2. Vegetable share in diet in selected Asian countries

Country	Latest year for which data are available	Quantity of total food (g/capita/annum)	Share (%) of vegetables in total food quantity	Share (%) of vegetables in food expenditure
Bangladesh	1989	904	12.5	8.8
China	1991	1013	9.3	11.0
India	1991	794	10.6	-
Indonesia	1993	712	5.3	5.3
Nepal	1992	1030	8.5	-
Pakistan	1991	1000	10.6	9.6
Philippines	1993	980	10.8	-
Sri Lanka	1993	800	11.0	9.0
Thailand	1986	742	14.3	-
Taiwan	1998	1661	27.8	22.3
Vietnam	1989	808	17.8	-

- implies that the information is not available.

Factors Affecting Demand

Despite the availability of household data, there is no rigorous analysis on the socioeconomic factors affecting vegetable demand. Only a few scattered efforts made to estimate the income and price elasticities of individual and all vegetables as a group are reviewed in this book. These elasticities are estimated using different approaches at different points in time, thus are difficult to compare. Some country papers do indicate that consumers prefer fresh vegetables, hence the small role of processed vegetables in the diet.

Income Effect

Short of rigorous analysis, however, vegetable consumption seems linked to income, suggesting that income growth in Asia will continue to put pressure on vegetable demand. The income elasticities reported in some country papers vary from as low as 0.1 to more than one. However, most of the vegetables fall in the range of 0.2-0.6, with an average of 0.4. The positive income elasticities do not imply that income growth will automatically take care of low vegetable consumption in Asia. The pressure on vegetable demand might simply convert to high prices if technological advances do not bring added supply. The off-season supply situation is even more serious, as income elasticity for the off season is thought to be higher than for the peak season, although no quantitative estimate on seasonal variation of income elasticity of demand is available.

Higher incomes not only generate more demand, but that demand is more diversified. For example, the variance of the distribution of consumption across vegetable species in Taiwan increased from 65 in 1975 to 80 in 1993 due to reduced concentration on major vegetables and inclusion of newer vegetables in the consumption bundle (Ali and Tsou 1997). Moreover, higher incomes will induce demand for high quality, pesticide-free and hygienic vegetables. However, such demand is still trivial in Asia.

Price and Technology Effect

In general, price elasticities for vegetables are negative, implying that decreasing the real prices of vegetables will increase consumption. In general, price elasticities of vegetables range from 0.2 to 0.8, with an average of 0.5, which is significantly higher than the price elasticity of cereal demand which ranges from 0.2 to 0.3, implying that vegetable research on technological innovations results a more equitable distribution of benefits among producers and consumers.

Regional Effect

Similar to the variation across countries, wide differences in demand were observed within countries. In Malaysia, for example, total annual per capita consumption in Kelantan is less than half of that in Persekutuan. Thus, integration of far-flung areas into the market economy is expected to create substantial additional demand.

Contrary to perception, vegetable demand in rural areas is not higher than in urban areas. Actually, some evidence from Malaysia, Indonesia, Bangladesh, and Thailand suggests that the opposite is true. This is because markets in urban areas fetch vegetables from diverse vegetable-growing regions and maintain a regular supply, while in rural areas, supply is limited to during the harvest period. This implies that urbanization will bring additional vegetable demand.

Supply and Demand Gap

Production is not keeping pace with rising demand. Growth in vegetable demand, generated by rising incomes, population, and urbanization in Asia, has ranged from 3 to 6% in South and Southeast Asia. Supply has not risen accordingly. This has created a positive demand-supply gap in all countries and regions, except in Indonesia (Table 3).

Table 3. Vegetable supply and demand gap in major vegetable growing countries in Asian, 1980-93

Country	Growth in per capita Income (%)	Increase in vegetable demand (% per annum) due to Income[1]	Population	Urbanization[2]	Total demand	Domestic Supply (%)	Demand-supply gap (%)
East Asia							
Taiwan	8.4	0.00	1.24	0	1.24	-1.33	2.57
Korea	9.4	0.00	1.21	0.33	1.54	1.32	0.22
China	9.0	2.70	1.48	0.50	4.68	3.59	1.09
Southeast Asia							
Philippines	1.2	0.48	2.03	0.27	2.78	0.51	2.27
Indonesia	5.7	2.28	2.10	0.50	4.88	7.82	-2.94
Thailand	8.2	3.28	1.50	0.54	5.32	3.06	2.26
Malaysia	5.2	2.08	2.58	0.02	4.68	1.29	3.39
Vietnam	9.0	3.60	2.01	0.60	6.21	3.26	2.95
South Asia							
Pakistan	6.1	2.44	3.27	0.33	6.04	4.67	1.37
India	5.2	2.08	2.14	0.70	4.92	4.00	0.92
Bangladesh	2.3	0.92	2.01	0.76	3.69	0.07	3.62
Sri Lanka	3.2	1.28	1.42	0.09	2.79	-1.38	4.17
Nepal	4.6	1.84	3.50	0.30	5.64	5.51	0.13

[1]The demand for vegetables generated by enhanced incomes was estimated by multiplying income elasticity with the rate of increase in per capita income. The income elasticity was assumed to be 0.4, except for Taiwan and Korea where vegetable consumption is already at a high level, and additional income is assumed to generate no additional vegetable demand. In China, the income elasticity was assumed to be 0.30 as per capita availability is lower than in Taiwan and Korea, but higher than in other developing countries.

[2]Additional vegetable demand generated by urbanization was estimated by multiplying the percentage difference in vegetable consumption between urban and rural areas with the urbanization rate (%). A modest difference of 20% in vegetable consumption between urban and rural areas was assumed. Urbanization was estimated as the difference in population growth of the urban areas and the total population growth in a country.

Source: GDP and population growth rates are from Council for Economic Planning and Development (1995). The growth rates in vegetable production after deducting exports were estimated from data reported in various country reports in this book.

This results in an upward push in prices (Fig. 8). The demand pressure on prices can be observed in all regions, but the highest pressure was felt in East Asia, especially in China, where due to increasing incomes, demand for vegetables remained high. Despite price rises, policy makers appear unconcerned about shortages. This is because short supply in vegetables creates hidden hunger—deficiencies of micronutrients, less visibly startling than caloric malnutrition, but just as debilitating.

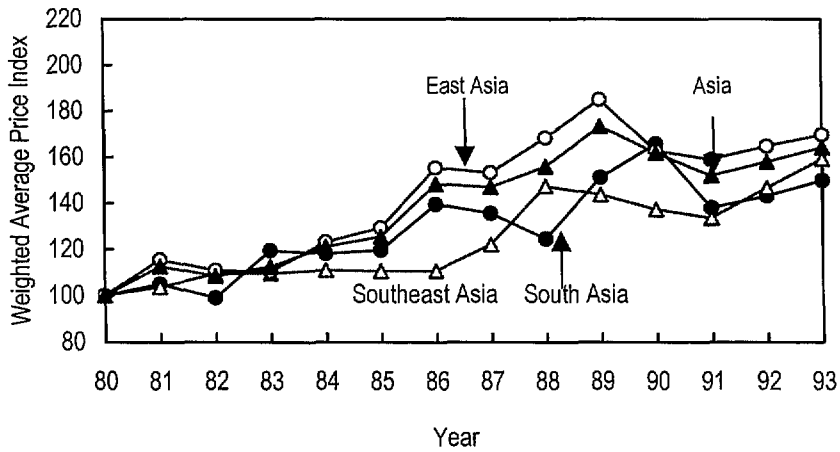


Fig. 8. Regional trend in the deflated or real vegetable prices in Asia

Not enough demand data are available for the 1990s to conclude consumers' response (especially in the low-income group) to rising vegetable prices. There are some indications that low-income consumers will shift from high-price and high-quality vegetables to low-price and low-quality vegetables, although total quantity consumed might remain unchanged.

Implications for Micronutrient Malnutrition

Low, stagnant (over time), highly seasonal availability, and the resultant high prices have serious consequences for micronutrient availability. Micronutrient deficiency afflicts more than 2 billion people worldwide, mostly living in poorer countries (Graham and Welch 1994). Some 40 million preschool children suffer from at least a mild vitamin A deficiency (WHO 1992), and 0.7 million new cases are added every year (UNACC/SCN 1987). Some 7% of preschool children in India exhibit clinical symptoms of vitamin A deficiency, with subclinical deficiency levels likely to be much higher (Vijayaraghavan et al. 1987). About 1.5 billion people, or 30% of the world's population, suffer iron deficiency (Brown 1991; McGuire 1991; Gopalan 1984). Between 40 and 50% of pregnant women and 24% of children in China are affected by iron deficiency (Dong-sheng 1992).

Empirical evidence from many countries suggests that micronutrient deficiency is now far more serious than protein-energy malnutrition (PEM). For example, Calloway (1995) showed that while the energy requirements of toddlers were met in Egypt and Mexico, 36% and 43% of these same toddlers, respectively, were anemic and 32% and 68%, respectively, were vitamin A deficient. A survey of six villages in Maharashtra and Andhra Pradesh, India, found that 11-15% of children under 12 years old consumed less than the critical amount of energy, while 4-29% and 4-41% of preschool children had clinical vitamin A and B-complex deficiency symptoms, respectively (Walker and Ryan 1990). Bouis (1991) found that the number of households affected by micronutrient deficiency in the Philippines far exceeds the number affected by PEM. An 11-country survey turned up similar findings (Kurz and Johnson-Welch 1994). The International Food Policy Research Institute has discerned a rising trend in micronutrient deficiency in many Asian countries. Many of the country reports in this book also highlight micronutrient deficiency.

Diversification and Vegetables

Many factors are behind the present push for diversification of cereal-based cropping systems in Asia. Foremost is a concern for sustainability in the continuous cereal-cereal rotation (Cassman and Pingali 1993). Other considerations are diversification of risk, income, and food, and enhanced efficiency of farm resources.

Crop diversification is also getting a pull from consumers who now show a greater awareness of the advantages of diversifying a cereal-based diet with vegetables, fruits, livestock products, and seafood. Declining rice prices (Pingali 1992) and shortages of water, due to deteriorating irrigation infrastructure, reduced profitability of irrigation investment, and/or competing water demand for domestic use (Rosegrant and Pingali 1994), are driving farmers to replace rice with more water-efficient crops. All of these factors provide impetus for the expansion of vegetable cultivation.

Vegetables in the cropping system can help break the pathogen cycle in cereal-cereal rotations. And integration of leguminous vegetables, such as mungbean, can improve the productivity and profitability of the cereal-cereal system (Ali 1998; Ali et al. 1997). Vegetables utilize water most efficiently in terms of both production and economic efficiency (Ali 1999), and vegetable production engages more labor of vulnerable population groups, such as women and children (Braun et al. 1989; Wann et al. 2000). Throughout this book, evidence is provided that suggests replacing rice with vegetables can generate additional income and employment.

To what extent can vegetables diversify the existing cereal-based system? Across-country variation in the proportion of vegetable to cereal area suggests both potential and limitation for diversification. It is as high as 28% in East Asia (excluding China), but as low as 3-5% in South and Southeast Asia (Table 4). These variations are mainly due to differences in economic conditions, such as input and output prices, access to markets and price information, and risk-covering policies, and physical factors, such as climate, irrigation, erosion, drainage, soil chemistry, and topography.

Some marginal improvements have been made in diversifying Asian cereal-based systems. In 1980, the vegetable growing area was equivalent to only 4.5% of the cereal-growing area; by 1993 this figure had risen to 6.3%. The increase is more prominent in East Asia, mainly due to expansion in vegetable area (45%) and reduction in cereal area (10%). Small gains were also made in South Asia, but the proportion remained almost stagnant in Southeast Asia (Table 4).

Table 4. Vegetable area as a percentage of total cereal area by region, 1980-93

Year	South Asia	Southeast Asia	East Asia (excluding China)	China	Asia
1980	3.3	3.7	24.7	5.4	4.5
1981	3.3	3.7	24.9	5.7	4.6
1982	3.5	4.3	24.9	6.0	4.9
1983	3.6	3.8	24.2	6.0	4.8
1984	3.6	4.7	24.5	6.1	5.0
1985	3.9	4.6	25.2	6.6	5.3
1986	3.9	5.0	26.5	6.7	5.4
1987	3.9	4.3	25.7	6.9	5.4

Contd. Table 4.

Year	South Asia	Southeast Asia	East Asia (excluding China)	China	Asia
1988	3.9	4.7	25.8	6.8	5.4
1989	4.1	5.6	25.1	6.9	5.6
1990	4.0	3.9	25.1	7.2	5.4
1991	4.2	3.9	26.6	7.7	5.7
1992	4.2	4.0	27.1	8.4	6.0
1993	4.3	4.0	27.5	9.1	6.3

Increase in the value of vegetable production relative to the value of cereal production has been quite dramatic. In Asia as a whole, the proportion almost doubled from 17% in 1980 to 30% in 1993. The change was pervasive, mainly due to increases in vegetable prices relative to cereals (Fig. 9).

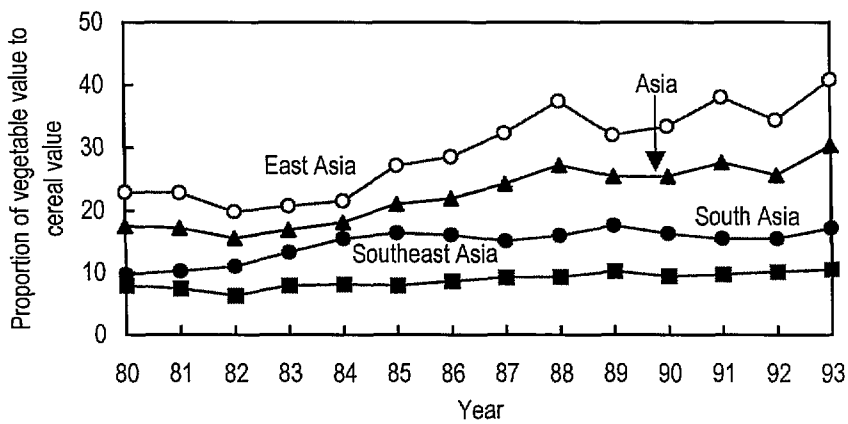


Fig. 9. Regional trends in the value of vegetable production as a proportion of cereal production value

Constraints and Possibilities

Environmental factors can limit diversification of agricultural production systems. For example, uplands already have quite a high degree of diversification, while hot, humid lowland tropics are environmentally unsuitable for vegetable cultivation. Generally, temperature, in particular high night temperature in tomato (Peet and Willits 1993), and flooding (Midmore and Poudel 1996) limit vegetable cultivation.

However, technologies that help overcome these environmental stresses are available, and depending upon vegetable prices and physical factors, harsh environments can be ameliorated. For example, vegetable farmers on the periphery of Bangkok build and maintain ditches and dikes (called *sorjan* systems) to manage flooding in vegetable fields. Similar systems are used to grow year-round vegetables in China (Plucknett et al. 1981) and in Indonesia (Pingali 1992). Technologies, such as hydroponics for the tropics, are also available (AVRDC 1995). Planting chili on raised (40cm versus 20cm) and narrow (1.0m versus 1.5m) beds can improve plant survival and total fruit yield in the rainy season (AVRDC 1992). Grafting of tomato on eggplant rootstocks improves flood survival and enhances yield many-fold; combining raised beds, fruit set hormones, and simple plastic rain shelters

increases tomato yield three-fold (AVRDC 1993). Some of these technologies are discussed in the country reports. These technologies are expensive to install, operate, and maintain, and require high management skills. Thus, they are economically viable only when vegetable supplies are limited and prices are high. Modifying these technological solutions so that they become economically viable for a wider range of environments is a continuos challenge for vegetable researchers.

In the dry season in the irrigated lowlands, it is relatively easy to switch to vegetable crops. However, sometimes entire irrigation structures need to be rehabilitated (water flow-rate at the head, irrigation canals, channels and drainage, field slope, etc.) to make rice fields suitable for vegetable cultivation (Moya and Miranda 1989). Pingali et al. (1989) argued for system management (software) changes, rather than structural (hardware) changes. Sometimes, however, hardware changes are more economical, especially in the long term. For example, growers in Batac, northern Philippines, developed a separate irrigation system for vegetables—portable rubber pipes—and now avoid the large water losses that occur in water channels used to irrigate rice.

Apart from environmental factors, soils and drainage sometime affect diversification. For example, in Batac, about 90% of the course soils were observed to be under vegetables, and about 75% of the fine soils under rice cultivation (Mirjam 1997). However, good external drainage can facilitate expansion of vegetable cultivation on soils with poor internal drainage (i.e., heavy soils). In upcountry Banderawaela, Sri Lanka, where external drainage is good due to slope, vegetable farmers use 10-20 t of manure on every crop and change the topsoil every 3-4 years. A similar situation exists in the Cameron Highlands of Malaysia (Midmore et al. 1996). However, these techniques designed to ameliorate poor soils or poor internal drainage increase cost, thus, they are economically viable only where market access is good and prices are reasonably high.

Another constraint to diversifying cereal-based systems with vegetables is the high labor requirement. Throughout this book, labor requirements for vegetable cultivation are compared with those for field crops, such as rice. Vegetables can require up to 10-times more labor than do cereal crops, but 3-times is a good general average figure (this, on average, amounts to one year-round job for every hectare of cereal replaced with vegetables). Without mechanization, the high labor requirement can limit vegetable production area.

Moreover, vegetable production is much more costly than cereal production. The former has high input intensity, and a high proportion of hired labor compared to family labor. To overcome this constraint, informal arrangements, such as obligatory sale of output to a commission agent who provides inputs and other financing, are quite common in Asia. With the development of financial markets, the cost of finance could decline; however, high financial requirements, combined with the high risk of vegetable cultivation, will continue to be a major constraint.

Vegetable Production Systems

Vegetable types

Based on the part of the plant consumed, vegetables can be divided into three categories—leafy, stem, and fruit vegetables. They can also be classified according to perishability, or shelf life: 1-6 months (such as onion and chili); 6-10 days (such as tomato, eggplant, gourds, etc.); 2-5 days (mainly leafy vegetables, such as spinach, kang kong, mustard leaf, etc.). The second group is the largest in most countries, contributing more than half of the total vegetable supply, while the contributions from the first and third groups depend on factors such as consumer preference, development stage of the country, trade possibilities, etc. Longer-shelf-life vegetables are more prominent in South Asia than in

Southeast Asia. However, the contribution of leafy vegetables to the total vegetable supply is increasing in South Asia.

Socioeconomic changes in Asia will likely lead to a shift in the relative importance of different types of vegetables grown in various vegetable production systems.

Agroecological Zone, Cropping and Cultivation Systems, and Markets

In each country paper, the specialized vegetable production centers with respect to individual and overall vegetables are identified. Proximity to market and transport infrastructure is the major factor determining the location of these centers, and ecoregion seems to play a relatively lesser role. Favorable ecoregions lose their comparative advantage due to: (i) the localized nature of consumer preferences, (ii) difficulty hauling vegetables longer distances, (iii) overcoming the localized environmental and soil constraints by using external inputs, (iv) adaptation by farmers (farmers select vegetable species suited to unfavorable ecoregions, e.g., they grow flood and heat tolerant vegetable species, such as eggplant and leafy vegetables, in the hot tropics). Due to the combined effect of these factors, the concentration of vegetables in favorable ecoregions is not as great as in other crops, such as wheat and cassava, which travel and store well and which are not subject to restrictive localized consumer preferences. Vegetables tend to be ubiquitously distributed in all ecoregions, except in the cool subtropics with winter rains (where concentration of vegetable production can be partly due to a favorable environment and partly due to high income levels of the consumer) (Table 5).

Table 5. Vegetable and cereal production distribution (%) across [FAO-defined] agroecological zones (AEZ)

AEZ	Vegetables	Wheat	Cassava
Warm, arid, and semiarid tropics	7.2	0.6	15.4
Warm, subhumid tropics	5.9	0.1	30.4
Warm, humid tropics	7.7	0.5	48.7
Cool tropics	3.9	1.5	0.8
Warm, arid, and semiarid tropics (summer rain)	8.1	30.1	0.5
Warm, subhumid subtropics (summer rain)	6.8	9.3	0.4
Warm/cool humid subtropics (summer rain)	13.7	19.1	3.9
Cool subtropics (summer rain), including temperate	11.9	18.9	0.0
Cool subtropics (winter rain), including temperate	34.8	19.9	0.0

Source: TAC (1992).

Classification Based on Proximity to Consumption Centers

With respect to proximity to consumption centers, vegetable cultivation can be classified into three groups: home gardening (vegetables produced in the backyard for home consumption or for barter); peri-urban production (near and around large urban centers); and the trucking system (production distant from the consumption centers).

Peri-urban production, when situated in an unfavorable ecoregion (such as the hot-wet tropics), is a response to the market's failure to supply vegetables efficiently from distant but more favorable ecoregions (such as temperate regions and highlands) and failure to absorb unemployed urban labor. When market efficiency improves, the advantages of peri-urban production fade. The declining

contribution from peri-urban production in Thailand, Vietnam, and China can be taken as evidence. These changes, however, are exerting pressure on transportation systems.

Similarly, when markets are efficient in supplying vegetables and in absorbing surplus labor, there is little incentive to produce vegetables in home gardens. Home gardening requires surplus family labor, land, and know-how. Aside from this, insect pests, lack of seed and year-round water, and lack of interest are major constraints. Actually, the return to labor engaged in home gardening in Bangladesh (US$0.1/day) was found to be too small to be attractive at all (AVRDC 1994). The recent increase in consumer preference for pesticide-free vegetables might renew interest in home gardening, but such incentive will be temporary, just until production systems adjust to consumer demand.

In Bangkok and Hong Kong, where transport infrastructure is relatively developed, peri-urban production contributes just 26% (Keift 1994) and 18% (assuming all production in Hongkong is peri-urban, Speece 1994) to the total vegetable supply, respectively, compared to 75% in Ho Chi Min City (Jansen et al. 1995) and 60% in Kathmandu (Jansen et al. 1994), where infrastructure is underdeveloped. Even where infrastructure is not well developed, as in Ho Chi Minh city, relaxation of a government ban on vegetable imports from the uplands of Da Lat increased the share of upland produce in the city market (Khiem et al. 2000). Only production of more perishable vegetables is concentrated near Ho Chi Minh City (Jansen et al. 1995). The role of home gardens has largely diminished in Taiwan, Japan, and Korea, and is fast diminishing in Thailand and the Philippines.

Classification Based on Intensity

Vegetable production systems can also be defined with respect to intensity, i.e., intensive, year-round vegetable production systems, and extensive systems, where vegetables might be grown along with other field crops. The characteristics of these systems are discussed in country reports, and are summarized here (Table 6). As each system possesses unique characteristics and constraints, research agendas can be developed separately for each system around these constraints. The Asian Vegetable Research and Development Center has adopted this approach in organizing its programs and projects.

The increasing diversity in vegetable demand is expected to be met by expansion in the more diverse intensive system. However, diversified demand can be met by regional rather than farm diversification. In the former case, a particular farm need not be diversified. Rather, extensive farms specialized in a particular vegetable, can make that vegetable a regional specialty. In the future, regional diversity, where each region specializes in a particular vegetable, will probably dominate over farm diversity. It is more certain, however, that the intensive system will shift from lowlands around big cities to uplands, away from big consumption centers. The availability of such upland locations and transportation links will determine the extent of the shift.

The extensive vegetable production system, on the other hand, is expected to expand as pressure to diversify cereal-based production systems increases. The relative importance of intensive and extensive systems, more an academic question, will depend on factors such as consumer preference, concern for sustainability in the cereal-based system, improvement in farm management skills, development of agricultural service industries in rural areas, and trade links between rural production and urban consumption centers.

Table 6. Characteristics of intensive and extensive systems

Characteristic	Intensive system	Extensive system
Types of crops	Leafy, perishable, and short-duration	Fruit and root crops with medium and long durability
Cropping and input use intensity	High	Low and seasonal
Disease and insect pressure	High	Low
Soil degradation and excessive input use	Serious	Moderate
Dependence on agribusiness services, such as credit, commercial seedlings, etc.	High	Low
Production frontier	Near to the potential	Wide gap between potential and farm-level yields
Farm size	Relatively small	Relatively big
Proportion of hired labor	High	Higher than in cereal crops, but lower than in an intensive system
Structures for crop protection—shed, raised bed, etc.	Sophisticated	Simple
Diversity in vegetable production	High	Low
Contact with consumers	More personal	Less personal
Managerial skill of farmers	High	Higher than required for cereal crops, but lower than required to manage an intensive system

In any case, the implication for research is that it cannot be focused only on the few main vegetable crops. However, targeting many vegetables at one time is impractical. Therefore, the only solution is to identify the production constraints specific to each vegetable-based production system, and develop research agendas around the major constraints within various systems.

Component Technologies

Different component technologies are used to raise vegetables under various environments. These technologies include tools and equipment (manual, animal, and machine) to prepare land in different ways (i.e., flat, raised bed, etc.), different seeding methods (direct in line or broadcast, transplanting, and propagation), a wide variety of crop management methods (including crop protection, such as staking, mulching, covering, etc., against environmental stresses), crop protection methods (use of chemicals and integrated pest management), various types of fertilizer applied in a variety of ways (broadcast, dibbling, drilling, etc.), weeding (manual and chemical), various irrigation techniques (flood, furrow, drip, and sprinkle), and harvesting methods (manual and machine). Within a country, or even at a single site, various component technologies can be found. Such is the diversity and complexity of vegetable cultivation. The objective of this book was not to make a comprehensive review of the component technologies used in vegetable cultivation in different countries or regions. Rather, when a component technology was deemed important by a researcher in any production system, it was described in detail. However, analysis of the socioeconomic factors behind the adoption or non-adoption of advanced production technologies in vegetables is lacking in the literature.

From the evidence provided in this book, it is certain that more advanced technologies, as reflected by higher fertilizer, pesticide, and management labor, are used in vegetables than in cereals. Once farmers learn how to manage advanced production technologies in vegetable cultivation, they start to use these in cereal cultivation. Thus, vegetable farmers are found to produce more productive rice

crops than do non-vegetable farmers (AVRDC 1999). In this way, vegetables become a stepping stone for overall agricultural development.

The adoption of various component technologies depends upon the socioeconomic conditions in which farmers operate. These conditions include input-output prices and the farmer's management skill. With the fast changing economic environment in Asia, the component technologies and their relative shares in total production cost are expected to change. In general, wage rates and opportunity cost of family labor are expected to increase at a faster rate than material input costs, such as fertilizer and pesticides. Material costs will decline because of infrastructure development and increasing competition between different agencies engaged in the manufacture and distribution of these inputs. Therefore, there will be more demand for mechanization. The proportion of hired compared to family labor increases as family members take up more regular off-farm employment. On the other hand, as crop production requires more management input at higher productivity levels in the intensive system, the demand for family labor, despite high opportunity cost, might increase. As machines cannot substitute management labor, both machine and labor share might increase.

These changes can be seen through a comparison of factor shares in vegetable production for developed and developing economies (Fig. 10). For example, factor share of total labor in onion production is 62.7% in Taiwan (29.2% family + 33.5% hired) compared to only 43.6% in India (21.1% family + 22.5% hired), and 35% in Nepal (35% family + 0% hired). Similarly, machine share is high at about 14.9% in Taiwan compared to 3.7% in India and 8.0% in Nepal. The shares of material inputs, such as seed, energy, fertilizer, chemicals, and manure, show the opposite tally. For example, the seed and energy share in Taiwan is only 5.3%, while it is 32.2% in India, and 33.0% in Nepal. The chemical share is 17.1% in Taiwan, 20.6% in India, and 24% in Nepal. Similar differences in tomato production across Taiwan, India, and Nepal can be observed.

Marketing

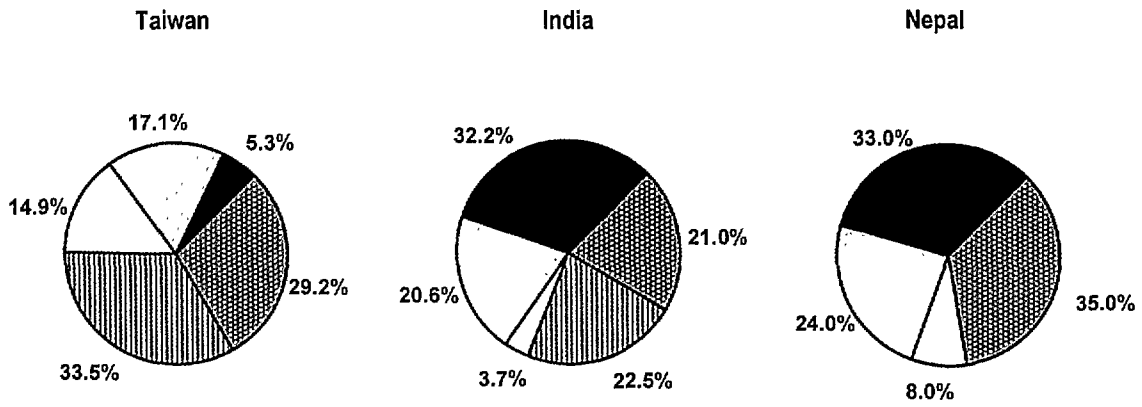
Marketing is the process of discovering and translating consumer needs into product and service specifications, or creating demand for these products/services and then expanding this demand. Marketing in vegetables is particularly important as up to 90-98% of the output of most vegetables is sold, except for root and tuber crops for which a significant proportion is saved for seed (Singh and Sikka 1992), and vegetables produced in home gardens. Markets can be categorized by their degree of competition, i.e., from a perfectly competitive market to monopoly. A common approach to market research is to describe various marketing systems and compare their relative efficiency. Various actors engaged in different systems are listed, and their functions are described in each country report. In this chapter, conclusions arrived at in the marketing sections of each report are summarized.

Marketing Systems

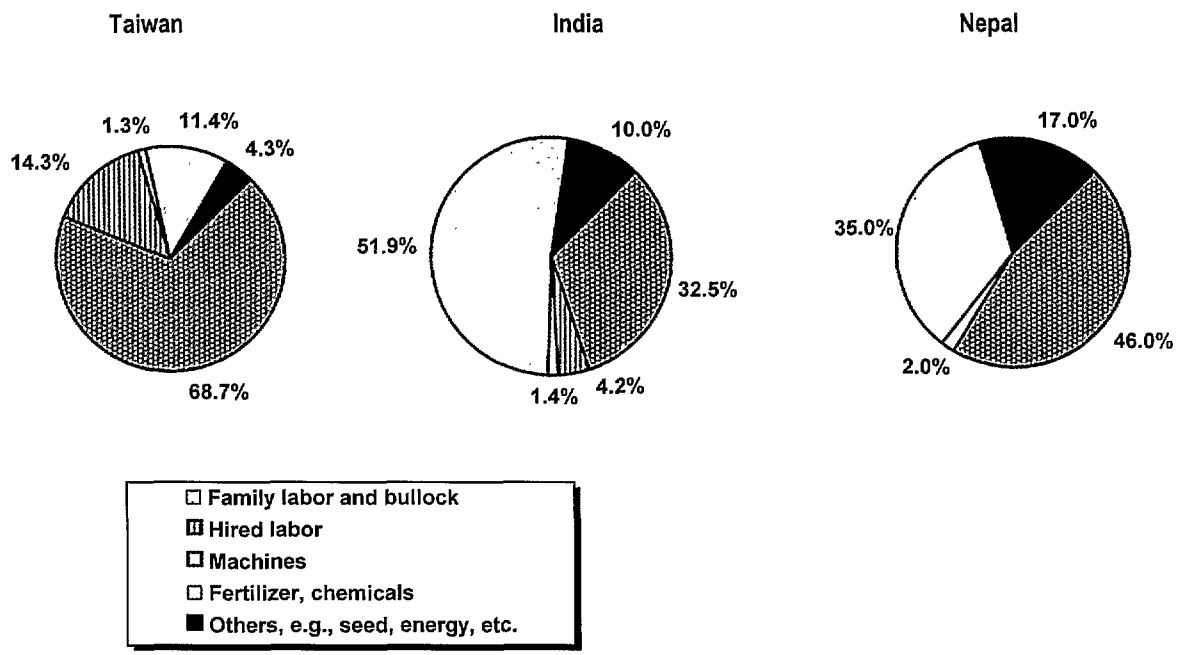
Many marketing systems are reviewed in each country report. From this review it can be concluded that marketing systems for vegetables are complex, and tend to vary across vegetable species, location, end use (fresh or processed), and destination (local, town, big city, or export market). However, we can group these into three general systems.

The first system engages a central wholesale market. This system is dominant in Taiwan, Korea, Malaysia, and Japan, and is being institutionalized in Thailand and Indonesia. It seems that with the development of an economy, this system evolves as an efficient vegetable marketing system.

Onion



Tomato



Source: For Taiwan, PDAF (1994), for India, Government of India (1991), for Nepal, Thapa and Paudyal (2000).

Fig. 10. Budget share of different inputs in total cost of onion and tomato production in India (1978), Taiwan (1993), and Nepal (1992)

The main characteristic of the second system is the absence of any central wholesale market. Trade takes place in traditional sites in capital cities. No one person or group controls the trading. Typically, several price levels for a commodity prevail at any time. Thus, prevailing prices do not truly reflect consumer preferences. Several inter-agent transactions at the same marketing level can be observed (Librero and Rola 2000). This marketing system still dominates in most developing economies, such as the Philippines, Thailand, Indonesia, India, Bangladesh, and Pakistan.

In the third type of vegetable marketing system, farmers bring their produce to nearby markets and sell to retailers or directly to consumers. Small farmers, especially those on the periphery of big cities, practice this system. Producers have a direct link with consumers and can adjust their produce according to consumer preferences. Farmers' markets, where producers can have a stall at minimal cost, are being set up in big cities in Indonesia and Malaysia to encourage this marketing system, which is pervasive in northern Vietnam and China. In this system, the producers' share of the consumers' price can be high, but marketing costs can also be high. For example, labor required for vegetable marketing in China accounts for about one fifth of the farm labor devoted to vegetables. The economic efficiency of this system is not clear, but it is certain that it limits expansion of vegetable cultivation.

Marketing Margins

This book reviews marketing margins at various levels of marketing channels, and discusses the roles played by various marketing agents. Upward trends in the marketing margins, estimated from the secondary price data, are obvious for all vegetables in many countries (except for certain vegetables in Malaysia). This is mainly due to an increase in transportation costs as cultivation shifts to more remote areas. Another reason is rising wages. Rising marketing margins will put more pressure on prices, which are already drifting upward at quite a high rate.

It is generally perceived that marketing agents exploit producers and consumers by charging a fixed and high margin on their investment. No rigorous analysis is available on the rate of return on investment made by marketing agents. However, the perception might be false because: (i) marketing margins in the off season are lower than margins in the peak season, (ii) price variability is generally lower at the retail or wholesale level than at the farm gate, (iii) the correlation between prices paid by agents and marketing margins was found to be negative in Malaysia, implying that when agents pay higher prices, they have to reduce their margin, mainly by reducing their profit. All these imply that marketing agents do in fact adjust their margins, which helps to reduce price variation. High marketing margins in vegetables can be attributed to poor infrastructure, such as roads, storage facilities, etc., which cause high post-harvest losses and create high risk in vegetable trading, rather than due to the monopolistic powers of the middlemen.

Generally, retailers receive high margins because of the small quantities they trade daily. Retailing in large quantities, such as by big grocery stores, can reduce cost, but such an option is not feasible at a low development stage because of high capital cost and the low accessibility to these stores. Moreover, these stores reduce opportunities for the self-employed small retailers.

Profit (which normally includes output losses) is a major part of the margin of all marketing agents, mainly because of high output losses and high prevailing interest on capital.

The means of transportation depends on the development stage of the economy, the distance the produce must travel, and the ultimate market to be served.

International Trade

In 1993, vegetable exports in Asia were worth US$1.60 billion, and imports were worth US$3.20 billion. This amounted to a deficit of US$1.60 billion. East Asia has gone from surplus to having large deficits, and the deficit is growing. All countries in this region, except China, are in deficit. China's surplus of about US$500 million meets less than a third of the deficit generated by its neighbors. On the other hand, South and Southeast Asia have small surpluses (Table 7).

Table 7. International trade in vegetables (million US$) in Asia

	South Asia			Southeast Asia			East Asia			Asia		
Year	Export	Import	Surplus	Export	Import	Surplus	Export	Import	Surplus	Export	Import	Surplus
1980	62	3	59	28	61	-33	1067	1050	16	1157	1115	42
1981	56	4	51	41	72	-31	1025	1172	-147	1122	1248	-126
1982	81	10	71	43	92	-50	975	964	11	1099	1067	33
1983	77	18	59	53	91	-38	869	829	40	999	938	61
1984	88	39	49	71	98	-27	945	1153	-208	1105	1290	-186
1985	60	39	21	68	94	-27	873	1083	-210	1000	1217	-216
1986	87	35	52	91	98	-7	1053	1224	-170	1232	1357	-125
1987	82	34	48	143	106	37	1133	1433	-300	1358	1573	-215
1988	97	27	70	159	137	22	1256	1997	-741	1512	2161	-649
1989	99	11	88	202	147	55	1328	2122	-794	1629	2280	-651
1990	97	27	70	230	156	75	1390	2195	-804	1718	2377	-659
1991	135	51	85	317	160	156	1482	2539	-1058	1933	2750	-816
1992	132	36	96	317	179	138	1549	2799	-1250	1998	3015	-1016
1993	147	29	118	184	178	6	1266	2995	-1729	1597	3202	-1605

Japan, Hong Kong, and Malaysia are big vegetable importers, with deficits of US$2198 million, US$228 million, US$97 million, respectively in 1992. The Philippines is also a net importer, although its deficit is small. Figures from the early 1990s show that Indonesia's vegetable trade is almost balanced. Thailand was the only net exporter in Southeast Asia throughout the 1980s and the early 1990s, and its trade surplus grew over time, reaching US$252 million in 1992.

Despite growth in vegetable trade in Asia, the percentage of the traded (imports and exports) to total production value is still less than 10%. However, in Hong Kong, Singapore, and Malaysia, 84%, 75%, and 60% of the total supply, respectively, is filled by imports. In Japan and Taiwan, the share of imports increased from 2% in 1980 to around 20% in 1993.

Data from Thailand reflect changes in the types of vegetables traded in international markets. The share of fresh vegetables in exports has declined, while in imports it has increased, indicating that Thais' preference for fresh vegetables has increased. Meanwhile, the share of frozen vegetables in exports has increased and the share of dried vegetables in imports has declined. Lack of data for other countries prevents us from drawing any general conclusions at the regional level.

International vegetable trade is highly variable in Asia. Imports and exports are normally used to manage crises in supply of major vegetables. For example, at times of glut, exportation is encouraged in order to save farmers from low prices. At times of acute shortage, imports are managed. When these crises pass, no effort is made to continue the trade.

Taiwan offers a good example of how international trade in vegetables can spur development. Exports of mushrooms and asparagus during the 1970s played a critical role in overall development of that country. Thailand is now following a similar pattern.

Research Needs

Commendable progress has been made in documenting various aspects of vegetable production, consumption, and distribution in major vegetable-producing countries in Asia. With few exceptions, data on area, production, and yield of individual vegetables are available. For most Asian countries, with the exception of Bangladesh and China, per capita availability estimated from production data generally matches consumption obtained through household consumption surveys, assuming some post-harvest losses. Even so, sampling technologies used to collect these data need to be improved.

The economics of vegetable production, estimated from various individual studies, are reviewed in each country report. These studies, however, were conducted at different times, in different regions, using different methodologies. Thus, they are not comparable. Unless accurate estimates of input use and costs are available for various crops in various regions (generated at the same time, using a standard methodology), the comparative advantage of these crops in various regions, as well as at the country level, cannot be determined. Moreover, technological changes occurring in the production sector cannot be deduced. Without these analyses, rational policies to encourage competitiveness in the international and regional markets cannot be formulated. Such analyses become increasingly important with the opening up of markets. An international organization, such as AVRDC, in collaboration with national research programs, should conduct comparative cost analyses and generate crop budget estimates for major vegetables grown in various regions.

Losses due to different biological and socioeconomic constraints need to be quantified. This would help in setting research priorities. So far, major insects and diseases affecting various vegetable crops have been identified. Loss figures for catastrophic cases are also available, which in most cases are close to 100%. But, how much loss each of the major diseases and insects actually accounts for and the frequency of their occurrence are unknown.

The yield gap in most vegetables is high. As documented in the India report, the gap between potentially achievable and actual yields ranges from 26 to 72% for various crops. Bridging this yield gap could generate substantial additional production. However, socioeconomic and institutional determinants of yield gap are unknown.

A related issue, almost unexplored until now, is the characterization of vegetable farmers. We know that vegetable farmers usually operate on a small scale, but what type of training, education, and attitude do they possess? What prompts a farmer to include vegetables in a cropping system, or specialize exclusively in vegetables? Why is vegetable cultivation not expanding on other small farms, despite high rate of return? What role does risk play? Why do vegetable farmers use high amounts of chemicals despite little or no crop response? Why do some farmers manage their fields very well while others do not? Is this due to lack of inputs, marketing constraints, or differential access to input supply, especially credit, extension, and education? The review of literature on various issues in this book suggests that these questions have yet to be answered. Therefore, it is suggested

that a project be initiated in selected countries to characterize vegetable farmers, and to determine the yield and profit sensitivity under various management practices and socioeconomic and biophysical environments. Among other things, learning more about vegetable farmers will help in planning effective training courses for them.

Recent research has shown that in low-income groups in Asia, micronutrient deficiencies are becoming more serious than malnutrition caused by the lack of major nutrients (Ali and Tsou 1997). More studies are needed to determine which micronutrients are lacking and in what segments of the population. Culturally acceptable and micronutrient dense vegetables need to be identified. Then, strategies to enhance the production of those vegetables should be formulated to improve the supply of the deficient micronutrient locally, and trade strategies should be designed to encourage their supply from other regions.

Most countries report monthly vegetable prices. Thus, seasonality in vegetable prices can be estimated reliably. However, associated seasonality in supply and consumption are rarely documented. Most of the household consumption surveys conducted in Asia do not take into account the seasonal pattern of availability. Vegetable consumption reported in these surveys reflects only the season in which the surveys were conducted. It is, therefore, recommended that seasonal supplies be reported along with seasonal prices. Moreover, household consumption surveys should be conducted at least four times a year.

Post-harvest losses for individual vegetables passing through various marketing channels are rarely quantified. This is critical in comparing the efficiency of various marketing channels, and for identifying ways and means to reduce these losses. Moreover, studies on the quantification of the monopoly power of marketing agents are needed. These will help to improve overall marketing efficiency.

Very little is known about the determinants of vegetable supply and demand. While income and demand elasticities from individual studies are reported for most countries, these studies have limited regional coverage, and have been conducted mostly for individual commodities, using a single-equation estimation approach. Moreover, very little is studied on socioeconomic and institutional constraints to vegetable consumption. The supply side is even less researched; supply elasticities are available for only a few commodities in a few countries. The importance of other factors, such as technology, institutions, and inputs, is not explored. Therefore, it is suggested to organize a regional project on the supply and demand of vegetables. This will help to identify factors creating the gap in demand and supply, and predict the gap at the country and regional levels with more accuracy.

Consumers' preferences are region specific. For example, Indians prefer large onions, while Filipinos prefer small onions. Preferences differ even within countries. This limits the scope of trade, but improves the potential scope of research to meet the gap in demand and supply. Consumers' preferences for various attributes in individual vegetables need to be quantified at the regional level to help in designing research strategies at the regional, national, and international levels.

Although demand for low-input or chemical-free vegetables is emerging, the contribution of such demand to total supply is still very small in Asia. At this stage, consequences of high input intensity on health and resource sustainability should be quantified and highlighted. This would help to popularize low-input or chemical-free vegetables, both among producers and consumers.

Conclusions

The stage is set for expanded vegetable consumption in Asia, which is currently lingering at a much lower level than is required for good health. Income and population growth and fast urbanization have created additional demand for regular supply of quality vegetables, while the need to diversify cereal-cereal production systems for sustainability has generated additional scope for vegetable cultivation. These forces are reinforced by consumer demand for a diversified diet.

This dynamism requires that more attention be given to vegetables, especially considering that the value of vegetable production has shot up to about one-third of the total value of cereal production in Asia. This high share of vegetables in the farm sector should not and cannot be ignored. Resource allocation, especially for vegetable research, largely based on their share in total cropped area, should now be based upon their share in farm product value.

With present vegetable production technologies, supply is only moderately responsive to increased demand, especially during the hot-wet season. Unless constraints to expanded vegetable cultivation are overcome, increased demand will simply drive up prices or promote imports. To correct this, high-yielding and low-cost technologies need to be developed, especially for the hot-wet season.

Both production- and trade-oriented policies should be used to meet the gap between demand and supply. Production-oriented strategies should focus on developing high-yielding and stress-tolerant varieties and effective management systems so that more farmers can produce more vegetables at lower per-unit costs while maintaining long-term resource productivity. Although many technologies are available to ameliorate stresses and reduce production risks, they are expensive, environmentally unfriendly, and adoption is limited. Making these technologies economically viable and environmentally friendly for a wider range of environments is a challenge for researchers.

With the continuous improvement in transport infrastructure, proximity to consumption centers is a less important determinant in the location of vegetable cultivation. This development also lends itself to trade-oriented strategies as production can be promoted in once-remote vegetable growing regions. As imports are expensive for developing economies and consumers' preferences for vegetables are localized, such trade-oriented strategies have to focus on enhancing the domestic trade. Production in more remote regions creates jobs and incomes for upland farmers, and reduces migration to cities. Enhanced income might also help save forest resources, as farmers engage in more productive vegetable cultivation. However, these regions normally use input-intensive, environmentally unfriendly, and unsustainable technologies (Midmore et al. 1996). Therefore, projects to introduce environment friendly and resource sustainable technologies in these otherwise favorable ecoregions should be given high priority.

Long-distance trade, however, requires efficient marketing systems so that vegetables move cheaply and quickly without quality losses. Moreover, the scope of the trade is limited to those vegetable species with a long shelf life, and that possess common quality traits preferred everywhere. Before implementing such strategies, consumers' preferences need to be documented at the regional level, and changes in these preferences, with changes in income level, need to be tracked.

The new macroeconomic environment has altered relative factor costs—the costs of labor (especially hired labor) and machinery are increasing, while material costs are decreasing. Therefore, demand for mechanical technologies to offset high labor costs, along with uniform-maturing vegetable varieties suitable for mechanical harvesting, will remain high in Asia. However, such a trend might aggravate already high seasonality in vegetable supply, as most of the output will be ready to harvest at the

same time. This adds a dimension to vegetable varietal research: to spread supply, the new vegetable varieties should also be photo insensitive, so that they can be grown at any time of the year.

Many capital-intensive and labor-saving technologies might become economically feasible if factor prices change. These technologies could overcome environmental constraints, and obscure the relative advantage of uplands in vegetable production. However, because vegetable production (especially using capital-intensive technologies) requires more cash than does production of other field crops, capital shortage will remain a serious constraint.

As material costs decline relative to the total cost of vegetable production, the incentive to overuse these inputs increases. Thus, the demand for input-free vegetables must come from consumers. In anticipation, researchers should assign a high priority to the development of chemical-free production technologies and to ensuring sustained resource productivity in agriculture. If consumers had a simple means of spot-checking pesticide levels then they might be encouraged to offer differential prices for pesticide-free vegetables, and thus provide economic incentive for producers to adopt pesticide-free technologies.

A strong vegetable sector means healthy consumers, wealthy and busy (employed) producers, diversity in income sources, and sustainability in agriculture production systems. With current production technologies, the area under vegetables in South and Southeast Asia would need to triple in order to raise per capita availability on par with East Asia. This would require 14 million additional hectares for vegetable cultivation in these regions. Assuming this area would come from cereals, an additional 14 million jobs would be generated. About the same number of jobs would be created in post-harvest handling of the additional vegetable output of 128 million t. At an average price of US$300/t (in 1993), this would generate an additional income of US$37 billion to farmers in Asia. About the same income would go to traders for moving this output to consumers. To achieve this, policy makers need to focus more attention on the design of appropriate production and marketing strategies for vegetables.

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Appendix 1 (Estimation Procedures)

Trend Analysis

Trends in area, production, and yield of various vegetable crops were quantified econometrically by estimating the following equation:

$$lnY_i = \alpha_o + \gamma_i T + \mu_i T^2 \quad (1)$$

where Y_i is the area, production, or yield of the *i*th crop, T is the trend variable having values of 0, 1, 2, ... for various years, T^2 is the square of the trend variable, and *ln* is the natural logarithm. The coefficient γ_i represents the linear, while μ_i the non-linear trend in the dependent variable. Coefficients not statistically significant are not reported. The signs on γ_i and μ_i represent the special nature of trend in the estimated variable. For example, if γ_i is positive, and μ_i is negative, it implies that the variable has an increasing trend in the earlier years, but the rate of increase has declined or might even become negative in the later years.

Risk in Vegetable Cultivation

The risk involved in the cultivation of various vegetables and field crops was estimated by the detrended coefficient of variation in area, production, and yield. The coefficient was estimated as follows:

$$Y_i = \alpha_o + \gamma_i T + \varepsilon \quad (2)$$

where Y and T are as explained above. The ε is the residual term assumed to be randomly and normally distributed, which can be estimated as:

$$\varepsilon = \hat{Y} - \overset{\alpha}{Y} \quad (3)$$

where $\hat{Y}$ is the estimated value from equation (2), and $\overset{\alpha}{Y}$ is the actual value of the dependent variable. A detrended variable is generated by adding the estimated residual at each data point into the mean value of the variable as follows:

$$\overset{*}{Y} = \overline{Y} + \varepsilon \quad (4)$$

where $\overline{Y}$ is the simple mean, and $\overset{*}{Y}$ is the detrended variable. It should be noted that the detrended variable is free from a linear trend. The coefficient of variation was then estimated from the detrended variable generated from equation (4).

Seasonality

Seasonality in vegetable supplies was estimated from average monthly data on prices and availability. It should be noted that seasonality estimated from daily data would be much higher than that estimated from monthly average data, but such data are much more difficult to get and will have more noise. Monthly data for several years were first converted into a monthly index using January as base

month in every year. This partially removed over-time trend in the data, if there was any. Monthly averages over the years were taken, and then seasonality was estimated as follows:

$$S_t = [(I_h - I_l) / I_l] * 100 \quad (5)$$

where I_h is the highest average monthly index value, and I_l is the lowest average monthly index value.

Marketing Margins

Marketing margins are defined at various marketing stages. For example, wholesale margins are defined as the difference in wholesale and farm-gate prices expressed as a percentage of retail prices. Similarly, retail margins are defined as the difference between the retail and wholesale prices expressed as a percentage of the retail prices. The total margins are defined as the difference in retail and farm-gate prices expressed as a percentage of retail prices. Unless otherwise specified, marketing margin for any marketing agent in a channel was defined in a similar fashion.

The marketing margin can be estimated either from secondary price information reported at various levels of a marketing channel, or by tracking the flow of a commodity as it passes through a marketing channel and noting the costs and cash flows at each stage. The first approach is called a macro approach, while the second is called a micro approach. The advantage of the macro approach is that it is simple, but it obscures some necessary details. Mostly, it can provide information about the extent of marketing margins between farm and wholesale, and wholesale and retail. It can also depict over-time changes in the marketing margin at various marketing levels. However, it does not tell who retains this margin and where marketing inefficiency lies. On the other hand, the micro approach can provide as detailed information as required, but it is difficult to implement and, if not done on a sufficiently large scale, might be site specific.

Cropping Intensity

Cropping intensity, sometimes referred to as planting or cropping index, is defined as:

$$\text{Cropping intensity} = \frac{\text{Cropped area}}{\text{Cultivated area}} \times 100,$$

where cultivated area is area available for crop cultivation, and on which at least one crop is sown in a year, while cropped area is cultivated area multiplied by the number of crops grown on the area in a year.

BANGLADESH

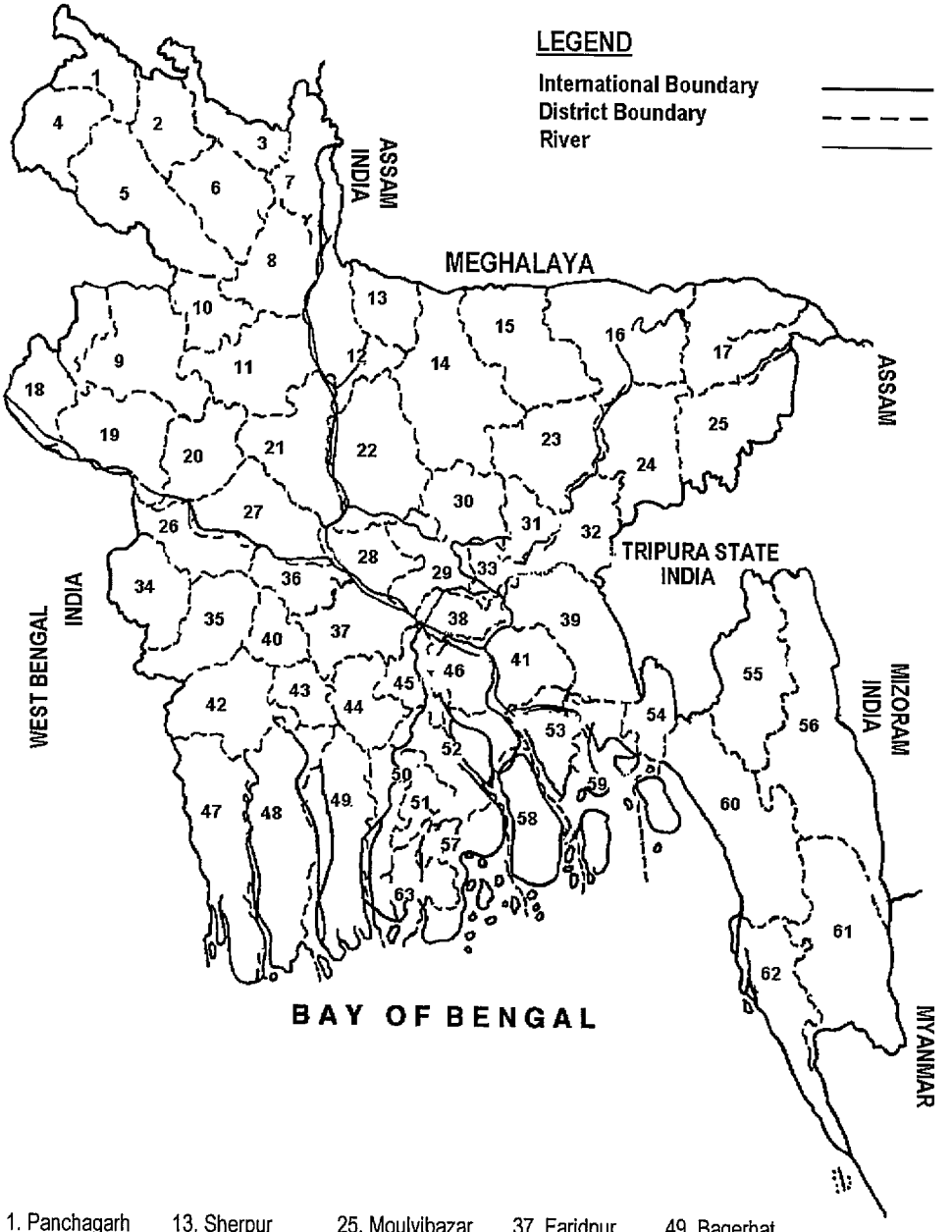
Shahiduzzaman M. Elias and Muhammad S. Hussain

Introduction

Bangladesh, with an area of about 144,000 km^2 and a population of 112 million, is one of the most densely populated countries in the world (775 persons/km^2) and among the lowest per capita income countries in Asia (US$210 in 1994). The population has grown dramatically, from about 75 million in 1970, equivalent to a population growth rate of 2%. Per capita cultivable land is about 0.09 ha. The share of agriculture in total GDP has declined steadily in recent years, but the agriculture sector still contributed about 37% of GDP and 65% of overall employment in 1992 (GOB 1993). About 80% of the population resides in rural areas. The country is divided into 63 administrative districts (Fig. 1).

In 1988–89, average daily per capita food consumption was 869 g, of which cereals constituted 57.6%, non-cereal plant food 34.5%, and food products of animal origin 7.9% (GOB 1990). Vegetables made up 12.5% of the diet. However, the average food consumption figures conceal the deprivation suffered in the country; about half of the population consumes less than the recommended intake of energy, protein, and micronutrients.

About 150 different crops are grown in Bangladesh, but rice occupies about 74% of the total cultivated area. Wheat, pulses, oilseeds, sugarcane, jute, potato, vegetables, annual and perennial fruit, tobacco, tea, and spices are the other major crops. During 1993, the area under vegetable cultivation, excluding potato and sweet potato but including chili, onion, ginger, and garlic, was about 0.30 million ha (1.5% of the total cropped area). Average yield of vegetables is 4.7 t/ha, so vegetable production in the country totaled about 1.4 million t (with a value of about BDT10 billion). Per capita daily availability of vegetables in Bangladesh is only 34 g/day (which is low even compared to levels in neighboring countries), so to supply the AVRDC-recommended minimum per capita daily requirement of 200 g of vegetables, national production of vegetables needs to be increased to well over 8 million t. This would require massive effort. Intensive vegetable production would also improve nutritional security, employment and income generation, foreign exchange earnings, and diversification of food production.



1. Panchagarh
2. Nilphamari
3. Lalmonirhat
4. Thakurgaon
5. Dinajpur
6. Rangpur
7. Kurigram
8. Gaibandha
9. Naogaon
10. Jaipurhat
11. Bogra
12. Jamalpur
13. Sherpur
14. Mymensingh
15. Netrakona
16. Sunamganj
17. Sylhet
18. Nawabganj
19. Rajshahi
20. Natore
21. Sirajganj
22. Tangail
23. Kishoreganj
24. Hobiganj
25. Moulvibazar
26. Kushtia
27. Pabna
28. Manikganj
29. Dhaka
30. Gazipur
31. Narsingdi
32. Brahmanbaria
33. Narayanganj
34. Chuadanga
35. Jhenaidah
36. Rajbari
37. Faridpur
38. Munshiganj
39. Comilla
40. Magura
41. Chandpur
42. Jessore
43. Narail
44. Gopalganj
45. Madaripur
46. Shariatpur
47. Satkhira
48. Khulna
49. Bagerhat
50. Perojpur
51. Jhalakati
52. Barisal
53. Lakshmipur
54. Feni
55. Khagrachari
56. Rangamati
57. Patuakhali
58. Bhola
59. Noakhali
60. Chittagong
61. Bandarban
62. Cox's Bazar
63. Barguna

Fig. 1. Administrative districts of Bangladesh

General Information

Geography

Bangladesh is mostly flat, and comprises the delta of three major river systems—the Meghna, the Brahmaputra, and the Padma (Ganges). These rivers and their tributaries form a network of waterways. Other major features include the Pleistocene uplands in the north-west as well as the Modhupur tract, and the Barind tract rising from 10 to 50 m above the plain. In the Chittagong area in the south-east, Tertiary hills average some 300 m asl and reach their highest elevation, nearly 1000 m asl, at the Burmese border.

The country is prone to natural disasters, especially cyclones and flooding, which affect agricultural production in general and vegetable production in particular. Agricultural land makes up 64% of the country, forests account for almost 15%, urban areas occupy 8%, and other land uses and water takes up the remaining 13%.

Topography

Five agricultural land types have been defined in Bangladesh on the basis of flood depths, i.e., high land (seasonal flood depth less than 0.30 m), medium-high land (flood depth between 0.31 and 0.90 m), medium-low land (flood depth varying between 0.91 and 1.80 m), low land (flood depth greater than 1.80 m) and very low land (flooded to a depth of 1.80 m or more seasonally or perennially). A detailed distribution of agricultural land types by administrative division is shown in Table 1. Most agricultural activities are intimately related to, and dependent on, flooding conditions. About 80% of the vegetable area in the country is concentrated in those agroecological zones having high and medium-high land. Few vegetables are grown in lowlands during the hot-wet season.

Table 1. Distribution of agricultural land types by division, 1991 (in km²)

	Area (km²)					
Division	High land	Medium-high land	Medium-low land	Low land	Very low land	Total
Chittagong	17014	9534	5512	4526	1007	37592
Dhaka	5198	10632	6026	3918	997	26772
Khulna	4672	19607	3189	648	0	28117
Rajshahi	6335	19302	2816	1866	155	30474
Total	33220	59075	17543	10958	2159	122955
Homesteads						10848
Urban						791
River belts						9405
Grand total						143999

Source: GOB (1992).

Climate

The tropical monsoon climate of Bangladesh comprises three distinct seasons:

- the premonsoon season from March to May, with little rainfall and temperatures as high as 40°C
- the monsoon season from June to October, characterized by high humidity, rainfall, and temperatures (25–35°C)
- the dry winter season from November to February, characterized by cool temperatures (12–28°C) and little or no precipitation.

On average, 2000 mm of rain falls on 80% of the country annually. Seasonal and annual variability in rainfall is followed by considerable yearly variation in agricultural production, particularly in vegetables. Monthly mean temperatures range from 28°C in July to 18°C in February.

Soils

The soils of Bangladesh are mainly alluvial with little profile development. Generally, soil characteristics do not pose a major constraint to vegetable production. A reconnaissance soil survey carried out between 1963 and 1975 provided comprehensive information on soils, land levels in relation to seasonal inundation, and land use, together with interpretations in terms of land capability and crop suitability.

Social Taboos

Vegetables in Bangladesh are consumed in curries, as mixed vegetable "bhaji" dishes, and in the raw form. The following are some common taboos working in favor of or against vegetable consumption:

- Some old people in Bangladesh believe that taking sweet gourd as a curry can cause stomach problems and remittent fever, particularly during the monsoon season. Sweet gourd is also thought to cause allergic responses in some people.
- Indian spinach is thought to cause or exacerbate cough. It might also cause allergies.
- A baby might suffer from stomach problems if the breast-feeding mother eats too much leafy vegetables.
- Eating leafy vegetables at night is considered a sign of poverty.
- It is believed that eggplant causes skin disease.
- After giving birth, a woman should consume more gourd to stimulate breast milk production.
- Bitter gourd can cure many diseases and also help in blood refinement/purification.
- Green papaya and leafy vegetables can cure constipation and keep the liver healthy.

Major Vegetable Species, and Planting Seasons

More than 70 kinds of subtropical vegetables are grown in Bangladesh; some characteristics and growing information of the major ones are presented in Table 2. Rangpur, Rajshahi, Dinajpur, Jessore, Khulna, Dhaka, Faridpur, Comilla, and Chittagong are leading vegetable production areas.

Vegetables are classified as rabi (grown during the winter months of October–March) or kharif (grown during the summer months of April–September).

Vegetable cultivation is concentrated in the high and medium high lands during the kharif season, and in the low lands during the winter season, which is normally dry.

Spring vegetables are short-duration varieties grown between the late winter and early summer seasons. Most vegetables in Bangladesh are seasonal in production, and the period of their availability is rather narrow. However, some vegetables are grown year round and do not have a specific cultivation period (e.g., eggplant, pumpkin, cucumber, and bitter gourd).

Table 2. Planting time, edible parts, and major growing districts for major vegetables in Bangladesh

Vegetable (% of area of all vegetables)[a]	Part used	Planting season[b]	Major growing districts (% of the total area of a given vegetable)[c]
Arum (3.5)	Leaf	Not available	Tangail (10.0), Dinajpur (8.7), Jessore (8.3), Khulna (6.7), Sylhet (6.0), Rangpur (5.7)
Ash gourd (1.3)	Fruit, leaf	Feb.-Oct.	Rangpur (8.5), Sylhet (7.4), Dhaka (7.0), Rajshahi (6.3), Bogra (6.0), Barisal (5.9)
Bengal spinach (0.6)	Leaf	Nov.-Mar.	Jessore (12.5), Kushtia (9.1), Khulna (8.6), Rangpur (8.0), Faridpur (7.5), Rajshahi (7.0)
Bitter gourd (1.4)	Fruit	Feb.-Oct.	Dhaka (11.5), Rangpur (9.7), Jessore (7.2), Dinajpur (7.1), Rajshahi (7.0)
Bottle gourd (2.3)	Fruit, leaf	Nov.-Apr.	Dhaka (10.8), Sylhet (10.4), Barisal (9.7), Comilla (8.3), Faridpur (6.2), Rangpur (6.0)
Cabbage (2.4)	Leaf	Nov.-Mar.	Jessore (12.2), Rangpur (9.2), Rajshahi (8.0), Khulna (7.6), Dinajpur (7.2), Kushtia (6.6)
Cauliflower (2.5)	Curd	Nov.-Feb.	Jessore (10.8), Rangpur (9.5), Dhaka (8.4), Tangail (6.9), Rajshahi (6.7), Dinajpur (6.3)
Chili (21.0)	Fruit	Mid April-mid July	Comilla (12.8), Bogra (11.1), Barisal (10.3), Patuakhali (9.8), Noakhali (9.7), Faridpur (8.8)
Cucumber (1.1)	Fruit	Year round	Dhaka (7.8), Faridpur (7.5), Rangpur (6.7), Bogra (6.2), Rajshahi (5.6), Tangail (5.3)
Eggplant (8.5)	Fruit	Year round	Winter: Chittagong (9.1), Jessore (7.9), Rajshahi (7.6), Bogra (7.5), Rangpur (7.0), Dhaka (7.0)
			Summer: Jessore (14.0), Dinajpur (8.5), Bogra (7.9), Rajshahi (7.1), Khulna (7.1), Kushtia (7.0)
Hyacinth bean (2.2)	Fruit, seed	Nov.-Feb.	Dhaka (10.1), Comilla (10.0), Noakhali (9.9), Chittagong (9.9), Jessore (6.7), Kishorganj (6.3)
Mungbean (17.9)	Seed	Mid Sep.-mid Dec.	Faridpur (23.7), Jessore (24.), Pabna (6.4), Rangpur (7.8)

Contd. Table 2.

Vegetable (% of area of all vegetables)[a]	Part used	Planting season[b]	Major growing districts (% of the total area of a given vegetable)[c]
Onion (10.5)	Bulb	Mid Nov.-Dec.	Faridpur (21.1), Pabna (9.3), Rajshahi (8.3), Jessore (8.2), Dhaka (8.0), Dinajpur (6.7)
Radish (6.0)	Root, leaf	Oct.-Mar.	Comilla (8.1), Sylhet (7.0), Rangpur (6.9), Chittagong (6.5), Dhaka (6.3), Jessore (5.9)
Pumpkin (3.5)	Fruit, leaf	Year round	Winter: Barisal (11.7), Sylhet (7.1), Faridpur (6.4), Jessore (6.2), Dhaka (5.7), Chittagong (5.5)
			Summer: Jessore (7.6), Rangpur (7.6), Dhaka (7.5), Barisal (6.6), Dinajpur (6.6), Faridpur (5.6)
Tomato (3.5)	Fruit	Nov.-Mar.	Comilla (15.7), Dhaka (13.3), Sylhet (7.7), Chittagong (7.6), Jessore (6.5), Rajshahi (4.8)
Ridged gourd (1.5)	Fruit	Feb.-Oct.	Dhaka (8.4), Rangpur (8.2), Chittagong (7.2), Rajshahi (7.2), Jessore (6.8)
Pointed gourd (1.2)	Fruit	Feb.-Oct.	Rajshahi (16.1), Rangpur (12.5), Jessore (11.7), Dinajpur (11.4), Kushtia (9.4), Pabna (9.3)
Stem amaranth (1.2)	Stem, leaf	Mar.-Oct.	Dinajpur (8.2), Kushtia (8.2), Jessore (7.5), Rangpur (6.7), Tangail (6.5), Mymensingh (6.0)
Indian Spinach (0.8)	Leaf	Nov.-Feb.	Kushtia (13.8), Khulna (10.9), Jessore (9.1), Dinajpur (7.1)
Lady's finger (1.1)	Fruit	Mar.-Oct.	Chittagong (7.9), Dinajpur (6.8), Dhaka (6.8), Khulna (6.5), Rangpur (6.2)
Snake gourd (0.7)	Fruit	Feb.-Oct.	Jessore (9.7), Barisal (9.4), Dinajpur (7.2), Rangpur (6.7), Tangail (6.5)
Yard long bean (0.7)	Fruit	Mar.-Oct.	Dhaka (3.5), Chittagong (2.3), Comilla (2.1)
String bean (0.7)	Pods and seed	Mar.-Oct.	Chittagong (15.1), Rajshahi (7.5), Dhaka (7.5), Rangpur (7.4), Jessore (7.0)
Other vegetables (3.9)	-	-	Khulna (12.0), Faridpur (11.0), Kushtia (8.1), Jamalpur (6.6)

[a] Average of 1991–93.
[b] The information on planting is from Rashid (1989), except for arum, chili, mungbean, onion, and string bean, which is from GOB (1993).
[c] Average of 1988–90.

Trend Analysis

Production

Total vegetable area in Bangladesh in 1993 was about 300,000 ha, which produced about 1.4 million t. Seventy percent of the output was produced during winter (rabi or winter season). Since 1972, the area under all vegetables in Bangladesh has increased at an annual rate of 1.2%, while vegetable production and yield both increased at quadratic rates (Table 3).

No significant trend in the production of garlic and chili was observed, while the production of ribbed gourd, arum, Indian spinach, stem amaranth, cabbage, tomato, radish, Hyacinth beans, winter spinach, ginger, and other vegetables increased at a linear rate. Yields per unit area of most of these

vegetables either declined or remained static, so most of the increase in the production of these vegetables came from an increase in cropped area (Table 3).

Table 3. Trend for vegetable production in Bangladesh, 1972–93

Vegetable	Area		Yield		Production	
	T	T^2	T	T^2	T	T^2
Summer vegetables						
Arum	0.056	-	-0.009	-	0.048	-
Ash gourd	-	0.002	-0.029	0.001	-0.047	0.003
Bitter gourd	-0.014	0.002	-0.043	0.001	-0.057	0.003
Chili	-0.018	0.001	-0.023	0.001	-0.041	0.002
Cucumber	-	0.001	-0.028	0.000	-0.039	0.002
Eggplant	-	-	-0.015	-	-0.014	-
Indian spinach	-	0.002	0.041	-0.002	0.051	-
Lady's finger	0.047	-	-0.044	0.001	-0.018	0.002
Other vegetables	-0.096	0.004	-0.031	0.001	-0.127	0.005
Pointed gourd	0.046	-0.001	-0.017	-	0.031	-0.001
Pumpkin	-0.031	0.002	-0.031	0.001	-0.061	0.003
Ribbed gourd	0.041	-	-0.032	0.001	0.001	-
Snake gourd	-0.037	0.002	-0.012	-0.000	-0.049	0.002
Stem amaranth	0.049	-	-0.021	0.001	0.040	-
String bean	-0.034	0.003	0.299	-0.011	0.265	-0.008
Total summer vegetables	-	0.001	-0.008	-	-0.018	0.001
Winter vegetables						
Bottle gourd	0.015	0.001	0.007	-	0.020	0.001
Cabbage	0.040	-0.001	0.010	-	0.035	-
Cauliflower	0.046	-0.001	0.024	-0.001	0.069	-0.001
Chili	-0.009	-	0.012	-	-	-
Eggplant	0.006	-	-0.012	0.001	0.000	-
Garlic	-	-	-0.004	-	-	-
Ginger	0.016	-	-0.005	-	0.011	-
Hyacinth beans	0.033	-	-0.007	-	0.026	-
Onion	0.006	-	-0.038	0.001	-0.032	0.001
Pumpkin	0.028	-	-0.004	-	0.024	-
Radish	0.039	-	0.010	-	0.049	-
Spinach	0.046	-	-	-	0.048	-
Tomato	0.027	-	-	-	0.026	-
Other vegetables	0.015	-	-	-	0.020	-
Total Rabi vegetables	0.009	-	-	0.001	0.020	-
Total vegetables	0.012	-	-	0.0003	-	0.001

The linear term in the production equation for pointed gourd, string beans, and cauliflower was positive. However, negative quadratic coefficients indicate that the production of these vegetables increased in the beginning years, but then decreased in the later period and will ultimately stagnate or decline. However, the opposite was true for pumpkin, lady's finger, bitter gourd, ash gourd, cucumber, snake gourd, summer chili, other summer vegetables, and total summer vegetables.

Prices

Real or deflated prices of vegetables show an increasing trend between 1974 and 1991 for all vegetables. The overall weighted average price index increased at about 2.7% per annum. The highest price increases were observed in tomato, cucumber, all types of gourds, beans, and pumpkin (Table 4). The increase in the real prices of vegetables is consistent with the static level of vegetable production in Bangladesh, because additional demand is generated by increased population as well as by higher incomes.

Table 4. Annual growth rates (%) in the wholesale deflated price[1] of vegetables in Bangladesh, 1974–91

Vegetables	Growth rate	Vegetables	Growth rate
Tomato	7.0	Lady's finger	4.3
Cucumber	6.6	Garlic	3.9
Ribbed gourd	6.2	Arum	3.5
Bitter gourd	6.0	Cabbage	3.5
Pumpkin	5.7	Ash gourd	3.2
Hyacinth bean	5.6	Spinach	3.2
String bean	5.5	Indian spinach	3.1
Snake gourd	5.4	Onion	2.2
Pointed gourd	5.0	Ginger	0.0
Eggplant	4.9	Radish	-1.0
Bottle gourd	4.9	Mungbean	2.7
Cauliflower	4.6	Overall vegetables[2]	2.7

[1]Current vegetable prices were deflated by the consumer food price index.
[2]Weighted average vegetable price index was estimated by using the Laspeyre Index (Pearce 1983).
Source: GOB (various issues).

Risk in Vegetable Production

Risk in vegetable production was measured by estimating the detrended coefficient of variation (CV) in vegetable production, area, and yield (Table 5). Despite the counterbalancing effect of different vegetables, the CVs in area, production, and yield of total summer and winter vegetables are higher than the corresponding CV in rice production, indicating that vegetable production is more risky than cereal production. The CVs in area of all individual vegetables are higher than rice; also the CVs in yield of about half the vegetables reported in the table are higher than the corresponding CV in rice.

Table 5. Detrended coefficients of variation (%) in vegetable area, production, yield, and wholesale prices, 1972–92

Vegetable	Production	Area	Yield	Wholesale prices
A. Winter vegetables				
Eggplant[1]	4.14	2.52	2.25	39.04
Pumpkin[1]	16.76	29.64	29.65	37.41
Cauliflower	4.99	3.10	3.39	34.32
Cabbage	6.37	3.83	5.29	34.54
Bottle gourd	7.18	5.06	4.29	27.64
Tomato	9.39	3.16	9.60	41.71
Radish	5.13	3.78	2.49	29.61
Hyacinth beans	5.02	3.82	2.86	31.15
Spinach	8.85	5.35	6.97	12.22
Onion	8.54	2.53	7.47	23.63
Garlic	4.52	2.15	3.31	48.65
Ginger	3.57	3.73	2.76	30.04
Chili[1]	19.95	6.13	19.81	36.31
Other winter vegetables	4.49	9.21	16.37	-
B. Summer vegetables				
Eggplant[1]	6.96	4.17	4.26	-
Pumpkin[1]	12.26	8.19	5.03	-
Pointed gourd	5.80	3.73	2.77	36.71
Lady's finger	11.04	9.27	7.59	27.63
Ridged gourd	8.02	6.50	3.89	27.65
Arum	5.67	5.37	3.52	20.21
Bitter gourd	11.47	8.50	5.06	25.26
Ash gourd	11.38	9.35	3.54	9.21
Cucumber	8.03	7.20	2.68	27.64
String bean	24.06	10.69	36.91	28.90
Indian spinach	10.25	11.64	10.24	25.13
Snake gourd	8.08	7.75	2.81	33.85
Stem amaranth	4.60	5.44	3.11	-
Chili[1]	9.93	4.30	6.41	-
Other vegetables	24.66	19.09	4.82	-
All summer vegetables	6.67	3.31	5.79	-
Rice	4.03	2.03	4.69	4.50

[1]Although production figures are available for summer and winter, prices are not. So CV in the annual prices of these vegetables is reported in the winter season only.

Variability in production leads to variability in prices. The individual price variability was found to

range from 9.21% in ash gourd to 48.65% in garlic. Again, the CV for price for each vegetable was many times more than that for rice. As well as production induced variability, speculation also adds to the variability in vegetable prices; speculation is less a problem in rice as it is minimized by government policies such as price support.

Seasonality in Vegetable Prices

Macro-level Evidence

Seasonal price indices of individual vegetable types were estimated considering wholesale prices in a three-year period, 1991–93, in all districts (Table 6). Wide seasonal variations in vegetable prices were observed. For perishable and semi-perishable vegetables with limited storage possibilities, prices were usually lowest in the peak harvesting period and highest just before harvest. Seasonal variation in prices was observed to be stronger for short-duration, seasonally available vegetables than for long-duration, year-round vegetables.

Monthly prices of all vegetables as a group were estimated using the relative share of each vegetable in the total vegetable arrivals in the Dhaka market. Despite the counter-balancing effect of the prices for the various vegetables, high seasonality in overall vegetable prices can be observed. Prices are lowest in March and highest in October, producing 40% seasonality in prices.

Generally, seasonality is higher at the farm level than at the retail level (Table 7) mainly because middlemen help to smooth out seasonality by adjusting their profits. However, urban consumers face lower seasonality than do rural consumers because the former shop at relatively more developed markets which reduce seasonality by bringing supplies from various ecoregions. Rural markets are less developed and less connected to the production and supply centers. This results in gluts and shortages, and thus high seasonality.

Table 6. Price indices of vegetables by month, average of 1991–93*

Crop	Month												Seasonality
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Cabbage	100	69	64	57	-	-	-	-	-	-	208	153	265
Cauliflower	100	88	89	-	-	-	-	-	-	-	-	149	69
Spinach	100	93	122	96	-	-	-	-	-	-	302	189	225
Eggplant	100	70	77	100	135	165	191	186	179	205	177	134	193
Pointed gourd	100	106	135	87	75	75	80	77	78	88	87	71	90
Ash gourd	100	87	91	102	103	114	104	103	98	108	127	131	51
Bottle gourd	100	82	73	69	80	130	114	123	120	146	145	126	112
Pumpkin	100	82	73	67	68	75	81	88	95	107	126	120	88
Bitter gourd	100	109	100	65	58	69	81	80	88	99	112	107	93
Lady's finger	100	90	112	90	76	77	70	78	88	100	123	125	79
Cucumber	100	98	151	188	157	180	202	232	222	261	215	198	166
Radish (local)	100	106	95	165	238	179	206	259	302	294	282	165	218
Radish (HYV)	100	95	45	-	-	-	-	-	-	-	157	137	249

Contd. Table 6.

Crop	Month												Seasonality
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Hyacinth bean	100	69	64	65	-	-	-	-	-	-	232	170	263
Tomato	100	84	91	151	124	-	-	-	-	218	240	125	186
Snake gourd	-	-	-	100	54	82	65	60	61	54	67	65	85
Ridged gourd	100	133	53	66	59	61	56	62	65	73	69	63	151
Red amaranth	100	118	106	116	128	147	140	130	129	153	121	11	129
Indian spinach	100	-	88	79	84	71	70	72	88	102	101	91	46
Stem amaranth	100	141	102	87	90	93	91	96	75	85	83	123	88
String bean	100	70	77	89	83	99	96	92	95	117	103	95	67
Potato (local)	100	72	76	93	114	128	139	140	141	151	164	178	147
Potato (HYV)	100	66	70	87	104	117	145	144	144	154	173	183	177
Onion	100	96	97	79	92	95	98	107	117	129	156	138	97
Chili (green)	100	94	86	90	70	62	92	118	93	137	141	107	127
Chili (dry)	100	171	162	160	152	137	162	168	162	166	164	138	71
Mungbean	100	107	103	101	91	92	95	94	97	99	101	98	18
Garlic	100	83	50	59	69	73	72	77	83	84	85	95	100
Ginger	100	114	119	125	140	188	154	160	156	120	119	119	88
All vegetables	100	110	97	103	109	115	121	126	126	136	133	109	40
Rice (course)	100	102	106	107	99	101	101	102	104	103	96	93	15

* Price indices are calculated with the January price set to 100, except in snake gourd where the April price is equal to 100. (Source: GOB various issues)

Table 7. The seasonal price indices and seasonality of selected vegetables for growers and rural and urban consumers

Vegetable	Market level	Monthly price indices						Actual average price (BDT/quintal)	Seasonality
		Oct.	Nov.	Dec.	Jan.	Feb.	March		
Cabbage	Farmer	237	133	59	53	16	-	321	1381.3
	Rural consumer	209	145	88	41	15	-	445	1293.3
	Urban consumer	144	130	123	82	19	-	1177	657.9
Cauliflower	Farmer	269	147	66	63	35	18	522	668.6
	Rural consumer	236	159	94	53	39	16	665	505.1
	Urban consumer	204	145	135	52	38	24	2204	436.8
Radish	Farmer	207	110	110	51	34	-	238	508.8
	Rural consumer	175	133	133	58	37	-	397	373.0
	Urban consumer	151	148	148	40	38	-	806	297.4
Tomato	Farmer	140	140	90	84	35	46	925	300.0
	Rural consumer	160	160	98	81	36	43	1122	344.4
	Urban consumer	161	161	98	88	41	31	1908	292.7

Source : Survey data collected by BARI, Division of Agricultural Economics, 1990.

Field-level Evidence

Sabur (1990) also observed high seasonality in the prices for radish, tomato, eggplant, pointed gourd, pumpkin, and potato. Seasonality in vegetable prices was higher than seasonality in the price of rice. Potato, however, had high seasonality compared to other vegetables studied even though it has a relatively long storage life and is stored in cold storage during the off season. This might be because some vegetables like eggplant and pumpkin are planted and available throughout the year. In other cases, such as radish, the low seasonality relative to potato was because the seasonality was estimated based on available prices for only a few months.

Regional Disparity in Seasonal Vegetable Prices

Vegetable prices vary considerably from place to place; generally they are higher in non-producing areas than in the producing areas. Prices of most vegetables are relatively low in Jessore, Khulna, Rajshahi, Rangpur, Dinajpur, Dhaka, and Comilla (the largest vegetable producing areas) and relatively high in Patuakhali, Sylhet, Rangamati, Mymensingh, Tangail, and Noakhali (less important vegetable producing areas).

Regional vegetable markets seem not to be well integrated as is reflected by different monthly price variations for the same vegetable. For example, eggplant prices are more seasonal in Jamalpur district than in Faridpur district. Also, prices move in opposite directions (Fig. 2); when prices are lowest in Faridpur in June, they are near their highest levels in Jamalpur and Chittagong. The same is true for other vegetables.

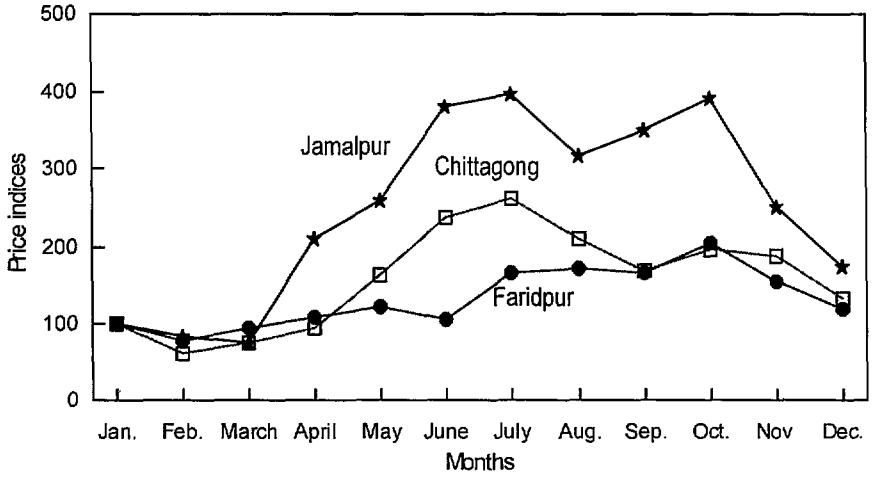


Fig. 2. Regional disparity in seasonal eggplant prices in Bangladesh (average 1991–93)

Farm Management Practices

Many different cropping patterns are followed in vegetable cultivation (Table 8). The available farm-level studies show that winter vegetables are usually sown between August and November (except for hyacinth beans which are sown during July and August), and are harvested from October to April. Sowing and harvesting times for summer vegetables vary for different types of vegetable.

Table 8. Information on agronomic practices for different vegetables in Bangladesh

Vegetable	Sowing time (Month & Week)[1]	Land & soil type[2]	Management practices[3] P	D	W	S	Harvesting time (Month & Week)[1]	Cropping pattern	Reference
Bitter gourd	April to August	HL, MHL	6	9	4	-	July to Nov	(i) Bitter gourd-Fallow (ii) Fallow-Bitter gourd-Potato	Hossain et al. 1994
Cabbage	Sep-i to Nov-iii	HL, MHL	7	8	2	-	Oct-ii to Feb-iii	(i) Rice-Cabbage-Rice (ii) Bitter gourd/Jute,-Cabbage/Potato-Cucumber/ Amaranth	Huq and Rahman 1993
Cauliflower	Sep-i to Nov-iii	HL, MHL	7	8	3	-	Nov-i to Feb-ii	(i) Rice-Cauliflower-Rice (ii) Bitter gourd/Snake gourd, -Cauliflower/Potato, Cucumber	Huq and Rahman 1993
Chili	Sep-i to Nov-ii	HL, MHL	8	17	5	-	Dec-iii to Apr-iii	(i) Aus (HYV)-Fallow-Chili (ii) Jute-Fallow-Chili	Elias and Hossain 1984
Eggplant	Sep-ii to Nov-iv	L	7	8	6	2	Dec-iii to Feb-iv	(i) Rice-Eggplant (ii) Jute-Eggplant (iii) Fallow-Eggplant	Hoque et al.1991
Ginger	Mar-i to Apr-iv	HL, SL	4-12	4-12	3-4	-	Dec-ii to Jan-iv	(i) Annual crop/intercrop	Ahmed et al. 1990b
Hyacinth bean	Jul-ii to Aug-iii	HL, MHL	5	6	5	6-10	Oct-iii to Mar-ii	(i) Rice-Countrybean (ii) Bitter gourd/Eggplant - Countrybean	Huq and Rahman 1993
Mukhikachu	Dec-ii to May-ii	HL & MHL, SL, L, CL	3-10	4-12	8	-	Jul-iii to Oct-ii	(i) Mukhikachu-T.aman (ii) Mukhikachu-Fallow (iii) Mukhikachu-Lentil	Ahmed et al. 1990a
Mungbean	Aug-iii to Feb-ii	HL, MHL	1	0-7	0-1	0-7	Oct--iv to Jan-ii	(i) T.aus-T.aman-Mungbean (ii) Fallow-Fallow-Mungbean	Elias et al. 1986
Onion	Nov-ii to Jan-ii	MHL, SL to C	6	16	2	-	Mar-iii to Apr-ii	(i) B.Aman-Onion (ii) Jute-Fallow-Onion	Elias et al. 1988
Panikachu	Feb-I to Mar-ii	HL & MHL	9	11	6	-	July to Sept	(i) Panikachu-Potato (ii) Panikachu-Radish	Baksh et al. 1990
Pointed gourd	Sep-iii to Nov-iv	HL, MHL	7	8	-	-	Feb-ii to Nov-iv	(i) Potato-Pointed gourd	Ullah et al. 1994
Potato	Sep-iii to Jan-ii	HL, MHL L, SL	6	11	1	2	Nov-i to Apr-iv	(i) Aus-Aman-Potato (ii) Sesame-Aman-Potato (iii) Jute-Fallow-Potato	Elias et al. 1984
Radish	Aug-iv to Oct-iv	HL, MHL	8	9	2	-	Oct-i to Jan-ii	(i) Rice-Radish-Rice (ii) Jute-Radish-Potato/ Lentil,	Huq and Rahman 1993
Tomato	Sep-ii to Nov-iii	HL, L to S	5	7	3	2	Dec-ii to Apr-iv	(i) Jute-Fallow-Tomato	Matin et al.1994
Teasle gourd	Feb-i to April-i	S, Red C	-	-	-	-	May to Oct.	(i) Kakrul-Bean & Bottle gourd-Kakrul (ii) Kakrul-Fallow-Kakrul	Barman et al. 1990

[1]i, ii, iii, and iv - refers to the weeks of a month.
[2]Land and soil type, MHL=Medium highland, HL=Highland; S=Sandy; C=Clay; L=Loam; SL= Sandy loam; CL= Clay loam.
[3]The symbols denote the following management practices; P = plowing (no.); D= leveling (no.); W= weeding (no.); S= spray (no.).
" - " implies information is not available.

Most vegetables are cultivated at high or medium-high elevations and the predominant soil types are loam, sandy loam, and clay loam. Vegetable growers perform 5 to 10 plowings and 6 to 12 levelings per crop. Usually 2 to 4 weedings are carried out. The number of top-dressings of fertilizer depends on the type of vegetable.

Economics of Vegetables

Commercial Vegetable Cultivation

Input Use

Levels of inputs in vegetable cultivation in Bangladesh, as reported in different farm-level studies, are summarized in Table 9. There is wide variation in the level of human labor input (the extremely high labor use in pointed gourd is mainly a consequence of its prolonged growing season). Human labor is available from three different sources: own family, seasonally or permanently hired labor, and casual hired labor. Family labor typically supplies about 60–80% of the total labor requirements. Disposal and marketing of vegetables also requires large labor inputs, because many vegetables are perishable and must be marketed quickly. Homestead vegetable garden production, especially, increases employment opportunities for women, because it is mainly women who take care of these gardens. Thus, production of vegetables provides ample opportunity for employment.

Table 9. Input use (per ha) for different vegetables

Name of crop	Labor (days)		Tractor (BDT)	Seed[1]	Irrigation (BDT)	Manure (kg)	Fertilizer (kg)				Pesticide (BDT)	Reference
	Human	Pair of bullock					Urea	TSP	MP	Total		
Bitter gourd	330	41	-	5.80 kg	581	10088	424	504	139	1267	3541	Hossain et al. 1994
Cabbage	234	20	353	42450 N	1397	4933	562	736	140	1448	3375	Huq and Rahman 1993
Cauliflower	270	22	266	33375 N	2221	9806	552	640	205	1497	1124	Huq and Rahman 1993
Chili	268	62	-	15.00 kg	772	19745	361	100	43	504	145	Elias and Hossain 1984
Eggplant	209	34	-	2.79 kg	91	7816	-	-	-	647	644	Sabur 1990
Eggplant	478	54	-	30750 N	-	11076	282	165	93	440	314	Hoque et al. 1991
Hyacinth bean	421	24	328	5.76 kg	2319	1007	249	262	9	520	5438	Huq and Rahman 1993
Mukhikachu	501	41	-	940 kg	322	10440	348	197	63	608	-	Ahmed et al. 1990a
Mungbean	69	15	-	14.00 kg	-	-	-	-	-	-	-	Elias et al. 1986
Onion	298	67	-	6.40 kg	-	2836	31	70	30	131	-	Elias et al. 1988
Panikachu	835	43	-	22640 N	1008	23146	536	242	100	778	13	Baksh et al. 1990
Pointed gourd	168	32	-	-	46	4889	-	-	-	727	398	Sabur 1990
Pointed gourd	1466	70	-	951 kg	2190	19150	323	420	115	858	5554	Ullah et al. 1994
Potato	257	31	803	1556 kg*	575	8870	450	469	264	783	823	Elias et al. 1984
Pumpkin	128	22	-	2.73 kg	-	6612	-	-	-	71	163	Sabur 1990
Radish	179	38	-	3.23 kg	-	4112	-	-	-	323	294	Sabur 1990
Radish	171	29	463	4.61 kg	1870	1022	218	327	87	632	429	Huq and Rahman 1993
Teasle gourd	472	-	-	294(T)	197	18409	896	326	94	1316	1987	Barman et al. 1990
Tomato	190	33	-	-	95	5785	-	-	-	667	202	Sabur 1990
Tomato	259	52	137	35250 N	951	9154	185	141	58	384	593	Matin et al. 1994

[1] Seed is expressed in number (N) if seedlings are used, in kg if seed, and T if tubers.
* weight of the tubers in kg.

In vegetable cultivation, animal power is used only for land preparation. For some crops animal power is supplemented by tractor power. Most vegetable growers use cow dung as manure; the amounts used vary greatly across vegetables. The same holds for average doses of inorganic

fertilizer. Some farmers use gypsum, boron, and calcium as well. Large quantities of fertilizer are applied to most crops, the exceptions being pumpkin and onion.

Factor Share

Production costs (both total and cash) vary widely (Table 10). Labor contributes most to the total cost of growing most vegetables, followed by fertilizer and manure. In mukhikachu, panikachu, cabbage, cauliflower, eggplant, onions, and potatoes, seeds and seedlings are also major costs. The high other costs in growing gourds and beans include the cost of protection/support with which these crops are grown.

Table 10. Factor share and costs of production in selected vegetables

Name of crop	Factor share (%)[a]						Cost (BDT/ha)		Reference
	Labor	Draft power	Seed/ seedling	Manure/ fertilizer	Pesticide	Others	Total	Cash	
Bitter gourd	29	6	9	23	8	24	46207	28221	Hossain et al. 1994
Cabbage	28	2	25	33	9	3	35901	29765	Huq and Rahman 1993
Cauliflower	33	3	21	37	3	2	34942	27205	Huq and Rahman 1993
Chili	47	10	4	35	1	2	10259	5710	Elias and Hossain 1984
Eggplant	47	8	2	35	5	4	13193	6564	Sabur 1990
Eggplant	59	6	18	15	1	0	25768	6635	Hoque et al. 1991
Hyacinth bean	46	3	3	10	14	24	38158	23713	Huq and Rahman 1993
Mukhikachu	50	7	24	16	0	4	34308	19435	Ahmed et al. 1990a
Mungbean	57	22	7	12	0	2	2473	1063	Elias et al. 1986
Onion	55	18	20	7	0	1	14906	5631	Elias et al. 1988
Radish	55	11	3	27	3	2	9505	4063	Sabur 1990
Radish	47	8	7	31	3	4	15466	11343	Huq and Rahman 1993
Rice	-	-	-	-	-	-	9655	3757	IRRI 1995
Panikachu	50	5	28	16	0	1	40083	-	Baksh et al. 1990
Pointed gourd	43	8	4	38	3	3	11579	5272	Sabur 1990
Pointed gourd	64	4	3	10	9	10	64213	31787	Ullah et al. 1994
Potato	22	4	36	27	4	7	18394	11431	Elias et al. 1984
Pumpkin	56	9	2	27	2	3	6780	3323	Sabur 1990
Teasle gourd	35	0	5	19	4	38	55481	25530	Barman et al. 1990
Tomato	48	8	3	35	2	4	11642	5984	Sabur 1990
Tomato	42	11	12	24	3	9	18571	9723	Matin et al. 1994

[a] The factor shares are estimated on the full cost basis.

Profitability

Variation across vegetables in gross and net return, benefit-cost ratio, and cost per kg of output is evident from Table 11. Even the same vegetable can show different economics of cultivation over a different time period. However, it is evident from the studies that vegetable growers receive higher

net return from high-priced vegetables. Thus, price is an important factor in determining returns from vegetable growing.

Table 11. Economic returns from selected vegetable and field crops

Vegetable	Yield (t/ha)	Price (BDT/t)	Gross return (BDT/ha)	Net return (BDT/ha)[a]		Benefit-cost ratio		Cost (BDT/kg)	Reference
				Full cost	Cash cost	Full cost	Cash cost		
Bitter gourd	12.94	7218	93398	46610	65177	2.00	3.31	3616	Hossain et al. 1994
Cabbage	31.84	2557	81415	44117	51650	2.18	2.74	1171	Huq and Rahman 1993
Cauliflower	20.10	3412	68581	31418	41376	1.85	2.52	1849	Huq and Rahman 1993
Chili	3.78	7984	30187	19156	24477	2.74	5.29	2918	Elias and Hossain 1984
Eggplant	14.94	3200	47805	34521	41241	3.60	7.28	889	Sabur 1990
Eggplant	28.36	5514	156374	130441	149739	6.03	23.57	914	Hoque et al. 1991
Hyacinth bean	18.63	5376	100155	59678	76442	2.47	4.22	2173	Huq and Rahman 1993
Mukhikachu	13.96	3990	55700	21070	36265	1.61	2.87	2481	Ahmed et al. 1990a
Mungbean	6.98	7440	5382	2911	4319	2.18	5.06	354	Elias et al. 1986
Onion	4.72	4920	23232	8326	17601	1.56	4.13	3158	Elias et al. 1988
Pointed gourd	31.81	6000	190884	124481	159097	2.87	6.01	2087	Ullah et al. 1994
Radish	12.43	2697	33524	16188	22181	1.93	2.96	1395	Huq and Rahman 1993
Panikachu	99.81	1676	167287	126196	-	4.07	-	412	Baksh et al. 1990
Pointed gourd	10.74	6200	66606	54981	61334	5.73	12.63	1082	Sabur 1990
Potato	30.35	902	27383	8414	15952	1.44	2.40	625	Elias et al. 1984
Pumpkin	23.71	1100	26086	19306	22763	3.85	7.85	286	Sabur 1990
Radish	18.15	2000	36303	26798	32240	3.82	8.94	524	Sabur 1990
Rice	2.63	8275	21763	12108	18006	1.25	4.79	3671	IRRI 1995
Teasle gourd	27.78	11706	325214	269537	301365	5.84	13.64	2076	Barman et al. 1990
Tomato	7.30	5300	38688	26951	32704	3.30	6.47	1608	Sabur 1990
Tomato	20.43	1610	32897	14326	23174	1.77	3.38	909	Matin et al. 1994

[a] Gross return is defined as price multiplied by yield, and net return is defined as gross return less cost. The cost estimates are given in table 10.

Vegetable cultivation is generally more profitable than rice growing, in terms of both benefit-cost ratio and net return per unit area. Thus, vegetable cultivation can help farm families raise their income levels. However, cost per kilogram of output is also generally higher for vegetables than for rice.

Homestead Vegetable Production

Traditionally, farmers all over Bangladesh have grown vegetables on their homesteads, primarily for family consumption. Chowdhury et al. (1992) observed a trend in the production and consumption of vegetables from the homestead for different farm categories; production was highest in the landless farm category and decreased with increase in farm size. Average production over all farm categories and sizes was about 165 kg/year. The package required few purchased inputs, and all labor could be

provided by family members, particularly women and children, so production costs were not high averaging BDT 120 per year. However, homestead farmers were found to consume most of their production. Only 10–30% of the produce was sold. Landless and marginal farmers sold higher proportions of their production than other groups.

Economic Constraints

Table 12 reviews major constraints associated with vegetable production.

Table 12. Prioritization of production constraints in vegetables

Production constraints	Tomato (A,B)	Pointed gourd (B,C)	Bitter gourd (D)	Mukhi-kachu (E)	Pani-kachu (F)	Onion (G)	Mungbean (H)	Ginger (I)
High price of seed	-	-	-	8	-	-	-	-
Shortage of quality seed	3	-	-	-	-	3	4	-
High price of fertilizer	4	1	1	9	-	-	-	5
High price of insecticide	4	1	1	-	-	-	-	-
Infestation of pests & diseases	1	-	5	4	1	-	1	2
Low price of product during harvest period	2	-	-	10	-	-	9	-
Cumbersome procedure of institutional credit	5	2	6	3	-	2	-	3
Lack of storage facilities	-	-	-	2	-	-	-	-
Erratic rainfall/ unfavorable weather	-	3	3	5	-	8	7	-
Lack of scientific knowledge about modern cultivation	-	2	-	-	6	3	-	-
Lack of irrigation facilities	-	-	-	6	6	-	-	-
Lack of funds/cash needed	-	-	-	11	-	-	-	-
Scarcity of human labor	-	-	-	7	-	-	-	-
Theft	-	-	-	-	5	-	-	1
Lack of planting materials	-	-	-	4	-	-	-	-
Lack of production technology	-	-	-	3	-	-	-	-
Damage by livestock/poultry	-	-	-	7	-	4	-	-
Poor yield	-	-	-	-	-	-	2	-
Incidence of pests & diseases in storage	-	-	-	-	-	5	-	-
Poor soil moisture at sowing	-	-	-	-	-	6	-	-
Lack of improved/desired varieties	-	-	-	1	-	5	-	-

Ranking 1 to 11 was done according to importance/priority of the problems; the higher rank indicates greater severity.

Sources: A. Matin et al. 1994. B. Sabur 1990. C. Ullah et al. 1994. D. Hossain et al. 1994. E. Ahmed et al. 1990a. F. Baksh et al. 1990. G. Elias et al. 1988. H. Elias et al. 1986. I. Ahmed et al. 1990b.

Bacterial wilt in tomato and eggplant, powdery mildew in cucurbits and beans, mosaic and leaf curl virus in tomato and yellow vein mosaic virus in lady's fingers are some of the major diseases that cause heavy damage to vegetable crops almost every year. In addition, aphids in beans and cole vegetables, fruit and shoot borers in eggplant, and diamondback moth in cabbage, are major insect pests causing considerable production loss.

Vegetable Marketing: Structure and Conduct

Market Intermediaries

The intermediaries involved in the vegetable marketing chain from producer to consumer are the Farias, Beparis, Arathdars, Paikers, and Retailers. The business characteristics of these intermediaries are shown in Table 13.

Table 13. Business characteristics of intermediaries in vegetable marketing

	(% of traders)				
	Faria	Bepari	Arathdar	Paiker	Retailer
Nature of business					
Independent	100	86	90	100	97
Joint	0	14	10	0	3
Source of financing					
Self	82	92	90	83	73
Friends/relatives	0	2	0	0	17
Arathdar	0	4	0	17	0
Bank	18	2	0	0	3
Cooperative	0	0	10	0	3
Others	0	0	0	0	3
Have permanent shop	9	51	100	0	91
Duration of business					
< 6 years	18	29	10	83	29
6 –10 years	37	27	50	17	23
11–15 years	18	32	20	0	17
16–20 years	9	12	0	0	17
21–25 years	9	0	10	0	7
>25 years	9	0	10	0	7
No. of staff					
None	100	98	0	100	56
One	0	2	20	0	17
Two	0	0	40	0	27
Three	0	0	40	0	0

Source: Sabur (1990).

Faria

Farias are petty traders who buy vegetables from producers in the village or in the local market and sell them to Beparis, or sometimes directly to local consumers. Farias conduct their business independently, and most are self-financed. They normally do not have a permanent shop in the market, and they have no permanent staff. About half have been engaged in vegetable trading for more than 10 years. About half are seasonal traders; the rest do business throughout the year. Some Farias also deal in other commodities, such as jute or paddy. None of them is reported to offer credit.

Bepari

Beparis are professional traders who buy goods from producers or Farias at the local markets, ship their consignments to urban wholesale markets and sell to retailers through commission agents. Most Beparis are independently organized and self-financed. They have no permanent shops or staff, but they do hire casual labor to perform a variety of marketing functions. Most Beparis have more than five years experience in the vegetable business, and are involved in vegetable trading throughout the year; some also deal in other agricultural commodities. Cash sales or purchases are very common at this stage of the marketing channel. There exists strong competition among Beparis, and entry into this type of business has few barriers. As a result, Beparis cannot make excessive profits.

Arathdar

Arathdars are commission agents who operate from a permanent base (shop or other establishment). Most Arathdars are independently organized and self-financed. They employ both day (or monthly) laborers and other staff to perform various functions, and many employ a few permanent staff. Both licensed and unlicensed Arathdars are found in the wholesale markets. Arathdars charge commissions from Beparis and retailers; these commissions differ according to the vegetable. Arathdars often advance loans to Beparis (on condition that the Bepari sell his vegetables to the Arathdar) and provide shelter and occasional meals to Beparis. Competition at this stage is comparatively less and there are major barriers to entry (such as limited space in the market); as a result, Arathdars can make excessive profits.

Paiker

Paikers buy vegetables from Beparis through Arathdars and sell them to retailers or consumers. They operate independently and manage their own capital; sometimes they borrow money from Arathdars. Paikers have no permanent staff and work on a cash basis. They do not have shops, but instead conduct and perform their business at the Arathdars' shops. Some Beparis who do not like to wait a long time before selling their vegetables dispose of their stock to the Paikers at the Arath centers.

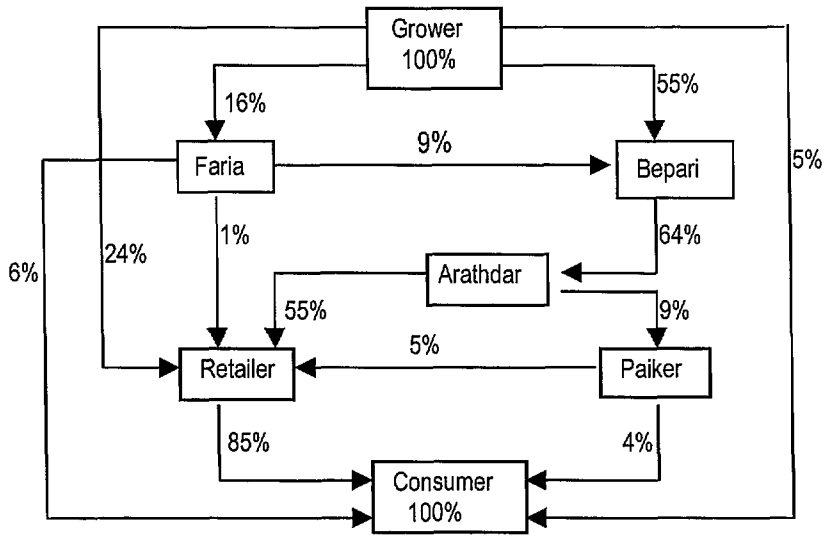
Retailer

Retailers, the last link in the marketing channel, buy vegetables from Beparis through Arathdars and sell them to consumers. Most retailers are independently organized and have a permanent shop in the market, although some, particularly in low-income areas, have no shop, but use the open marketplace. Most retailers are self-financed, but sometimes borrow money from friends and relatives. Some big retailers in high-income areas employ one or two people. In high-income localities, scarcity of space to set up a shop is an important barrier to entry, whereas in low-income areas, people who want to sell vegetables can simply sit in the open marketplace. Cash sales are very common in high-income areas, but in low-income areas retailers often sell vegetables on credit. Retailers sometimes make credit purchases from Beparis at Arath centers.

Market Flow System

The marketing flow for vegetables, in general, is depicted in Fig. 3. Vegetable growers usually sell their produce (55%) to Beparis, either in the local primary market or in the village. About 24% of their produce is sold directly to retailers in the local market. Growers also dispose of their vegetables

to Farias (16%) and a few even sell directly to local consumers in the market.



Source: Sabur (1990).

Fig. 3. Marketing channels for vegetables in Bangladesh

The following channels are investigated in detail in different studies discussed in the following sections.

1. Producer → Consumer
2. Producer → Retailer → Consumer
3. Producer → Bepari → Arathdar → Retailer → Consumer
4. Producer → Bepari → Paiker → Arathdar → Retailer → Consumer
5. Producer → Faria → Retailer → Consumer
6. Producer → Faria → Bepari → Arathdar → Retailer → Consumer

Marketing Functions

A marketing function may be defined as a major specialized activity performed in accomplishing the marketing process (Kohls & Uhl 1980). Pricing, transportation, storage, packaging, grading and standardization, and market information, are the various functions performed in vegetable marketing in Bangladesh.

Pricing

All traders involved in vegetable marketing follow the open bargaining method for fixing prices at the time of trading. The price is determined mainly by the number of buyers attending the market and the volume and quality of produce offered for sale. Because vegetables are highly perishable, sellers usually have low bargaining power vis-a-vis buyers.

Transportation

Transportation is concerned with the availability of market produce at the proper time and place (Sabur 1990; Batan 1994). Rickshaws, headloads, and country boats are the important means of transportation from the farm gate to the local markets. Headloads, rickshaws, push carts, and country boats are the major means of transportation used by Farias. On the other hand, Beparis mainly use trucks to carry vegetables from the local market to the urban wholesale market; sometimes they use country boats, trains, and passenger buses to ship their purchased produce. Vegetables are carried by rickshaw vans from Arath centers to various retail markets in Dhaka city.

Storage

Because they are highly perishable, vegetables require specialized storage facilities. Beparis and Farias do not store vegetables; they generally use bamboo baskets or sacks to keep their unsold vegetables in the open space in the market. Cold storage hardly exists at any stage of vegetable marketing in Bangladesh, mainly because consumers prefer to buy fresh vegetables and at least some varieties of vegetables are available in the market all year round. Also, consumers cannot afford to pay the additional costs of storage.

Packaging

Farias and Retailers do not pack their vegetables for transportation. Beparis do, however, mostly in long sacks made from two or three open sacks sewn together. For some vegetables (for example, tomato and bitter gourd) a kind of bamboo basket (*tukri*) is used during transport and for temporary storage.

Grading and Standardization

Grading means sorting vegetables according to quality. Standardization means having consistent and uniform specifications of quality among buyers and sellers from place to place and from time to time (Thomsen 1951).

Except for Farias, almost all traders grade their eggplant, tomato, and bitter gourd. Other vegetables are graded only occasionally. The purpose of grading is to facilitate sales and to obtain a higher price. At the retail level, vegetables are usually graded on the basis of size, variety, color, and defects.

Marketing Information

'Fellow' and 'higher' intermediaries in the market chain are the main sources of market information. For example, Beparis receive information from other Beparis and from Arathdars; retailers collect information mainly from Arathdars, Beparis, and from other retailers. About 90% of the intermediaries reported that they collect market information from other intermediaries by personal contact only. Although the Department of Agricultural Marketing regularly disseminates market prices of vegetables through newspapers, radio, and television, traders do not seem to make much use of these sources of information. Marketers agree that official prices do not reflect actual market prices.

Efficiency of Vegetable Marketing

Marketing Costs and Margins of Producers

In most cases, transportation is the major marketing cost at the growers' level. Headloads and rickshaws/rishshaw vans are the major modes of transport used by vegetable growers. When producers market their own produce, in most cases they do so in local markets (Table 14).

Table 14. Transportation mode, place of sale, and marketing cost for producers in selected vegetables

Vegetable	Marketing channel*	Transportation mode (% grower)				Sale place (% grower)			Market cost (BDT/t)				Reference
		Head/ shoulder	Van/rick-shaw	Bullock cart	Other	Farm	Village	Market	Transport	Toll	Other	Total	
Bitter gourd	5	-	-	-	-	-	62	38	359	113	200	672	Baten 1994
Cabbage	3	24	55	-	5	16	-	-	186	25	-	211	Ahmed et al. 1990b
Cauliflower	3	42	48	-	-	10	-	-	295	32	-	327	Ahmed et al. 1990b
Eggplant	3,6	42	62	4	4	-	30	70	53	-	11	64	Sabur 1990
Lady's finger	5	-	-	-	-	-	26	74	388	102	225	715	Baten 1994
Pointed gourd	3	67	67	-	17	-	67	33	107	-	39	146	Sabur 1990
Pointed gourd	3	-	-	-	-	-	31	69	428	113	275	816	Ullah et al. 1994
Pumpkin	3	67	100	67	-	-	87	13	60	-	16	76	Sabur 1990
Pumpkin	5	-	-	-	-	-	55	45	453	101	300	854	Baten 1994
Radish	3	83	100	-	-	-	87	13	53	-	9	62	Sabur 1990
Radish	3	26	57	-	5	12	-	-	250	66	-	316	Ahmed et al. 1990b
Tomato	1,2,3	32	62	-	4	2	-	-	225	77	-	302	Ahmed et al. 1990b
Tomato	3	75	75	-	-	-	77	23	69	-	26	95	Sabur 1990

- implies that information is not available.
* For channels corresponding to each number, see page 50.

Marketing Costs and Margins of Intermediaries

Marketing costs and margins of vegetable marketing intermediaries are shown in Table 15.

Faria

Transportation accounts for more than half of the total marketing cost incurred by Farias. The marketing margin varies, mainly due to variation in profits made by Farias. However, profit generally constitutes more than 50% of the marketing margin.

Paiker

Transportation accounts for more than 60% of Paikers' total marketing costs. There is considerable variation (in absolute terms as well as in terms of percentage contribution of different cost items) in margins for the various vegetables.

Bepari

Transportation and wastage are the major costs incurred by Beparis. The distance of the local assembling centers from the urban wholesale markets, the nature of the commodity, and the commissions paid to Arathdars are the key factors that determine the Beparis marketing costs. The margins vary, largely due to variation in profits. In most cases about two-thirds of the marketing margin is costs, with one-third left for profits.

Arathdar

The labor cost of employed workers, merged in "other costs" in Table 15, is the Arathdars' single highest cost item. The cost of entertaining Beparis and other people (personal expenses) is the second highest cost item. There is considerable variation in the profit of Arathdars. Even the margins of the same commodity vary considerably across studies.

Table 15. Marketing costs and margins (10 BDT/t) of marketing agents

Vegetable	Marketing cost								Marketing margin	Profit	Reference
	Tran-sport	Load/ unload	Market tolls	Wastage	Personal expense	Commi-ssion	Other	Total			
Farias											
Bitter gourd	33	N/A	4	10	5	N/A	2	54	147	93	Baten 1994
Eggplant	13	N/A	1	1	11	N/A	11	27	135	108	Sabur 1990
Eggplant	31	N/A	4	7	6	N/A	1	49	123	74	Baten 1994
Lady's finger	25	N/A	3	7	5	N/A	1	41	148	107	Baten 1994
Pumpkin	25	N/A	4	1	5	N/A	1	36	95	59	Baten 1994
Radish	5	N/A	3	N/A	20	N/A	N/A	28	49	21	Sabur 1990
Tomato	9	N/A	1	N/A	8	N/A	N/A	18	106	88	Sabur 1990
Paikers											
Bitter gourd	35	N/A	5	9	9	N/A	6	64	100	36	Baten 1994
Eggplant	33	N/A	4	6	8	N/A	2	53	138	85	Baten 1994
Eggplant	N/A	N/A	N/A	7	14	10	3	34	92	58	Sabur 1990
Lady's finger	27	N/A	5	5	7	N/A	3	47	159	112	Baten 1994
Pumpkin	33	N/A	5	2	9	N/A	2	51	98	47	Baten 1994
Tomato	N/A	N/A	N/A	13	13	62	4	92	135	43	Sabur 1990
Beparis											
Bitter gourd	35	3	1	45	12	13	1	110	176	66	Baten 1994
Cabbage	44	17	6	48	N/A	N/A	5	120	659	539	Ahmed et al. 1990b
Cauliflower	46	19	6	86	N/A	N/A	8	165	1204	1039	Ahmed et al. 1990b
Eggplant	73	7	3	10	6	27	2	128	163	35	Sabur 1990
Eggplant	31	5	2	41	10	13	2	104	125	21	Baten 1994
Lady's finger	28	3	1	23	13	10	2	80	96	16	Baten 1994
Radish	41	24	5	30	N/A	N/A	5	105	361	256	Ahmed et al. 1990b
Pointed gourd	62	14	8	57	21	19	3	184	229	45	Sabur 1990

Contd. Table 15.

Vegetable	Marketing cost								Marketing margin	Profit	Reference
	Tran-sport	Load/ unload	Market tolls	Wastage	Personal expense	Commi-ssion	Other	Total			
Pointed gourd	100	18	10	12	N/A	N/A	10	150	197	47	Ullah et al. 1994
Pumpkin	25	4	1	44	1	12	2	89	122	33	Baten 1994
Pumpkin	14	1	1	9	2	3	0	30	48	18	Sabur 1990
Radish	31	1	1	21	N/A	24	N/A	78	136	58	Sabur 1990
Tomato	80	16	3	60	32	30	4	225	386	161	Sabur 1990
Tomato	50	22	7	82	N/A	N/A	6	167	702	535	Ahmed et al. 1990b
Arathdars											
Bitter gourd	N/A	N/A	N/A	N/A	5	N/A	7	12	112	100	Baten 1994
Cabbage	N/A	N/A	N/A	N/A	2	N/A	3	5	146	141	Ahmed et al. 1990b
Cauliflower	N/A	N/A	N/A	N/A	2	N/A	3	5	259	254	Ahmed et al. 1990b
Eggplant	N/A	N/A	N/A	N/A	2	N/A	3	5	20	15	Sabur 1990
Eggplant	N/A	N/A	N/A	N/A	4	N/A	6	10	100	90	Baten 1994
Lady's finger	N/A	N/A	N/A	N/A	4	N/A	6	10	61	51	Baten 1994
Pumpkin	N/A	N/A	N/A	N/A	4	N/A	6	10	52	42	Baten 1994
Pointed gourd	N/A	N/A	N/A	N/A	2	N/A	3	5	135	130	Sabur 1990
Radish	N/A	N/A	N/A	N/A	2	N/A	3	5	53	48	Sabur 1990
Radish	N/A	N/A	N/A	N/A	2	N/A	3	5	90	85	Ahmed et al. 1990b
Tomato	N/A	N/A	N/A	N/A	2	N/A	3	5	121	116	Sabur 1990
Tomato	N/A	N/A	N/A	N/A	2	N/A	3	5	244	239	Ahmed et al. 1990b
Pumpkin	N/A	N/A	N/A	N/A	2	N/A	3	5	27	22	Sabur 1990
Rural Retailers											
Bitter gourd	13	3	3	1	10	N/A	10	40	68	28	Baten 1994
Cabbage	5	5	4	N/A	N/A	N/A	2	16	133	117	Ahmed et al. 1990b
Cauliflower	5	1	4	N/A	N/A	N/A	2	12	143	131	Ahmed et al. 1990b
Eggplant	13	3	3	11	11	N/A	12	53	133	80	Sabur 1990
Lady's finger	12	3	4	8	10	N/A	12	51	160	111	Baten 1994
Radish	5	3	4	N/A	N/A	N/A	2	14	159	145	Ahmed et al. 1990b
Pumpkin	13	2	2	8	10	N/A	10	45	103	58	Baten 1994
Tomato	5	5	5	N/A	N/A	N/A	2	17	197	180	Ahmed et al. 1990b
Urban Retailers											
Bitter gourd	45	8	6	24	6	9	6	104	332	228	Baten 1994
Cabbage	11	N/A	N/A	N/A	N/A	97	N/A	108	206	98	Ahmed et al. 1990b
Cauliflower	7	N/A	N/A	N/A	N/A	173	N/A	180	478	298	Ahmed et al. 1990b
Eggplant	44	7	6	13	5	8	7	90	252	162	Baten 1994
Eggplant	25	5	1	23	30	10	2	96	124	28	Sabur 1990
Lady's finger	41	8	6	13	6	8	6	88	169	81	Baten 1994
Radish	25	5	1	22	12	33	2	100	124	24	Sabur 1990

Contd. Table 15.

Vegetable	Marketing cost								Marketing margin	Profit	Reference
	Tran-sport	Load/ unload	Market tolls	Wastage	Personal expense	Commi-ssion	Other	Total			
Radish	11	N/A	N/A	N/A	N/A	60	N/A	71	207	136	Ahmed et al. 1990b
Pointed gourd	5	N/A	N/A	N/A	N/A	N/A	50	55	178	123	Ullah et al. 1994
Pumpkin	26	5	3	3	17	18	0	72	85	13	Sabur 1990
Pumpkin	39	9	6	2	6	8	6	76	109	33	Baten 1994
Pointed gourd	27	4	1	2	23	78	1	136	182	46	Sabur 1990
Tomato	10	N/A	N/A	N/A	N/A	163	N/A	173	281	108	Ahmed et al. 1990b
Tomato	25	5	1	76	23	61	2	193	238	45	Sabur 1990

N/A = not applicable

Retailer

Retailers' marketing costs are directly related to the distance between Arath centers and retail markets (transportation costs), the level of Arathdari commissions, the degree of perishability of the vegetables, and inversely with scale of operation. For the urban retailers, transportation costs, Arathdari commissions, personal expenses, and, in a few cases, wastage, are the major cost items. For the rural retailers, marketing cost is very low.

Retailers' margins, in general, are the lowest (both in absolute and percentage terms) among all intermediaries, despite the fact that they assume greater risks. Retailers' margins are directly related to the income status of the locality; i.e., in high-income localities margins are high and in low-income areas they are low. Sabur (1990) found that the marketing margins of intermediaries increase (in absolute terms) as prices increase, but the rate of increase in the margin is less than the increase in price.

Price Spread

The spread between farm price and retail price is another measure of marketing efficiency. It is the difference between the retail price and the value of an equivalent amount of food sold by farmers (Khols & Uhl 1980).

The producers' share of the consumers' price and marketing margin depends on various factors, such as processing and marketing services, perishability, bulkiness, distance of shipment, number of intermediaries in the marketing channel, unit price of the product, etc. On average, producers receive nearly 50% of the consumer's price (range 12–66%, depending on the vegetable) (Table 16). In most cases, the producers' share is high for high-priced vegetables, and low for low-priced vegetables.

Regressing the producers' share on number of marketing agents gave a significant negative relationship, implying that reducing the number of agents will increase the producers' share. Adding one agent to the channel causes a 12% reduction in the farmers' share.

Farias' profit accounts for the highest portion of the total price spread—one-third to three-fourths of the price spread between producers and consumers (Table 16). Therefore, policy efforts to reduce the

share of Faria profit could greatly reduce the price spread, and increase the contribution of producers' profit in the consumers' price. The Beparis' share of marketing costs is generally high, mainly due to the complexity of the functions they perform. Retailers' costs are also high because of the high cost of transportation, Arathdari commissions, and wastage.

Table 16. Contribution of marketing cost and profit (%) in the total price spread by various intermediaries

Vegetables	Marketing channel*	Marketing cost (%)				Profit (%)					% of consumer price received by producers	Reference
		Faria	Bepari	Paiker	Retailer	Faria	Bepari	Paiker	Arathdars' commission	Retailer		
Bitter gourd	5	19	-	-	19	33	-	-	-	29	53	Baten 1994
Eggplant	6	2	30	-	28	12	2	-	-	27	14	Sabur 1990
	3	-	45	-	33	0	12	-	-	10	36	
Eggplant	4	-	17	8	7	-	12	13	8	35	23	Baten 1994
	5	16	-	-	8	27	-	0	-	39	39	
Lady's finger	4	-	18	8	8	-	13	14	8	32	20	Baten 1994
	5	20	-	-	21	33	-	0	-	26	40	
Pointed gourd	3	-	45	-	33	0	11	-	-	11	66	Sabur 1990
Pumpkin	3	-	23	-	54	0	13	-	-	10	41	Sabur 1990
Pumpkin	4	-	19	6	8	-	17	13	8	30	12	Baten 1994
	5	25	--	-	28	26	-	-	-	20	37	
Radish	3	-	30	-	38	0	22	-	-	9	40	Sabur 1990
Tomato	6	1	18	-	23	12	21	-	-	25	31	Sabur 1990
	3	-	36	-	31	0	26	-	-	7	48	

- implies that the intermediary did not play a role in the marketing channel, these data was not available or not applicable.

* For channels corresponding to each number, see page 50.

The absolute profit obtained by traders varies from 310 BDT/t in pumpkin to 13250 BDT/t for cauliflower, which increases with the increase in vegetable prices, but decreases in percentage term. Profits as a percentage of investment by traders also vary for different vegetables, ranging from 8 to 151%. Traders' returns on investment were found to be more than 100% for cauliflower, cabbage, and pumpkin when sold in a longer channel, and returns were found to be low for pointed gourd (Table 17).

Marketing Constraints

Only a few studies on marketing constraints are available. The monopoly of traders in marketing, unstable prices, defective weighing, lack of marketplaces, high market tolls, low prices, and lack of good facilities at marketplaces are cited as major marketing problems faced by growers (Baten 1994; Sabur 1990). On the other hand, traders' problems include lack of capital, space, and information, price instability, problems in transport and in obtaining licenses, post-harvest infestation, and uncertain electricity supply (Ahmed et al. 1990b; Ullah et al. 1994). Baten (1994) reported that most Arathdars cited availability of capital and supply as the main factors affecting their volume of business, and Beparis cited price and vegetable supply as main determining factors affecting business volume. While retailers are concerned with demand and capital.

Table 17. Spread between producers' price and consumers' price, and traders' profit for selected vegetables

Vegetable	Marketing channel	Grower price (BDT/t)	Consumers price (BDT/t)	Producer share (%)	Marketing cost (BDT/t)	Profit of traders (BDT/t)	Investment by traders (BDT/t)	Profit (%) of invest-ment	Reference
Bitter gourd	5	3210	6010	53	1070	1730	4270	41	Baten 1994
Cabbage	-	3120	11770	27	2440	6210	5560	112	Ahmed et al. 1990b
Cauliflower	-	5220	22040	24	3570	13250	8790	151	Ahmed et al. 1990b
Eggplant	6	560	4000	14	2050	1390	2610	53	Sabur 1990
	3	1630	5500	30	2230	640	3860	16	
Eggplant	4	1760	7730	23	2410	3560	4170	85	Baten 1994
	5	1780	4590	39	930	1870	2710	69	
Lady's finger	4	1470	7340	20	2420	3440	3900	88	Baten 1994
	5	1460	3650	40	890	1290	2350	55	
Pointed gourd	-	8570	12320	70	2050	1700	10620	16	Ullah et al. 1994
Pumpkin	4	870	7570	11	2680	4020	3550	113	Baten 1994
	5	830	2240	37	760	650	1590	41	
Pointed gourd	3	7820	11930	66	3200	910	11020	8	Sabur 1990
Pumpkin	3	940	2270	41	1020	310	1960	16	Sabur 1990
Radish	3	1730	4330	40	1770	820	3500	23	Sabur 1990
Radish	-	2380	8060	30	1890	3790	4270	89	Ahmed et al. 1990b
Tomato	6	3750	12000	31	3500	4750	7250	65	Sabur 1990
	3	5670	11910	48	4180	2060	9860	21	
Tomato	-	9250	19080	48	3570	6260	12820	49	Ahmed et al. 1990b

* For channels corresponding to each number, see page number 50.
- implies that information is not available

International Trade

Bangladesh began to export fruit and vegetables in 1973–74; the value of exports that year was very small, at 1.4 million BDT. During the 1980s, exports took off, reaching 530.5 million BDT in 1987, before plummeting to one-fifth of that value in 1991. In the early 1990s, vegetable exports picked up again (Table 18). Among agricultural export items, vegetables have played an increasingly important role. The main vegetables exported by air include string beans, bitter gourd, lady's finger, teasle gourd, eggplant, snake gourd, ribbed gourd, bottle gourd, pointed gourd, Indian spinach, cucumber, tomato, arum, and red amaranth. Bangladesh does not import vegetables, although unofficial imports through the porous Indian border is unrecorded.

Table 18. Bangladesh exports of vegetables, 1979–93

Year	Quantity (t)	Value (million BDT)
1979	287	7.2
1980	343	10.3
1981	519	14.6
1982	1056	28.1
1983	1686	56.7
1984	1940	77.1
1985	2533	108.5
1986	8466	404.8
1987	10577	530.5
1988	8686	461.8
1989	5031	298.8
1990	4860	315.2
1991	2675	117.5
1992	4950	197.9
1993	7679	307.2

Source : GOB (various issues).

Export marketing is linked to the domestic marketing system. Fresh vegetables are generally collected by exporters from the Dhaka markets through different marketing channels. After procurement, they are stored, graded, packed in bamboo baskets or paper cartons (used boxes of imported goods) and transported to the airport for shipment. Some exporters collect vegetables directly from Kashimpur, Rupganj in Dhaka, Jessore, Kushtia, Rajshahi, Comilla, and Chittagong.

Supply and Demand

Per Capita Availability

Per capita availability of vegetables in Bangladesh since independence, estimated from the vegetable production data after adjusting for international trade, has varied between 28 and 34 g/head/day—far below the recommended level of 200 g/capita/day (Ali and Tsou 1997). The positive trend in annual growth in availability between 1972 and 1993 was negligible at 0.25%. The annual growth in the availability was higher between 1983 and 1993 (0.28%) than during 1972 and 1982 (0.19%).

Consumption by Rural and Urban Groups

The Household Expenditure Survey (HES) of 1988–89 estimated an average per capita monthly expenditure on food of 1672 BDT, or 65.4% of total consumption expenditure; this is lower than the 1973–74 value of 75.7% (GOB 1990).

The percentage distribution of monthly expenditures on major food items shows that cereals account for 50.6%, meat and fish products 12.6%, pulses 3.6%, vegetables 8.8%, milk and milk products

2.8%, edible oil 3.6%, condiments and spices 6.0%, fruit 1.1%, sugar and brown-sugar cake 1.7%, beverages 1.1%, and miscellaneous food 8.1%. During the period from 1973–74 to 1988–89, expenditures on cereals, edible oil, and spices decreased gradually, and expenditures on meat and fish products, vegetables, and miscellaneous food items increased considerably. The level of consumption of almost all food items is generally lower in rural areas compared to urban areas, except for rice, wheat, eggs, and pulses.

About 8.8% of household income is spent on vegetables. Consumers in rural areas in all income groups spend a slightly lower proportion of their income on vegetables than do consumers in urban areas, except in the lowest household income group (<750 BDT/month) which spends a relatively higher portion of total household income on vegetables (results not reported here).

National per capita monthly consumption of vegetables, including potato and banana, varies from 4.3 kg in the lowest income group to 6.7 kg in the highest income group (Table 19). Similar trends are observed for rural and urban areas. Except for the lowest income group in rural areas, rural dwellers consume less vegetables than urban dwellers in the corresponding income group. Some income groups in rural areas consume more 'other vegetables' (perhaps vegetables from home gardens) than the corresponding groups in urban areas.

Table 19. Monthly per capita consumption of vegetables (kg) by monthly household income groups, 1988–89

Household income group (BDT)	Percent of households	Total food (kg)	Vegetable consumption (kg)				
			Total vegetables	Leafy vegetables	Potato	Banana, papaya & eggplant	All others
< 750	3.80	16.81	4.30	1.65	0.57	0.53	1.56
750-999	6.30	20.34	4.49	1.27	0.78	0.70	1.75
1000-1249	8.53	21.74	4.77	1.24	0.96	0.74	1.84
1250-1499	9.05	23.18	4.77	1.16	0.99	0.62	2.00
1500-1999	17.66	25.56	5.37	1.26	1.00	1.02	2.09
2000-2499	14.36	26.46	5.02	1.05	1.07	0.75	2.15
2500-2999	9.85	26.95	5.04	0.99	1.20	0.78	2.07
3000-3999	13.02	29.68	5.25	1.01	1.34	0.75	2.16
4000-4999	6.53	29.81	5.65	1.13	1.40	0.88	2.26
5000-5999	3.42	32.13	5.55	1.01	1.59	0.80	2.15
6000-6999	2.23	33.76	5.85	1.04	1.52	0.83	2.45
7000-7999	1.39	38.01	6.02	1.00	1.72	0.87	2.43
8000-8999	0.95	34.68	6.47	1.25	1.48	0.71	3.03
9000-9999	0.69	35.99	6.67	1.25	2.11	0.88	2.43
10000-12499	0.80	30.39	5.54	1.16	1.61	0.75	2.02
12500+	1.35	41.79	6.70	1.27	1.62	0.82	3.00
All Groups		27.64	5.26	1.12	1.20	0.80	2.14

Contd. Table 19.

Household income group (BDT)	Percent of households	Total food (kg)	Vegetable consumption (kg)				
			Total vegetables	Leafy vegetables	Potato	Banana, papaya & eggplant	All others
URBAN							
< 750	0.80	18.17	4.02	0.87	0.91	0.70	1.54
750-999	1.87	19.36	4.61	1.56	1.19	0.66	1.20
1000-1249	2.61	21.92	5.50	1.43	1.34	0.92	1.81
1250-1499	3.84	23.29	4.99	1.09	1.32	0.79	1.80
1500-1999	13.04	26.49	5.69	1.53	1.40	0.88	1.89
2000-2499	13.52	26.50	5.31	1.21	1.39	0.74	1.98
2500-2999	10.90	29.45	5.97	1.18	1.67	0.83	2.28
3000-3999	18.76	28.83	6.00	1.27	1.71	0.81	2.21
4000-4999	10.63	31.76	6.29	1.27	1.83	0.87	2.32
5000-5999	6.62	31.55	6.11	1.43	1.54	0.76	2.38
6000-6999	4.43	36.35	6.60	1.47	1.93	0.82	2.39
7000-7999	2.29	39.48	8.60	2.08	2.25	0.93	3.34
8000-8999	2.13	33.93	6.11	1.19	1.68	0.61	2.63
9000-9999	1.87	43.03	7.99	1.87	2.12	0.90	3.09
10000-12499	2.77	36.95	7.44	1.89	1.96	0.84	2.75
12500+	3.84	48.88	7.92	2.22	1.95	0.93	2.83
All Groups		31.27	6.20	1.42	1.67	0.82	2.29
RURAL							
< 750	4.23	16.79	4.31	1.66	0.56	0.53	1.56
750-999	6.94	20.37	4.49	1.26	0.76	0.70	1.77
1000-1249	9.38	21.74	4.75	1.23	0.95	0.73	1.84
1250-1499	9.80	23.18	4.76	1.17	0.97	0.61	2.00
1500-1999	18.32	25.47	5.34	1.23	0.96	1.03	2.11
2000-2499	14.48	26.45	4.99	1.03	1.03	0.75	2.17
2500-2999	9.70	26.61	4.91	0.96	1.14	0.77	2.04
3000-3999	12.19	29.84	5.11	0.96	1.27	0.74	2.15
4000-4999	5.94	29.40	5.52	1.10	1.30	0.88	2.24
5000-5999	2.97	32.29	5.40	0.90	1.60	0.82	2.09
6000-6999	1.91	33.05	5.64	0.92	1.41	0.84	2.46
7000-7999	1.26	37.70	5.48	0.77	1.61	0.86	2.23
8000-8999	0.78	34.90	6.58	1.26	1.43	0.74	3.15
9000-9999	0.52	33.58	6.21	1.03	2.11	0.87	2.20
10000-12499	0.52	27.22	4.62	0.81	1.44	0.71	1.67
12500+	0.99	38.38	6.12	0.81	1.46	0.77	3.08
All Groups		27.11	5.13	1.08	1.13	0.80	2.12

Source: GOB (1990).

Seasonality in Vegetable Consumption

Monthly consumption and production data were not available. Therefore, the index of seasonality in vegetable consumption was estimated from vegetable arrivals in Dhaka markets (Fig. 4). Vegetable consumption was highest during March–May when overall vegetable prices were low, and lowest in October when overall vegetable prices were high. The highest availability of vegetables was double the lowest availability. Therefore, average vegetable consumption estimates based on the annual vegetable availability overlook the strong seasonality in vegetable supply.

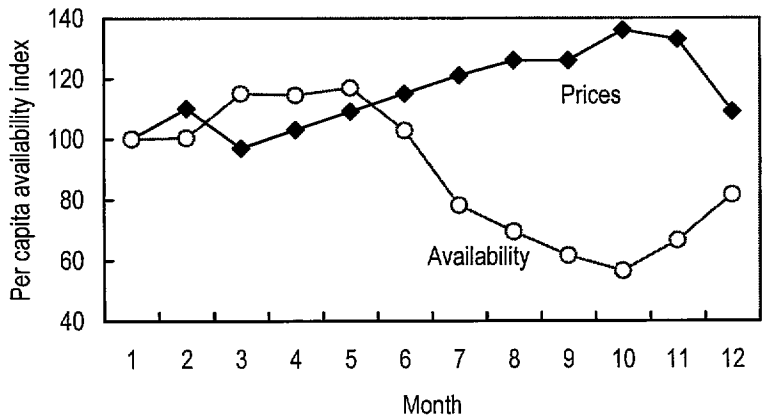


Fig. 4. Seasonality in vegetable price and availability in Dhaka markets, average 1991-93

Income and Expenditure Elasticities of Vegetables

Information on price and income elasticities for different vegetables is not available from HES, with the exception of potato for which elasticities were estimated for 1983–84, 1985–86, and 1988–89. Income and expenditure elasticities of demand for potato for all three periods were lower in urban areas (0.46–0.58 and 0.61–0.67, respectively) than in rural areas (0.74–0.89 and 0.92–1.0, respectively). Income elasticities of demand for potato have increased in urban areas over time, while corresponding elasticities in rural areas have shown a decline.

Government Policies

Research and Development

There is a growing awareness of the role of vegetable production in the national agricultural economy and in human health. Vegetable research has been encouraged through bilateral and multilateral collaboration with international agencies. Bangladesh is an active member of the South Asian Vegetable Research Network (AVRDC 1992) and the regional FAO/UNDP vegetable development project, RAS/89/041. Through these networks and projects, Bangladesh receives improved technologies for vegetables from other countries and assistance in developing its own research facilities. Several improved and off-season varieties of tomato, cabbage, and cauliflower have already been developed by BARI. Moreover, a homestead vegetable production model in a 6 x 6 m^2 area has been developed for small farm households, and has been widely accepted throughout the country. Non-governmental organization (NGO) workers are being trained in vegetable production,

preservation and processing in the villages.

Improved Domestic Vegetable Marketing

Direct government intervention in vegetable marketing is minimal. Buying and selling of vegetables is almost entirely in the hands of producers, private traders, and a small number of agricultural cooperatives.

Through the Agriculture Product Markets Regulation Act, passed in 1964 and amended in 1985, the Department of Agricultural Marketing (DAM) tries to regulate marketing charges, Arathdars' commissions, and other fees involved in vegetable marketing. Under the Act, some markets are designated as important, and in these the District Market Advisory Committee makes recommendations to set the market charges. Market functionaries are given licenses upon payment of the required fees. Efforts are being made by DAM to increase domestic consumption of vegetables, particularly potatoes, through motivational posters, booklets, food displays, and other means.

The government's main area of involvement in potato marketing has been in financing the construction of cold storage facilities. The Department of Industries has provided import licenses at reduced rates for equipment and material for such facilities, and capital and commercial loans are advanced to the investors through banks. The aim is a strong cold storage industry that will improve potato marketing and ultimately ensure fair prices to growers.

Incentives for Vegetable Exports

To cope with declining foreign exchange earnings from traditional commodities, such as jute, efforts are being made to boost exports of non-traditional items, including fruit and vegetables. For planned development and expansion of export trade of fruit and vegetables to other countries, the government regularly announces its export policy, and sets vegetable export targets. The following are some of the features of the 1991–92 export policy:

1. The establishment of "export villages" in selected areas to increase production of export-oriented vegetables;

2. Intensification of the search for export markets for vegetables in Western Europe and Japan;

3. Increase in the air cargo capacity of Biman, the national air carrier;

4. Encouragement in the use of improved packing materials and guaranteeing their availability in order to maintain freshness and quality of fruits and vegetables.

In addition, the Export Promotion Bureau (EPB), in cooperation with the Bangladesh Agricultural Development Corporation (BADC), has started a program for growing vegetables and fruits on selected farms (for example, in Aulokhola, Kashimpur, Hathihara, and Enayatpur). Under the Crop Diversification Programme, contract growing of potato is being tried. One cold storage facility with a 120-t capacity has been set up at Dhaka airport for air cargo of perishable commodities. The overall objective of these policies is to improve links between exporters and growers and to guarantee growers a legitimate price for their produce.

The government has taken various steps to enhance overall exports, including vegetables. These steps include:

- sending export delegates on market identification missions
- hiring consultants to recommend improved grading and packaging methods
- setting up trade fairs in other countries
- establishing a Sectoral Task Force to monitor progress in exports
- organizing meetings between exporters, customs and Biman officials, and traders.

Provision of Quality Seeds

The government recognized the importance of good quality seeds of high-yielding varieties suited to different ecological conditions. To ensure the production, processing, preservation, and distribution of good quality seed to farmers, the government has implemented a National Seed Policy through which private traders, as well as government agencies, are encouraged to produce and distribute quality seeds.

Reliable data on the quantity of vegetable seeds (except for potato) imported from abroad and produced locally by private seed companies are not available. However, of the present requirements for vegetable seed in Bangladesh—around 1000 t—the Department of Agricultural Extension (DAE) and private traders together supply only 36% (360 t) (Mondol 1994). The remaining 640 t of seeds are farmers' own, and these are usually of low quality, particularly with respect to genetic purity. Low-quality seed is a major cause of low vegetable yields in Bangladesh. On the other hand, adoption of improved varieties in recent years has substantially raised the yields of certain crops, such as tomato, eggplant, and cabbage.

Seeds of cabbage, kohlrabi, turnip, spinach, beet, and carrot are not produced in the country, and must be imported. Varieties of cabbage, carrot, and turnip, suitable for local seed production, have been identified, but these do not yet cover a substantial area.

Vegetable Research and Development

Achievements of Past Economic Research

The Agricultural Economics Division of BARI was created in 1978. Research on the socioeconomics and marketing of selected vegetable crops was started only during the late 1980s because the division was preoccupied with cereal crops. The Agricultural Economics Department of the Bangladesh Agricultural Institute (BAI), in collaboration with the Bangladesh Agricultural Research Council (BARC) and the Agricultural Economics and Rural Sociology faculty of Bangladesh Agricultural University (BAU), has conducted a few research activities related to the economics and marketing of vegetables.

The Agricultural Economics Division has completed research on certain economic issues relating to selected vegetables, including tomato, eggplant, cauliflower, cabbage, radish, hyacinth bean, bitter

gourd, teasle gourd, pointed gourd, mukhikachu, and panikachu. Marketing research has been carried out on tomato, cabbage, cauliflower, radish, and pointed gourd. BAI conducted research on the economics and marketing of eggplant, pointed gourd, radish, tomato, and pumpkin, and BAU did marketing research on eggplant, lady's finger, pumpkin, and bitter gourd.

The above-mentioned studies indicate that the production of vegetables is profitable compared to many other crops. The production of vegetables and their marketing is labor-intensive and creates ample employment opportunities. Homestead vegetable production will also increase the employment opportunities of women.

Vegetable economics studies have identified the constraints to higher vegetable production and productivity. Major constraints include seasonality, lack of improved varieties, shortage/non-availability of quality seeds, absence of appropriate management practices, lack of improved technologies, high cost of inputs, incidence of pests and diseases, lack of irrigation, lack of credit facilities, lack of extension services, high post-harvest losses, and poor marketing facilities.

The main vegetable marketing agents and channels have been identified and marketing margins quantified. Major vegetable marketing constraints have also been identified.

Needs and Priorities for Future Research

Mondol (1994) mentions the following strategies which could be adopted to improve production and marketing of vegetables in Bangladesh.

Production

- Improved varieties of vegetables, with resistance to major diseases and pests and tolerance to salinity, drought, and waterlogging, need to be developed. There is a particular need for tomato and eggplant varieties with resistance to bacterial wilt, lady's finger varieties resistant to yellow vein mosaic virus, and varieties of cucurbits resistant to powdery mildew.

- It is also necessary to concentrate on the generation of F_1 hybrids and heat-tolerant varieties of cabbage and cauliflower. The present program for breeding tomato varieties for heat-tolerance should be speeded up.

- Development of varieties of existing vegetables that can be sown at different times would help to reduce the seasonality problem.

- Strategies for the improvement of production should put emphasis on management practices and crop rotations which allow: timely cultivation, control of pests and diseases, and management of soil fertility.

- Technologies are needed to enhance and popularize vegetable production in homesteads.

- A seed corporation should be established with responsibility for production and distribution of quality seeds of recommended varieties of vegetables and potato. The private sector should also be encouraged to produce quality seeds of the recommended varieties.

Marketing

- The transport system should be improved by introducing refrigerated transport facilities and motorized boats to carry vegetables to distant markets. Improvements are also needed in the present handling, packaging, and marketing intelligence systems.
- Suitable storage technologies should be established at village and market levels.
- Establishment of suitable processing plants near cities is also necessary. Both the private and public sector should be involved in setting up these plants.
- Institutional credit should be provided to growers to help them purchase necessary inputs, and to private entrepreneurs to establish processing plants.
- Vegetable producers should be provided with market information on the price and supply situation on a regular basis, to enable them to bargain with traders more effectively.

Socioeconomic Research

The following aspects of socioeconomic research should be explored:

- The causes of decreasing or stagnant productivity in vegetable cultivation.
- Optimum utilization of resources and inputs in different ecoregions.
- Domestic resource costs of major vegetables.
- Vegetable export potential to different countries.
- Relationship between health and vegetable consumption.
- The impact of improved technologies along with the constraints to technology transfer.
- Feasibility of management practices for vegetable cultivation in the summer season.
- Causes of unstable vegetable prices.
- Economic assessment of the potential for the processing of vegetables.
- Compatibility and economic viability of homestead gardens.

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CHINA

Shiqing Ma, Jikun Huang, Debin Wang and Dongyu Qu

Introduction

China extends over cold, temperate, subtropical, and tropical regions; one quarter of the territory in the tropics or subtropics. Two-thirds of the country is mountainous, hilly or high plateau regions; the western regions are more mountainous than the eastern, which are mainly plains. China's population in 1995 was 1.2 billion, 71% of which resided in rural areas. Per capita net income was US$500, and was growing at the rate of 10.2% per year. The main crops in China are rice, wheat, maize, soybean, and vegetables accounting for 20.4, 19.5, 14.3, 8.6, and 6.0% of the total cropped area, respectively, in 1994 (State Statistical Bureau 1995).

During 1993, vegetables were grown on about 4 million ha. On average, two crops were grown on this land during the year, so that cropped area was around 8.1 million ha. The average yield of each crop was 15.4 t/ha, so the total output for all vegetables in the country was 125.5 million t. The total value of these vegetables was more than 100 billion yuan (US$18 billion), or about one quarter of the value of all cereal production. Annual average per capita availability of vegetables at the farm level was about 103 kg. The major vegetables are Chinese cabbage, potato, radish, garlic, pakchoi, cabbage, chili, tomato, and cucumber. The main vegetable growing areas in the country are Shandong, Henan, Hebei, Sichuan, Jiangsu, and Hubei.

Daily per capita food consumption in China is about 1 kg. Cereals and vegetables account for 58.6 and 30.4%, respectively; other food sources include livestock, fish products, sugar, oil, etc. (State Statistical Bureau 1995).

General Information

Climate

China has four distinct seasons. In most parts of the country January is the coldest month (lowest temperature –50°C) and July is the hottest (highest temperature +45°C). Temperatures vary greatly from south to north. The frost-free period in north-eastern China is limited to 80–150 days, but in the south it is as long as 250–350 days. Average annual rainfall is 630 mm. The highest rainfall occurs on the south-eastern coast, which receives 1600–2000 mm annually, but toward the north-west, precipitation declines to as little as 250 mm in some drought-prone areas. The amount of sunshine

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increases from north to south; the western region receives the most intensive sunlight. During the summer, typhoons and thunderstorms occur along the south-eastern coast. Hail frequently occurs in inland areas.

Ecoregions and Regional Distribution

Vast area, complex topography, and, especially, diversity of climate, create a great variety of eco-environments for crop production in China. Based on climate and cropping systems, the country can be divided into eight regions (Table 1 and Fig. 1).

Regions 1 to 4, in eastern China, are characterized by plains and lower hills, rich water resources, and increasingly high average temperatures from north to south. Several crops may be grown each year in some areas. Three of these regions (2, 3, and 4) account for some 75% of the total growing area, and of the total vegetable production.

Regions 5 to 8, in western China, are at higher altitudes and are more arid. Temperatures are lower, but there is intensive sunshine and day and night temperatures vary widely. Due to the diverse climatic conditions in these regions, a convenient transportation system, if present, would favor year-round vegetable supply.

Table 1. Vegetable growing areas and production shares, average planting indices, and marketable surpluses by ecoregion, 1992

Ecoregion	Cropping system (crops per year)	Share of total vegetable growing area (%)	Share of total vegetable production (%)	Planting index *	Marketable surplus (% of production)
1 North–east	Single cropping	9.52	9.85	1.32	81.7
2 North China	Double cropping	28.41	39.58	1.88	91.2
3 Yangtze River middle and lower reaches	Triple cropping	28.02	24.41	2.76	88.3
4 South China	Multiple cropping	18.98	11.36	3.97	74.7
5 Northwest Yellow Plateau	Double cropping	6.20	5.90	1.67	75.4
6 Southwest Erect	Triple cropping	4.73	4.77	2.74	89.4
7 Qinghai–Tibet Plateau	Single cropping	3.75	3.73	1.16	89.2
8 Inner Mongolia–Xinjiang	Single cropping	0.40	0.40	1.17	44.4

*Number of crops grown on a given plot in a year
Source: State Statistical Bureau (1993).

Major Vegetable Species

About 209 species of vegetables belonging to 31 families (excluding variants of the same species) are grown in China. However, of these, 80 to 90 are more popular species grown on a commercial basis. National-level data for individual vegetables are reported on 24 vegetables for only few years; these vegetables are grown on about two-thirds of the total vegetable area in the country. More than 83% of that area is devoted to the 15 most important vegetables. Regional distribution data for these 15 vegetables (Table 2) show that there is wide variation in yield across regions.

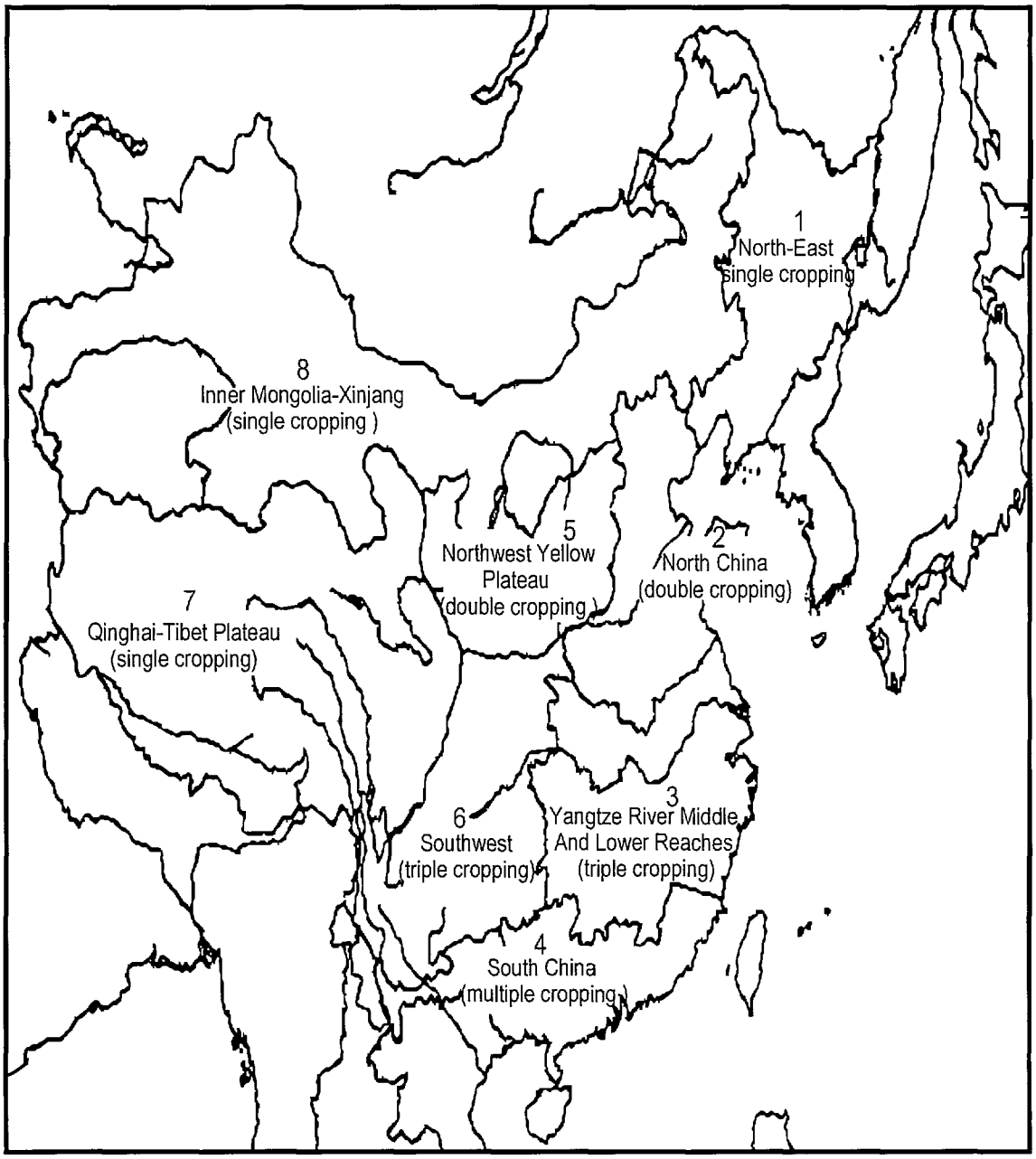


Fig. 1. Ecoregional map of China

Table 2. Regional share in vegetable area, production, and yield of major vegetables, 1991

Species	Province	Cropped area (000 ha)	Share of total growing area (%)		Production (000 t)	Share of total production (%)		Yield (t/ha)
			Individual vegetable	All vegetables		Individual vegetable	All vegetables	
Chinese cabbage	National	605.90		13.53	35780.00		24.33	59.05
	Shandong	79.33	13.09	1.77	7640.00	21.35	5.20	96.31
	Hebei	93.61	15.45	2.09	6266.50	17.51	4.26	66.94
	Henan	80.00	13.20	1.79	4320.00	12.07	2.94	54.00
	Sichuan	69.13	11.41	1.54	2753.60	7.69	1.87	39.82
	Heilongjiang	70.10	11.57	1.57	2499.30	6.99	1.70	35.65
Potato	National	574.40		12.83	9380.00		6.38	16.33
	Shaanxi	123.33	21.47	2.75	2100.00	22.38	1.43	17.03
	Heilongjiang	60.27	10.49	1.35	1397.30	14.89	0.95	23.18
	Neimenggu	70.06	12.20	1.56	877.10	9.35	0.60	12.52
Radish	National	326.19		7.29	12872.93		8.75	39.46
	Sichuan	78.71	24.13	1.76	3126.00	24.28	2.13	39.72
	Henan	46.67	14.31	1.04	2100.00	16.31	1.43	45.00
Garlic	National	295.41		6.60	4973.36		3.38	16.84
	Shandong	66.85	22.63	1.49	1100.00	22.12	0.75	16.45
	Jiangsu	46.67	15.80	1.04	900.00	18.10	0.61	19.28
	Henan	37.33	12.64	0.83	616.00	12.39	0.42	16.50
	Shaanxi	36.67	12.41	0.82	600.00	12.06	0.41	16.36
	Anhui	30.00	10.16	0.67	490.00	9.85	0.33	16.33
Pakchoi	National	249.97		5.58	7386.14		5.02	29.55
	Jiangsu	80.00	32.00	1.79	2300.00	31.14	1.56	28.75
	Hubei	36.36	14.55	0.81	904.50	12.25	0.62	24.88
	Zhejiang	30.67	12.27	0.69	841.80	11.40	0.57	27.45
Cabbage	National	241.51		5.39	8688.78		5.91	35.98
	Sichuan	70.53	29.21	1.58	2730.00	31.42	1.86	38.71
	Hubei	29.63	12.27	0.66	731.80	8.42	0.50	24.70
Chili	National	238.74		5.33	4598.44		3.13	19.26
	Hubei	36.19	15.16	0.81	836.30	18.19	0.57	23.11
	Sichuan	49.93	20.91	1.12	759.00	16.51	0.52	15.20
	Henan	18.67	19.61	0.42	280.00	6.09	0.19	15.00
Tomato	National	216.79		4.84	8376.22		5.70	38.64
	Shandong	33.85	15.61	0.76	1863.20	22.24	1.27	55.04
	Henan	26.67	12.30	0.60	1040.00	12.42	0.71	39.00
	Sichuan	23.80	10.98	0.53	703.00	8.39	0.48	29.54

Contd. Table 2.

Species	Province	Cropped area (000 ha)	Share of total growing area (%)		Production (000 t)	Share of total production (%)		Yield (t/ha)
			Individual vegetable	All vegetables		Individual vegetable	All vegetables	
Cucumber	National	194.18		4.34	7580.00		5.16	39.04
	Shandong	33.91	17.46	0.76	1629.30	21.50	1.11	48.05
	Henan	22.67	11.68	0.51	1360.00	17.94	0.92	60.00
	Hebei	21.50	11.07	0.48	449.20	5.93	0.34	20.89
Eggplant	National	174.08		3.89	5787.33		3.94	33.25
	Shandong	30.66	17.61	0.68	1521.10	26.28	1.03	49.61
	Sichuan	29.00	16.66	0.65	700.40	12.10	0.48	24.15
	Heilongjiang	16.14	9.27	0.36	411.40	7.11	0.28	25.49
Green Chinese onion	National	157.48		3.52	5636.67		3.83	35.79
	Shandong	53.55	34.00	1.20	2357.70	41.83	1.60	44.03
	Hebei	18.45	11.72	0.41	740.40	13.14	0.50	40.13
	Hubei	18.14	11.52	0.41	531.80	9.44	0.36	29.32
	Henan	15.33	9.74	0.34	529.00	9.39	0.36	34.51
Spinach	National	129.69		2.90	3206.57		2.18	24.72
	Hubei	21.30	16.42	0.48	178.80	5.58	0.12	8.39
	Hebei	15.14	11.67	0.34	469.70	14.65	0.32	31.02
	Henan	13.33	10.28	0.30	280.00	8.73	0.19	21.00
	Jiangsu	12.00	9.25	0.27	370.00	11.54	0.25	30.83
Celery	National	125.18		2.80	5427.64		3.69	43.36
	Shandong	24.80	19.81	0.55	1503.00	27.69	1.02	60.60
	Henan	20.00	15.98	0.45	930.00	17.14	0.63	46.50
	Sichuan	16.80	13.42	0.38	564.00	10.39	0.38	33.57
	Jiangsu	13.33	10.65	0.30	370.00	6.82	0.25	27.76
	Hebei	11.63	9.29	0.26	650.20	11.98	0.44	55.91
Chinese chive	National	105.28		2.35	3752.25		2.55	35.64
	Shandong	26.68	25.34	0.60	1006.20	26.82	0.68	37.71
	Hebei	14.68	13.94	0.33	708.30	18.88	0.48	48.25
	Jiangsu	13.33	12.66	0.30	600.00	15.99	0.41	45.01
Mustard	National	96.39		2.15	3301.61		2.25	34.25
	Sichuan	32.80	34.03	0.73	1007.00	30.50	0.68	30.70
	Zhejiang	13.33	13.83	0.30	600.00	18.17	0.41	45.01
	Yunnan	10.40	10.79	0.23	390.00	11.81	0.27	37.50
	Hubei	9.04	9.39	0.20	302.30	9.16	0.21	33.44

Source: Ministry of Agriculture (1993). Total production figures from FAO (1993).

Cultivation Time

Vegetables are grown at different times of the year in different ecoregions (Table 3). Therefore, if adequate transportation infrastructure is available, and local production is surplus to local demand, many vegetables could be supplied to the whole country all year round.

Table 3. Cultivation and harvest times of major vegetables, by region

Vegetables	Cultivation months	Harvesting months	Ecoregions
Chinese cabbage*	July	October	1, 7, 8
	August	November	2, 5
	August–September	November–January	3, 6
	September–October	December–February	4
Cabbage	June	October	7, 8
	April–May	June–July	1
	March–April	May–June	2, 5
	November–December	April	3, 6
	October–November	January–March	4
	June–August	October–December	1, 2, 5, 6
Tomato	May	July–August	1, 7, 8
	April	June–July	2, 5
	March–April	May–June	3, 6
	February–March	April–May	4
	October–December	December–February	4
Cucumber	May	June–August	1, 7, 8
	April	May–July	2, 5
	March–April	April–July	3, 6
	February–March	March–June	4
	December–February	January–March	4
	June–July	August–October	2, 5
	July–September	September–November	4
Green onion	June–July	October	1
	June	October–November	2, 5, 8
Garlic*	March	September	7
	April	July–August	1, 8
	March or October	May–June	2, 5
	September	May	3
Spinach*	February–April	March–June	1, 7, 8, 2, 3, 5
	August–September	September–November	1, 2
	August–December	October–February	4, 3
Potato*	May	August–October	1, 5, 6, 7, 8, 2
	February–March	May–July	2, 3, 4
	August	October–December	2, 3
	November–January	January–March	4

* Time of sowing seed; all others are transplanting times.
Source: Senior author's experience.

Developments in Vegetable Production

Change in Policy

Like any other production system in China, the vegetable production and sales system has faced three transitions since the founding of the People's Republic of China in 1949:

- a change from uncontrolled vegetable production to planned production and sales (1950–1977)
- a change from planned vegetable production to the family responsibility (partially controlled) system (1978–1984)
- a change from partially controlled vegetable pricing to market pricing (since 1984).

Before the creation of the People's Republic of China, decisions on vegetable production and sales were made by farmers themselves, based on economic factors. Farmers and farming collective units sold the vegetables they produced to consumers and peddlers. In 1953, state organizations began involving themselves in the management of all aspects of the vegetable business, including collective and private units. From this date until 1977, the policy was one of "planned planting and planned sale"; planting area, variety and species, planting layout and rotation, and sale time, quantity and price were controlled by the government through the commune management. Transportation between production and sale points in the cities was taken care of by the national government. The general work guideline was to "decide sales based on surplus over consumption in the commune". The Ministry of Agriculture was responsible for decisions related to production, and the Ministry of Commerce was in charge of commercial activities through state vegetable companies, from the central government down to the commune. Nationwide production bases were established at the commune and so-called brigade levels. All vegetable products had to be sold to state vegetable shops in the cities.

Beginning in 1978, a family responsibility system (FRS) was instituted by which farm lands were contracted and leased. Farmers had their own plots, and could produce what they chose. Free markets were allowed to reopen. The FRS vegetable production policy was to control major varieties, but to free up others. The state shops controlled 60–80% of the vegetable business involving major varieties in the big cities. The rest went to free markets for sale. Vegetable production was decided according to a central plan. But within this plan, decisions on what species and varieties to plant, their rotations, and the time and quantity to sell were made and adjusted by the farmers. Until 1984, local governments set seasonal prices to protect consumer interests. Beginning in 1984, the fixed (planned) prices were gradually replaced by market prices in the big cities. And since the early 1990s, the prices of all vegetables in China have been determined by the market. This followed a series of other reforms, such as construction of markets and a shift from the state monopolized market system to a system of multiple dealers, including state, collective, and private companies.

These reforms since 1979 facilitated rapid progress in vegetable production in China. The application of science and technology in vegetable production has been greatly improved. The following are the major changes that have occurred due to reforms in China's agricultural system.

Expansion of Protected Cultivation

After the vegetable production and sale system in China was reformed in 1984, the area of vegetable

production under some form of protection increased from about 31,000 ha to almost 159,000 ha in 1991 (Table 4). The most dramatic increase was in greenhouse cultivation, due mainly to the extension of solar greenhouses, which are covered with straw matting and monochinal (one side exposed) roof (Fig. 2). Even so, compared with the total vegetable growing area, the protected area is still very small, accounting for 4.8% of total vegetable planting area. However, there is great potential for this technology to expand, because yields per unit area under protective cover can be double those in open fields, and economic returns can be double or quadruple. Especially in regions where temperatures are low and winters are long, protected cultivation has played a key role in supplying vegetables in the winter. The best zone for the expansion of protected vegetable cultivation in China is the mid-lower plain of the Yellow River (32–37° N), which has suitable soils, convenient transportation, intense sunshine and heat resources, and milder winters.

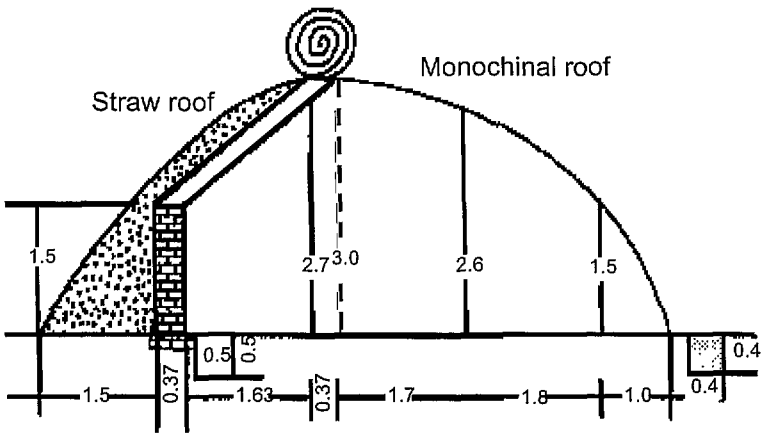


Fig. 2. Solar greenhouse covered with monochinal and straw roof (dimensions in meters)

Table 4. Development of protected and mulched vegetable cultivation area, 1984-91

Year	Protected area (000 ha)				Mulched area (000 ha)	
	Greenhouse	Large plastic booth	Medium & small plastic booth	Total area	Area	Percentage of total vegetable planting area
1984	2.27	6.53	22.52	31.32	89.25	2.10
1985	4.49	9.13	33.20	46.82	99.61	2.10
1986	7.95	12.96	47.46	68.37	140.00	2.64
1987	12.92	19.22	69.19	101.33	283.07	5.08
1988	15.42	22.53	79.01	116.96	262.56	4.35
1989	19.70	24.79	88.32	132.81	275.93	4.39
1990	25.47	27.99	85.79	139.25	256.16	3.88
1991	30.47	30.27	98.21	158.95	344.57	4.98

Source: Ministry of Agriculture (1991).

Plastic Mulch Technology

Plastic film mulch was introduced from Japan to China in 1979, and extension of this technology to

large areas began in 1981. Within 10 years the technology was being used on nearly 350,000 ha, or about 5% of the total area planted to vegetables (Table 4). Use of this technique enabled field vegetables to be harvested 10–20 days earlier than before, and resulted in a 20% increase in yields and improved income from vegetable cultivation. It also helped to improve year-round vegetable supply, and smoothed seasonality.

Shading Nets

Shading net technology was developed in the early 1980s, and was first applied to vegetable production in China on a large scale in 1987. By 1992 30 million m^2 of nets was being used on 12,000 ha of vegetable growing area. Shading nets can improve vegetable yields and quality by preventing damage from high temperatures, thunderstorms, hail, typhoons, diseases, and pests. The use of nets has tremendous potential in the southern regions in the summer and fall, but the technique can also be applied in the intensive management areas of northern China for seedling nurseries in the summer, for plastic mulch booths in the fall, for high-value vegetable cultivation, and for seed collection.

Breeding Research

National projects on heterosis and resistance breeding were established in the 1960s. Four hundred superior F_1 hybrids of 20 vegetable species have been released and are now being grown on 267,000 ha. In 1983, a national scientific breakthrough project on vegetable breeding was implemented and coordinated by the Institute of Vegetables and Flowers (IVF) and the Chinese Academy of Agricultural Sciences (CAAS); 200 breeders and pathologists from 20 institutions were involved. Thirty thousand accessions of germplasm have been collected and 121 new cultivars with desired characteristics are being grown on 635,000 ha. Today, F_1 hybrids are grown on 60% of the tomato area, 85% of the cabbage area, 80% of the Chinese cabbage area, 80% of the cucumber area, and 60% of the chili area. Substitution of new varieties has been speeded up. Seedling cultivation has become much more intensive and has been commercialized with the help of electrical heating systems.

Trend Analysis

Area and Production

The reforms described above encouraged vegetable cultivation in China, and there were spectacular expansions in area planted and total yield (Table 5). Average yields have remained more or less static at about 15–17 t/ha.

Table 5. Trends in vegetable production, 1980–1993

Year	Cropped area (000 ha)	Total production (000 t)
1980	5161.8	83000
1981	5297.5	81687
1982	5436.7	83021
1983	5579.5	85938
1984	5726.2	93213

Contd. Table 5.

Year	Cropped area (000 ha)	Total production (000 t)
1985	5876.7	99501
1986	6031.1	104771
1987	6189.6	109963
1988	6030.5	112656
1989	6290.4	114337
1990	6690.5	116524
1991	7142.0	118207
1992	7624.1	119786
1993	8138.6	125509

Source: The total vegetable area for 1980, 1988, 1989, 1990, and 1993 was taken from State Statistical Bureau (1993). For other years, it was extrapolated using a linear trend. The total vegetable production for all years was taken from FAO (various issues 1980–93).

The relative importance of vegetables changes over time (Table 6). The growing area and production of traditionally popular vegetables, such as Chinese cabbage, mustard, and radish, have stabilized or have even decreased, while those of other, highly nutritious but previously unpopular vegetables, such as carrots, Chinese chives, and lettuce, have greatly increased. In addition, production of garlic, chili (dried), and onions, which are important items for export, is increasing fast. Asparagus production has been stymied by asparagus root rot.

Table 6. Area , production , and yield of major vegetables, 1989–91

Category	Area (000 ha)			Production (000 t)			Yield (t/ha)		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
Asparagus	56.7	24.3	24.7	1,325	420	505	23.3	17.3	20.4
Broccoli	65.0	122.8	94.5	1,608	2,383	2,486	24.7	19.4	26.3
C. cabbage	631.7	619.7	605.9	33,609	33,548	35,781	53.2	57.4	59.1
C. chive	80.2	90.3	105.3	2,245	3,059	3,752	28.0	33.9	35.6
Cabbage	209.3	233.9	241.5	7,082	8,436	8,689	33.8	36.0	36.0
Carrot	65.3	98.3	109.7	1,723	2,960	3,033	26.4	30.1	27.6
Celery	97.3	120.0	125.2	3,806	5,109	5,428	39.1	42.6	43.4
Chili	198.4	251.5	238.7	3,402	4,801	4,598	17.1	19.1	19.3
Cowpea	97.2	106.2	110.9	2,360	2,589	2,698	24.3	24.4	24.3
Cucumber	158.7	175.4	194.2	6,129	7,204	7,580	38.6	41.1	39.0
Eggplant	145.7	155.9	174.1	4,165	5,110	5,787	28.6	32.8	33.2
Garlic	235.4	258.1	295.4	4,220	4,389	4,973	17.9	17.0	16.8
Green C. onion	114.7	114.3	157.5	3,598	3,475	5,637	30.5	30.4	35.8
Lettuce	86.6	100.9	111.4	2,277	2,844	3,155	26.3	28.2	28.3
Mustard	100.3	95.4	96.4	2,847	3,161	3,302	28.4	33.1	34.3
Onion	43.9	58.9	61.4	1,195	1,677	1,811	27.2	28.4	29.5
Pakchoi	222.1	247.1	249.9	4,585	6,942	7,386	24.7	28.1	29.6
Pepper	82.8	88.6	87.1	2,349	2,338	2,371	28.4	26.4	27.2
Potato	528.1	700.0	544.4	5,170	9,443	9,380	29.8	12.8	16.3

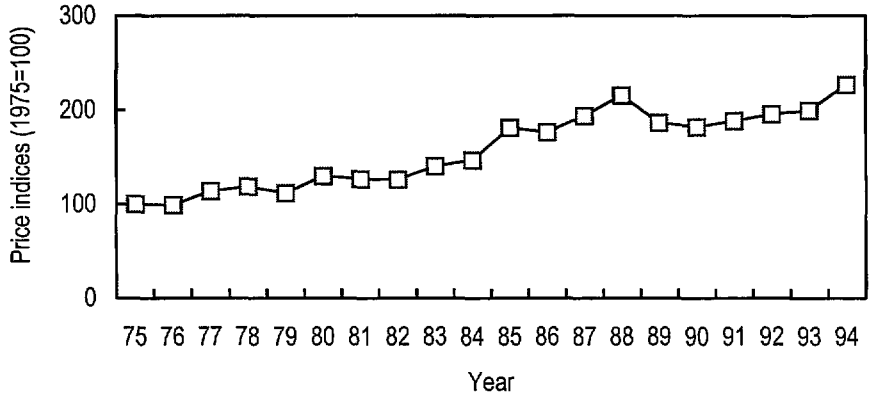
Contd. Table 6.

Category	Area			Production			Yield		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
Radish	303.0	322.5	326.2	11,145	17,152	12,872	36.8	53.2	39.5
Snap bean	111.8	112.7	122.3	2,461	2,443	2,605	22.0	21.7	21.3
Spinach	98.7	122.8	129.7	2,256	2,815	3,206	22.9	22.9	24.7
Squash	41.7	52.0	54.0	1,119	1,534	1,615	26.9	29.5	29.9
Tomato	188.7	240.1	216.8	6,836	7,677	8,376	36.2	37.6	38.6

Source: Ministry of Agriculture (1993).

Prices

Despite the huge increase in vegetable production between 1975 and 1994, there has been a large increase in real retail prices (defined as the nominal prices divided by the consumer price index CPI) of vegetables (Fig. 3). This indicates a strong pressure on the retail prices of vegetables, more than that on other consumer items. Real retail prices of vegetables have increased by an average of 4.28% per year. This increase might partly be due to privatization of the vegetable marketing system; marketing margins are now added to the producers' price, which was not the case in the government-controlled system.

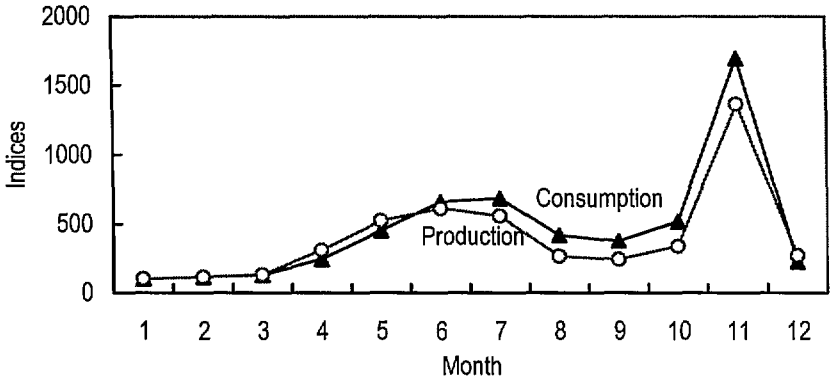


Source: State Statistical Bureau (1995).

Fig. 3. Trend in the real retail prices (nominal prices divided by CPI) of vegetables in China, 1975–94

Seasonality in Vegetables

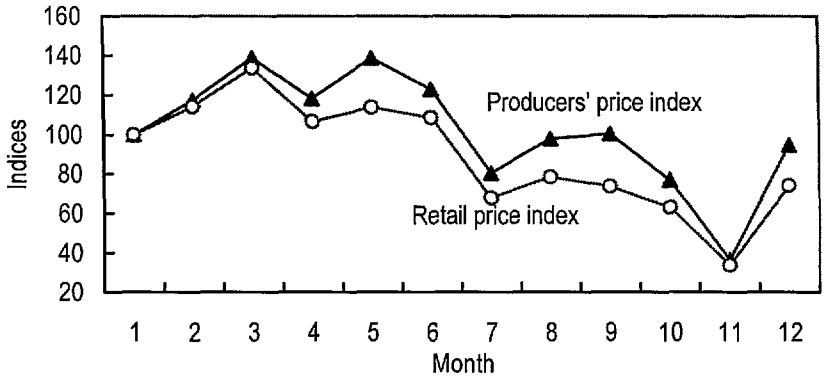
National-level data on monthly production, consumption, and prices of vegetables are not available to the authors. However, data for Beijing city indicate a strong seasonal pattern in vegetable production and consumption (Fig. 4). Actually, more than 25% of the annual vegetable production and consumption occurs in November, and only 2% in each month from January to March. This suggests that although annual vegetable production in China looks sufficient to meet the regional consumption level, production is below the required level during certain months.



Source: Official files of the Agriculture Bureau, Beijing.

Fig. 4. Seasonality in vegetable production and consumption in Beijing (average of 1987-88 and 1992-93)

Corresponding to seasonality in production and consumption, there is also strong seasonality in vegetable prices (Fig. 5). Average monthly prices of all vegetables are highest between January and June, and lowest during November. The weighted price index during the off-season can rise 3–4 times compared to that in the peak supply period.



Source: Official files of the Agriculture Bureau, Beijing.

Fig. 5. Seasonality in vegetable prices in Beijing (average 1987–93)

The overall seasonal pattern is, however, shaped by the seasonality in individual vegetables (Fig. 6). For example, the price of Chinese cabbage and radish is high between May and September, whereas prices of other vegetables are generally low in May and June. Chinese cabbage and radish are major vegetables in China (Table 2), so the seasonal pattern of these two vegetables influences the seasonal price pattern of all vegetables. Looking at the price of individual vegetable types, the off-season prices can be five to six times higher than those in the peak period.

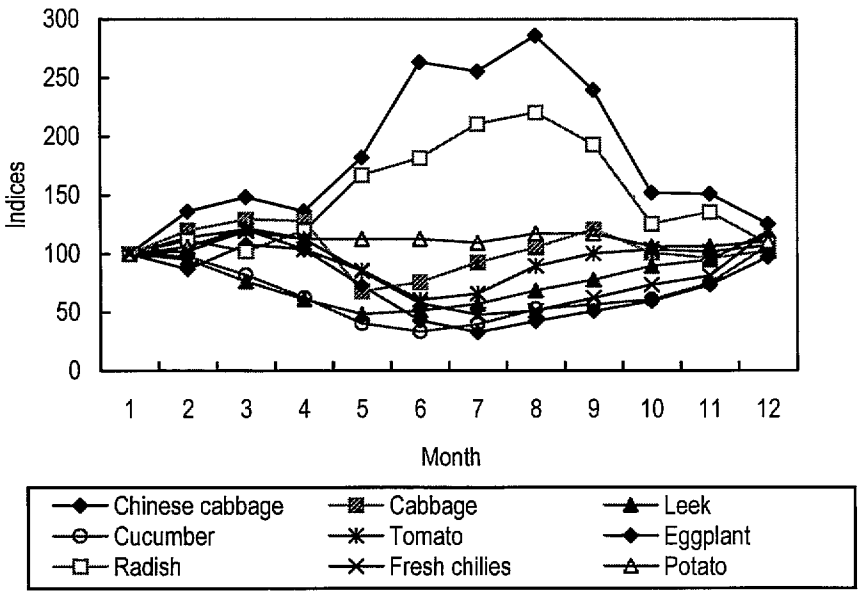


Fig. 6. Seasonality in prices of individual vegetable in Beijing (average of 1993–94)

Based on the monthly availability of vegetables in Beijing, the seasonal pattern of vegetable consumption in the city, especially during the peak supply period, has smoothed out since 1985–87. This is because supplies from more efficient producing areas have replaced peri-urban supplies. During 1985–89, 60–100% of the city's requirement was fulfilled by the peri-urban system; by 1992–93 this share had fallen to 10–60% (Fig. 7). Actually, the peri-urban production system in Beijing was producing more than the city required during the peak supply period, and could thus export the surplus to other cities and regions. The area devoted to growing vegetables in the Beijing suburbs declined from 15,300 ha in 1984 to 11,270 ha in 1993, and production shrank from 90,700 t in 1985 to 85,400 t in 1993. However, total consumption of vegetables in the city has increased as the low peri-urban production has been supplemented by supplies from outside. This trend should continue in the coming years.

Today, every big city and industrial center gets vegetables from different sources, such as:

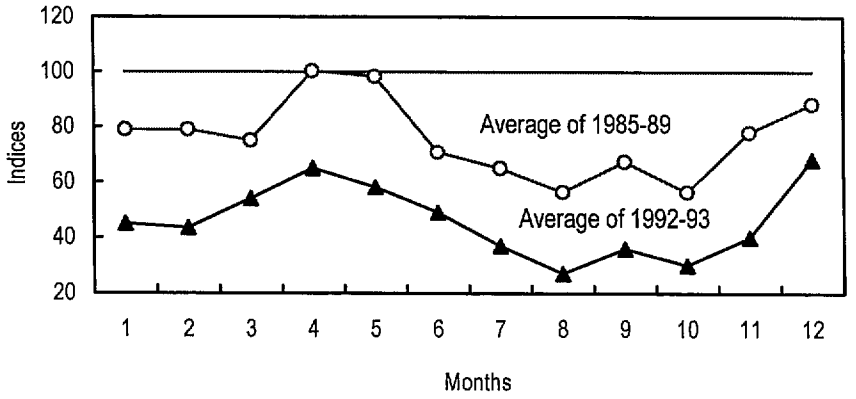
- suburbs producing high-value and fine vegetables during the winter and early spring
- outer suburbs growing popular vegetables
- field crop areas supplying off-season vegetables for the slack season.

A nationwide distribution of five commercial vegetable production zones has emerged. These zones are:

- Tangshan and Shandong for Chinese cabbage
- Guandong, Yunnan, Sichuan, Fujian, and Guangxi for winter supply

- Wan Huai region for vegetables in the spring slack period
- Zhangjiakou for vegetables in the late summer slack period in the highlands
- the Hexi Corridor of the north-west for supply from the east to the west in the late summer slack time.

These five production bases handle 6–8 million t of vegetables annually, and so have played an important role in the supply of vegetables to big cities.



Source: Official files of the Agriculture Bureau, Beijing

Fig. 7. Overall comparison of the share of the Beijing peri-urban system in the total consumption of the city

Economics of Vegetable Cultivation

Input Use

Wide variations in input use for vegetable growing are observed across different regions. Some regional and national data are shown in Table 7. In general, fertilizer, pesticide, and labor inputs for vegetable growing in field conditions are much higher than for rice cultivation. Vegetable production requires much less seed than rice production, but vegetable seeds are more expensive than rice seed, so a large proportion of a farmer's total costs goes to buying seeds. Large quantities of plastic sheeting are used in the cultivation of most vegetables, and more than is used in rice production. The demand for plastic sheets in China has increased dramatically as vegetable production has shifted to shed cultivation. The data presented for cucumber and tomato growing show that growing vegetables in sheds requires far more fertilizer, pesticides, and labor, but less seed, than field cultivation.

Table 7. Input use in vegetables and rice, nationally and by region, 1994

Crop	Region	Number of farmers sampled	Surveyed area (ha)	Seed (kg/ha)	Labor (days/ha)	Plastics (kg/ha)	Fertilizer (kg/ha)	Pesticide (Y/ha)
Cabbage	National	94	21.6	3.2	719	113	211	249
	Beijing	5	11.2	5.0	583	1212	81	159
	Dalian	8	7.2	NA	616	93	268	324
Cauliflower	National	51	5.4	1.4	786	23	370	432
	Beijing	9	3.6	2.0	431	317	173	246
	Hefei	5	0.1	NA	888	0	129	750
Celery	National	37	1.6	15.0	1101	29	470	520
	Dalian	3	0.5	15.0	566	75	296	225
	Xian	6	0.2	NA	1043	0	117	240
Chinese cabbage	National	126	65.5	4.5	654	1	347	56
	Beijing	14	29.1	3.8	500	0	172	NA
	Tianjin	41	7.5	4.8	486	0	351	NA
	Dalian	8	16.7	4.0	356	0	403	NA
Cucumber (shed)	National	42	9.6	2.6	1844	903	506	7502
	Beijing	5	3.5	3.9	1187	1746	229	8433
	Changchun	4	4.5	1.5	1550	348	357	2906
Cucumber	National	80	24.0	6.0	1149	253	273	521
	Beijing	10	8.5	5.4	715	984	183	386
	Dalian	8	12.8	NA	745	54	472	590
Eggplant	National	58	22.5	3.0	975	199	199	354
	Changchun	4	1.3	0.8	555	126	104	75
	Harbin	6	0.9	1.5	1202	75	43	361
Tomato (shed)	National	59	14.6	1.2	2118	789	587	6735
	Beijing	8	8.8	0.8	1071	1898	108	10658
	Tianjin	18	1.6	1.0	1731	833	274	6673
Tomato	National	78	6.4	2.5	1286	138	273	533
	Beijing	5	2.1	2.4	823	554	239	660
	Tianjin	28	1.9	1.5	1166	131	314	345
Early Indica	National	828	213.5	122.7	261	5	258	109
	Fujian	94	19.2	115.7	260	9	319	181
	Guangdong	284	66.2	66.2	246	4	245	153
Middle Indica	National	866	185.0	45.7	290	2	214	93
	Hubei	146	50.6	43.0	278	2	255	105
	Sichuan	427	63.1	62.3	377	7	169	106

NA = data are not available.
Source: Based on unpublished cost and production survey data from the State Price Bureau.

Experimental studies in various regions have also confirmed the high input intensity in vegetable production (Table 8). The estimates of labor use derived from these studies are lower than those reported in Table 7, probably because some of the operations on the experimental farms were mechanized, but vegetable production is still shown to be more labor intensive than rice production. Fertilizer use in these experiments is even higher than that reported in the farm-level studies, and large quantities of farmyard manure are also used. However, yields under model cultivation are very high, indicating a potential for yield improvement.

Table 8. Review of input use for major vegetables from studies in China

Vegetable studied	Region*	Yield (t/ha)	Input use (per ha)					Reference
			Manure (t)	Fertilizer (kg)	Pesticide (yuan)	Labor (days)	Seed (kg)	
Carrot	3, 4	50	50	450	750	350	12	Lu 1991
Cauliflower	5, 7	30	30	700	1200	450	3	Sheng, et al. 1994
Cucumber	5, 7	100	150	900	3000	700	3	Wang & Yuan 1991
Pakchoi	1, 2	100	75	750	1500	450	3	Liu 1991
Pepper	2, 4	75	75	900	3000	500	2	Guo 1991
Tomato	2, 5	90	90	900	3000	600	0.75	Gu 1991b

* The region numbering is the same as specified in Table 1.

Labor absorbs the greatest share of the total cost of vegetable production, so it is interesting to examine the labor requirements of various farm operations (Table 9). Although variation exists among crops and across regions for the same crop, generally the relative share of plowing, harvesting, and seeding labor in vegetable cultivation is lower than that in rice. Labor requirements for fertilizer and irrigation application are similar while marketing labor in China is much higher for vegetables than for rice. The share of other labor, which includes field and pre-product management, processing, manure application, etc., is also higher for most vegetables than for rice.

Table 9. Share (%) of different operations in the total labor use in vegetables and rice, 1994

Crop	Region	Plowing	Seeding	Fertilizer	Irrigation	Harvesting	Marketing	Others
Cabbage	National	9.9	10.8	11.1	9.0	17.5	18.1	23.5
	Beijing	2.1	1.5	2.9	5.3	23.8	10.6	53.9
	Dalian	10.9	10.7	8.6	12.5	17.9	6.0	33.4
Cauliflower	National	12.6	10.3	12.8	8.9	12.0	17.9	25.6
	Beijing	6.5	3.9	4.9	9.5	13.7	18.6	42.9
	Hefei	14.1	3.6	10.7	17.6	14.1	21.2	19.1
Celery	National	9.1	13.8	6.4	9.4	20.7	24.5	16.1
	Dalian	15.9	12.0	7.2	12.0	14.7	7.2	31.1
	Xian	8.2	7.2	5.8	9.7	16.1	37.3	15.8

Contd. Table 9.

Crop	Region	Plowing	Seeding	Fertilizer	Irrigation	Harvesting	Marketing	Others
Chinese cabbage	National	10.4	7.3	9.5	11.0	16.4	22.5	23.1
	Beijing	6.0	4.2	7.4	23.0	8.8	10.4	40.0
	Tianjin	11.1	7.4	6.2	9.9	17.9	15.4	32.1
	Dalian	7.9	7.3	11.2	18.3	17.1	8.4	29.8
Cucumber (shed)	National	8.1	7.5	6.2	8.0	17.7	17.7	34.8
	Beijing	3.8	1.3	3.9	6.3	19.5	18.3	46.8
	Changchun	12.5	11.2	6.4	4.1	18.8	10.3	36.7
Cucumber	National	9.4	6.8	9.4	7.1	15.3	19.7	32.3
	Beijing	3.9	3.5	2.8	5.7	19.7	15.4	49.0
	Dalian	12.5	11.8	6.2	11.7	23.9	5.8	28.1
Eggplant	National	11.0	8.0	10.1	5.6	20.1	19.8	25.4
	Changchun	8.5	12.6	8.5	0.9	21.1	20.2	28.3
	Harbin	7.0	12.5	6.8	0.0	32.7	13.2	27.8
Tomato (shed)	National	8.5	9.0	7.6	6.8	14.7	14.7	38.8
	Beijing	3.8	3.1	3.5	8.2	13.6	12.5	55.2
	Tianjin	14.4	11.7	3.4	3.2	16.6	11.4	39.5
Tomato	National	10.3	6.7	7.5	5.1	16.9	26.7	26.9
	Beijing	8.1	1.6	3.0	5.8	7.9	32.4	40.9
	Tianjin	10.3	11.2	3.0	5.7	19.5	15.7	34.7
Early Indica	National	14.6	19.5	6.1	6.5	26.4	2.5	24.5
	Fujian	16.2	18.5	6.2	7.7	23.8	1.8	25.8
	Guangdong	13.8	21.5	7.3	5.7	30.5	1.6	19.5
Middle Indica	National	14.5	21.4	5.2	6.9	28.3	2.1	21.0
	Hubei	12.9	18.3	5.4	8.3	20.5	4.0	30.9
	Sichuan	16.4	23.1	6.6	5.6	30.2	2.1	15.6

* Others include labor for field and pre-product management, processing, manure application, and other work.
Source: based on unpublished cost and production survey data conducted by State Price Bureau.

Factor Share

The structure of vegetable production costs varies for different vegetables and across regions (Table 10). For example, seed, manure, and fertilizer are major cost items in the cultivation of cabbage and cauliflower at the national level, while plastic costs are important when these crops are grown in Beijing. Also, plastic generally becomes a major cost item for vegetables grown under shed conditions. In celery growing, manure is always the single most expensive item, consuming more than two-thirds of the total cost. Fertilizer and manure are also important costs in Chinese cabbage growing. At the national level, seed, manure, fertilizer, and plastic are almost equally important cost items in cucumber, eggplant, and tomato under field conditions, although there are variations among regions.

Table 10. Factor share (%) in vegetable and rice production by region, 1994

Crop/Region	Seed	Manure	Fertilizer	Plastic	Pesticide	Draft	Machinery	Irrigation	Marketing	Other*
Cabbage										
National	19.0	21.4	17.1	7.9	5.6	2.9	2.1	4.0	7.3	12.7
Beijing	5.2	9.9	4.8	26.3	2.9	3.3	4.2	1.6	3.9	38.0
Dalian	26.9	16.0	11.1	9.6	3.5	0.1	3.4	5.5	18.2	5.7
Cauliflower										
National	15.5	22.9	28.2	1.9	8.4	1.6	0.6	4.9	5.0	10.9
Beijing	8.2	14.2	11.0	16.7	4.9	4.0	3.0	5.7	6.6	25.8
Hefei	16.7	44.6	11.2	0.0	16.7	0.0	0.0	4.8	0.0	6.0
Celery										
National	3.3	67.4	8.5	6.5	2.5	0.1	0.3	1.6	3.7	6.1
Dalian	3.8	63.6	6.3	3.4	1.2	0.6	0.7	3.7	13.3	3.3
Xian	3.9	71.3	3.2	1.6	1.7	1.0	0.0	3.2	3.5	10.6
Chinese cabbage										
National	6.8	15.6	29.7	1.3	8.5	5.7	2.0	7.0	8.9	14.5
Beijing	8.8	19.5	17.9	0.0	7.3	1.2	7.0	11.3	4.8	22.3
Tianjin	8.1	25.5	39.2	0.0	10.0	0.0	0.4	7.1	5.8	3.9
Dalian	8.1	20.0	15.3	0.0	8.3	0.1	3.3	11.6	26.8	6.6
Cucumber (shed)										
National	8.0	6.4	7.9	30.7	5.0	1.2	0.6	5.3	5.1	29.9
Beijing	12.3	4.1	3.1	35.8	2.8	2.2	0.8	0.5	9.8	28.7
Changchun	1.7	3.8	7.5	17.6	2.4	4.8	0.0	7.9	0.0	54.3
Cucumber										
National	13.2	15.5	12.8	15.0	6.4	1.7	2.9	2.7	2.8	27.0
Beijing	7.7	8.5	7.8	15.1	5.1	1.8	2.8	2.8	4.2	44.2
Dalian	26.9	15.0	15.0	4.5	5.5	0.1	3.8	6.3	10.4	12.5
Eggplant										
National	18.0	16.8	12.1	17.4	5.6	2.0	1.8	3.6	5.9	16.8
Changchun	1.7	3.6	5.2	6.0	1.0	12.8	4.3	3.2	0.0	62.2
Harbin	13.3	17.6	5.6	15.2	7.3	2.3	7.5	4.0	10.2	17.0
Tomato (shed)										
National	9.6	8.2	9.8	30.3	4.4	1.2	0.7	3.2	6.0	26.8
Beijing	4.6	4.4	1.8	45.9	2.2	1.6	1.3	1.1	7.9	29.3
Tianjin	6.8	15.0	6.2	38.8	9.4	0.0	0.0	1.9	1.1	20.8
Tomato										
National	12.8	13.6	13.8	15.3	7.0	1.2	0.6	2.8	8.0	25.0
Beijing	7.1	6.6	11.3	17.5	8.0	0.0	1.3	4.2	13.3	30.7
Tianjin	6.9	26.1	22.9	19.3	6.5	0.0	0.0	3.2	1.8	13.3

Contd. Table 10.

Crop/Region	Seed	Manure	Fertilizer	Plastic	Pesticide	Draft	Machinery	Irrigation	Marketing	Other*
Early Indica										
National	8.8	7.4	36.3	1.8	5.6	12.6	6.4	4.9	0.8	15.4
Fujian	9.0	3.3	40.6	3.0	8.4	10.6	6.3	1.9	0.8	16.1
Guangdong	6.2	4.6	39.7	1.6	7.0	9.6	11.1	4.0	0.5	15.6
Middle Indica										
National	9.5	6.4	34.2	1.0	5.3	15.3	4.8	7.5	1.0	15.0
Hubei	9.2	4.0	30.6	0.8	4.7	18.7	5.7	10.5	2.5	13.2
Sichuan	8.9	5.5	32.1	3.7	6.5	16.5	2.1	6.5	1.7	16.5

* Other includes costs for energy, repairing tools and equipment, pre-production and management, and other costs.
Source: based on unpublished cost and production survey data conducted by State Price Bureau.

The cost structure in vegetables contrasts with other field crops such as rice in many respects. For example, as shown above, fertilizer use in most vegetables is higher than in rice, but its relative share in the total cost is much lower in vegetables than in rice. The relative cost share for draft power and machinery is also generally higher for rice than vegetables. On the other hand, the relative shares of organic manure cost, of plastic (wherever it is used), and of marketing are generally higher in vegetables than in rice. The cost shares of pesticides in vegetable and rice are generally similar.

Costs and Returns

Vegetable cultivation is highly profitable in China (Table 11). Profitability in vegetables ranges from Y7340/ha for cabbage production in Dalian to more than Y54000/ha, the national average for tomato under sheds. By contrast, profitability in rice cultivation is never more than Y8000/ha. These large differences are due mainly to the very high yields per unit area achieved in vegetable cultivation. However, the production costs for vegetables are 2–10 times higher than those for rice, because of the high input intensity of vegetable cultivation. On the other hand, the benefit-cost ratios for vegetables are generally lower than those for cereal crops, partly because of the relatively high prices guaranteed by the government for cereals, and partly because of the high costs of vegetable cultivation. However, the production cost per kilogram is generally lower for vegetables than for rice. With few exceptions, vegetables generate higher returns per unit of labor when compared to early rice.

Profitability of Protected Peri-urban Cultivation in Beijing

In the Nanyuan township of Beijing, about half (665 ha) of the total cropped area in 1992 was devoted to vegetables, and about 18% of the vegetable area was under protected cultivation (eg., plastic sheeting). Total production from the protected cultivation reached 65,920 t and was worth Y26.2 million; net income was Y13.1 million. Some 3711 people worked in the production system.

Table 11. Economics of vegetable and rice cultivation by region, 1994

Crop	Region	Yield (t/ha)	Price (Y/kg)	Total revenue (Y/ha)	Total cost (Y/ha)	Net profit (Y/ha)	Benefit-cost ratio	Cost/kg (Y)	Profit per labor day (Y)
Cabbage	National	40.3	0.40	16310	4420	11890	2.7	1.10	16.5
	Beijing	42.2	0.36	15238	5436	9802	1.8	1.29	16.8
	Dalian	48.6	0.34	16681	9340	7340	0.8	1.92	11.9
Cauliflower	National	23.6	1.22	28903	5127	23776	4.6	2.17	30.2
	Beijing	28.8	0.65	18739	5061	13678	2.7	1.76	31.7
	Hefei	22.5	1.11	25000	4482	20519	4.6	1.99	23.1
Celery	National	51.7	0.88	45363	20436	24927	1.2	3.95	22.6
	Dalian	49.0	0.97	47719	18281	29438	1.6	3.73	52.0
	Xian	28.5	1.10	31262	14314	16948	1.2	5.01	16.2
C. Cabbage	National	57.6	0.34	19743	4453	15290	3.4	0.77	23.4
	Beijing	74.9	0.20	14667	3741	10926	2.9	0.50	21.9
	Tianjin	82.9	0.23	18978	3468	15511	4.5	0.42	31.9
	Dalian	77.2	0.26	20369	8391	11978	1.4	1.09	33.6
Cucumber	National	59.7	1.18	70759	24454	46305	1.9	4.10	25.1
(shed)	Beijing	57.7	0.87	50336	23534	26801	1.1	4.08	22.6
	Changchun	41.3	0.94	38716	16547	22169	1.3	4.00	14.3
Cucumber	National	40.5	0.69	27771	8116	19655	2.4	2.01	17.1
	Beijing	42.7	0.41	17455	7525	9930	1.3	1.76	13.9
	Dalian	30.7	0.84	25792	10828	14964	1.4	3.53	20.1
Eggplant	National	30.0	1.08	32298	6350	25949	4.1	2.12	26.6
	Changchun	26.5	0.58	15446	7519	7927	1.1	2.84	14.3
	Harbin	29.2	0.71	20604	4959	15645	3.2	1.70	13.0
Tomato	National	60.0	1.27	76402	22220	54183	2.4	3.71	25.6
(shed)	Beijing	60.3	1.09	65473	23246	42227	1.8	3.86	39.4
	Tianjin	50.9	1.14	58141	17175	40965	2.4	3.37	23.7
Tomato	National	45.9	0.87	40014	7617	32397	4.3	1.66	25.2
	Beijing	54.8	0.66	36237	8223	28015	3.4	1.50	34.0
	Tianjin	62.0	0.41	25279	5330	19949	3.7	0.86	17.1
Early Indica	National	5.4	1.20	6434	1932	4502	2.3	3.59	17.2
	Fujian	5.3	1.30	6976	2150	4827	2.2	4.02	18.6
	Guangdong	5.1	1.65	8340	2189	6151	2.8	4.32	25.0
Middle Indica	National	6.8	1.28	8742	1744	6998	4.0	2.56	24.1
	Hubei	8.2	1.24	10184	2221	7962	3.6	2.70	28.6
	Sichuan	7.0	1.30	9106	1622	7485	4.6	2.31	19.9

The free market price is estimated as the gross value (including by-products) divided by yield.
The government prices were slightly higher than the free market prices during 1994 in most cases. The gross revenues are estimated at the free market prices.
Source: based on unpublished cost and production data from a survey conducted by State Price Bureau.

An economic analysis of peri-urban vegetable production in Nanyuan township is shown in Table 12. Landholdings are generally small. Labor inputs in protected fields are about twice those in the other systems. Yields are enormous, especially from the protected field and mixed vegetable systems. Gross revenue, profit, and cost in protected cultivation are also higher than the national averages discussed previously for the open field. Gross income, cost, and net income range from Y75000 to 90,000/ha for vegetable cultivation under protection, compared to a range of Y15,000–30,000 for open-field production. However, net income per person is very similar in all three systems, at about Y3500.

Table 12. Economic analysis of vegetable production under different protection systems in Nanyuan township, Beijing

Field type	Area (ha/person)	Labor (person years/ha)	Yield (t/ha)	Gross income (Y/ha)	Cost (Y/ha)	Net income (Y/ha)	Net income (Y/person)
Open field (no protection)	0.151	4.65	55.44	28800	12600	16200	3484
Protected field	0.100	10.05	113.85	87000	51100	35900	3572
Mixed	0.139	5.55	99.20	39400	19600	19800	3568

Source: Senior author's survey in Beijing suburb.

Another study examined the costs and benefits of different vegetable production systems, and compared them with wheat production (Table 13). Vegetable cultivation costs were found to be about 40–70% higher, and the returns more than five times higher, than for wheat cultivation. The costs are highest in a heated greenhouse system; the profits are highest in a solar greenhouse system.

Table 13. Relative profitability of vegetable production under different production systems compared to wheat production (a case from northern China)

Production system	Cost relative to wheat	Net income (Y/ha)	Profit relative to wheat
Wheat	1	30,000	1.0
Open field vegetables	1.40	150,000	5.0
Plastic mulch vegetables	1.45	225,000	7.5
Plastic tunnel vegetables	1.55	300,000	10.0
Greenhouse (heated) vegetables	1.70	225,000	7.5
Greenhouse (solar) vegetables	1.60	450,000	15.0

Source: Senior author's survey in Beijing suburb.

Constraints in Vegetable Production

Yields of vegetables per hectare in China have stagnated. The economy is booming, so cities are expanding and major vegetable fields around suburbs are bound to be taken over for housing. There is therefore an urgent need to develop large new areas for vegetable cultivation. However, newly developed vegetable fields lack the necessary infrastructure and related technology. Therefore, they are more at risk from climate, natural disaster, and changing markets.

Lack of transportation infrastructure (such as suitable packaging materials, pre treatment facilities, cold storage, freezers, and refrigerated vans) is a serious constraint. Middle- and long-range transportation of vegetables is mostly by train, but large quantities of vegetables overload the system, causing long delays, and produce even rots at stations.

With the advent of protected cultivation, specialized production, and an increase in the exchange of seeds and seedlings among regions, vegetable pests and diseases are increasingly a serious problem.

Pollution caused by misuse of chemicals in vegetable production is becoming a serious problem. Producers, consumers, and policy makers need to focus on encouraging integrated pest management (IPM) and the judicious use of chemicals.

Production constraints for different vegetables were investigated and the results are presented in Table 14. Disease is a serious problem for pakchoi, potato, cucumber, tomato, pepper, and mustard. Climatic stresses are important for pakchoi, petsai, and pepper, while lack of high quality seeds is a critical constraint to potato, chive, and green onion production.

Table 14. Review of production constraints of major vegetables by region

Vegetable studied	Region	Vegetable production constraints						Reference
		disease	pests	climatic stresses	post-harvest loss	weeds	non-availability of good quality seed	
Cabbage	3, 2, 5	*	**	*	*	*	*	Fang 1991
Celery	2, 3	**	*	*	*	**	*	Lu 1989
Chive	2, 3, 1	**	**	*	*	***	**	Wang 1986
Cucumber	2,1,3	***	**	**	**	*	*	Wang 1991
Eggplant	2, 3, 1	**	**	*	*	*	*	Wu 1982
Garlic	2, 3, 5	*	**	*	*	**	*	Gu 1991b
Green onion	2, 3, 1	*	*	**	*	**	***	Chen 1987
Mustard	3	***	**	*	*	*	*	Jian 1989
Pakchoi	1, 2, 6	***	*	***	**	*	*	Liu 1991
Pepper	3, 2, 4	***	**	***	**	*	*	Guo 1991
Petsai	3, 2, 4	**	***	***	*	**	*	Wang 1990a
Potato	1, 2, 6	***	*	*	***	*	***	Qu 1990
Radish	3, 2	**	**	**	*	*	*	Wang 1990b
Spinach	2, 3, 5, 1	**	*	**	*	*	*	Zhang 1988
Tomato	2, 6, 3	***	*	*	**	*	*	Gu 1991a

Three stars indicate most serious problem. Region numbers are the same as shown in Table 1.

Marketing System

Vegetable marketing has been changing dramatically since 1979 when market reforms were initiated. The most important change has been the explosion of free markets. At the beginning of the reforms, there were just under 39,000 free markets in China. By 1990 the number had increased to more than

72,000, and over the same period the volume of business through these free markets increased 11-fold. Free markets accounted for only one-tenth of the total volume of retail sales in 1979, but for one-fifth by 1991. Vegetable farmers sold up to 50% of their produce in the free market in 1991, up from 15% in 1979. Now all vegetables supplied to consumers are from free markets, except in some parts of Beijing, Tianjing, and Shanghai. Business in China is shifting from being predominantly retail to a combination of retail and wholesale. Wholesale free markets owned by the state or collectives have been established for vegetables and fruit. In 1993, about 400 wholesale markets were set up and won a 40% share (by volume) of domestic trade at the national level; in the big cities, their share was 60–70%. At the same time, some state-owned shops have been leased to cooperatives or individuals. The number of vegetable peddlers has greatly increased.

Marketing Channels

In China today there are several channels for bringing fresh vegetables from farmers to consumers.

Direct sale – farmers sell their produce directly to consumers. This channel dominates at the township and county level (small and medium-size cities) and accounts for about 15% of national consumption.

Farmers' cooperative – farmers' cooperatives→wholesale market→retailers→consumers. Since the 1980s, all brigades and communes producing vegetables have been considered farmers' cooperatives. They ship vegetables to wholesale markets or retail shops. This channel mainly serves large and medium-size cities and accounts for 60–70% of national consumption.

Direct marketing channel – farmer cooperatives→vegetable retail shops; farmer cooperatives→supermarket chains; farmer cooperatives→hotels. Because fewer people are involved, market margins for vegetables are lower than in other channels. This channel has become increasingly important in recent years, and accounts for an estimated 10% of national consumption.

Shippers' channel – farmer→shipper→wholesaler→retailer→consumer. This is the longest marketing channel for fresh vegetables. Normally farmers choose to sell produce to shippers, either in their fields before harvest or at local wholesale markets. Grading and packing are handled mainly by the shippers. The shippers ship the produce from producing regions to wholesale markets or to wholesalers who operate away from the production place. This channel is especially important for transportation of vegetables from south to north, and accounts for about 5% of national consumption.

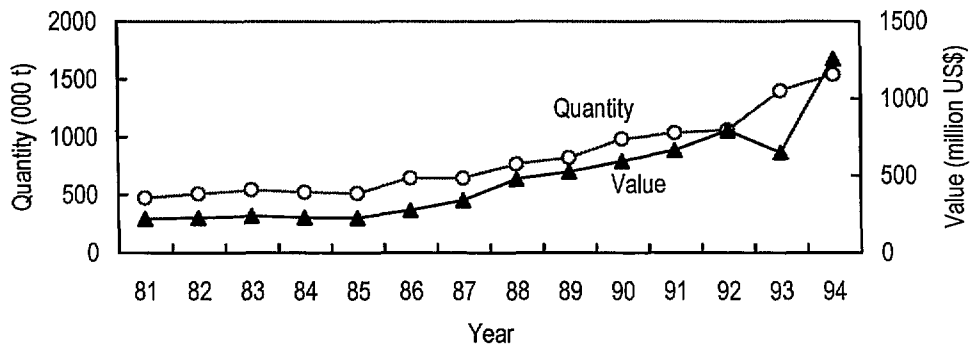
Marketing Margins

Based on marketing information in Beijing, the farmers' share of the consumer price is 20–30%. The farmers' share tends to rise for off-season vegetables.

International Trade

Vegetable exports from China reached 1.5 million t, and were worth the equivalent of US$1.26 billion, in 1994. Between 1981 and 1994 the volume of exports increased at an annual rate of 9.2%, and the value of exports increased at 13.2% (Fig. 8). In one year (1993 to 1994) the value of exports

almost doubled. However, export of vegetables still accounts for less than one percent of total production.



Sources: Ministry of Foreign Economic Relation and Trade (1992), State Statistical Bureau (1992b, 1993, 1994, 1995)

Figure 8. Vegetable export from China

Supply and Demand

The Chinese people traditionally prefer fresh over canned (processed) vegetables. Improvements in vegetable production and economic development in the country have caused major changes in vegetable availability. Rapid urbanization is creating a substantial demand for fresh vegetables to be transported from rural areas. Meanwhile, demand for quality will increase. Customers will demand clean vegetables that look good and are nutritious, fragrant, and, especially, free from pesticides.

Per Capita Availability

In 1993, per capita availability of vegetables reached 103 kg, up from 83 kg in 1980. Over this period the availability improved at an annual rate of 2.1%, although most of the improvement occurred betwee 1983 and 1987, and there has been little increase since then (Fig. 9).

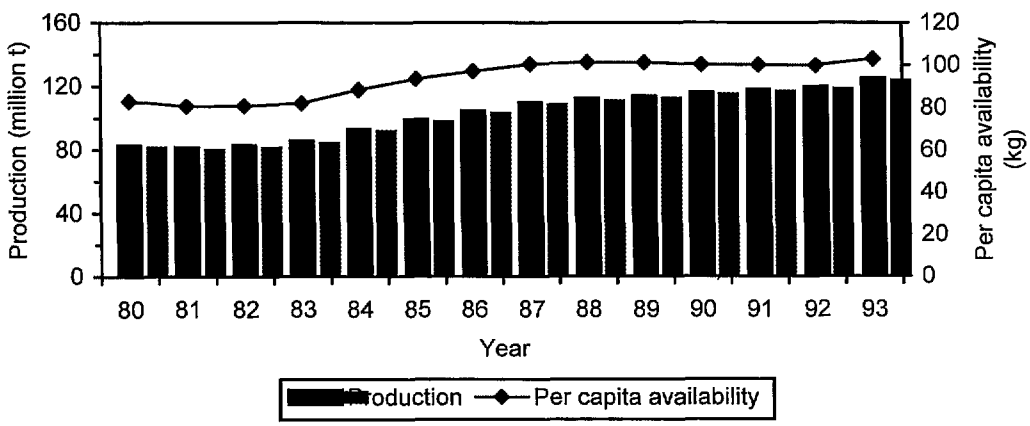


Fig. 9: Per capita vegetable production and availability in China, 1980–93

Vegetables in the Consumption Pattern

The State Statistical Bureau publishes data on household consumption by food item. However, grain data reported there are not for processed grains. Therefore, the contribution of different food items to total food consumption is misleading. For this reason, here we report the results from a mini survey conducted for this purpose (Table 15).

Table 15. Annual per capita food consumption, rural and urban China, 1991

Food item	Rural		Small city		Large city	
	Quantity (kg)	Share (%)	Quantity (kg)	Share (%)	Quantity (kg)	Share (%)
Grain	199.4	53.9	138.7	38.8	118.6	32.0
Red meat	12.2	3.3	23.9	6.7	27.4	7.4
Pork	11.2	3.0	16.8	4.7	19.0	5.1
Poultry	1.3	0.4	3.4	1.0	4.9	1.3
Eggs	2.7	0.7	5.8	1.6	9.5	2.6
Milk	1.2	0.3	2.5	0.7	10.6	2.9
Fish	2.2	0.6	6.4	1.8	8.7	2.3
Edible oil	5.7	1.5	6.2	1.7	7.2	1.9
Vegetables	127.0	34.4	121.3	33.9	126.6	34.2
Fruit	6.8	1.8	32.8	9.2	38.0	10.3
Total	369.7	100	357.8	100	370.5	100
Total per capita per day	1.0	-	1.0	-	1.0	-

Source: Huang and Bouis (1995); Huang and Rozelle (1995).

In China, people in urban areas consume about 1 kg of food every day, one-third of which is vegetables. The proportion of grain in the diet is higher in rural areas than in urban areas; however, the shares of fruits and livestock products in diets are higher in urban areas.

In terms of budget allocation for food by urban dwellers, vegetables rank third, after meat and grain (Table 16). (No such budget data are available for the rural population, or for China as a whole.)

Table 16. Expenditure and relative share of food items in China (urban dwellers), 1991

Food item	Expenditure (Y)	Share (%)
Meat and related products	170.0	21.7
Grain	102.5	13.1
Fresh vegetables	85.7	11.0
Aquatic products	40.9	5.2
Eggs	35.9	4.6
Dry vegetables	10.1	1.3
Others	337.4	43.1
Total food	782.5	100.0

Source: State Statistical Bureau (1992a).

Trend in Per Capita Consumption by Income Group

Data on per capita vegetable consumption by income group in urban areas are available from household consumption surveys (Table 17). In contrast to the vegetable availability estimates, consumption estimates suggest a serious decline in the consumption of vegetables, which emphasizes the need to validate production and consumption data in China. Overall, per capita annual consumption declined from 156 kg in 1983 to 112 kg in 1994.

Table 17. Trends per capita in vegetable consumption (kg/year) by income group in urban areas, and overtime comparison between urban and rural groups, 1983–94

Year	Overall average	Income group in urban areas (Y/month)							Urban	Rural
		<240	240–300	300–420	420–600	600–720	720–840	>840		
1983	156	108	148	156	166	173	171	NA	NA	NA
1984	142	98	130	143	153	160	174	NA	149.0	140.0
1985	134	125	140	137	149	152	165	180	144.4	131.0
1986	137	125	127	132	137	143	155	168	145.3	134.0
1987	133	123	130	137	142	148	158	173	142.6	130.0
1988	134	131	133	141	146	154	162	176	147.0	130.0
1989	136	129	133	138	145	148	159	177	144.6	133.0
1990	135	117	125	129	133	137	149	163	136.7	134.0
1991	128	115	117	122	126	132	141	155	132.2	127.0
1992	126	111	115	119	122	129	140	155	124.9	129.1
1993	111	105	111	114	119	128	137	144	120.6	107.4
1994	112	103	110	117	119	125	136	145	120.8	107.9
Growth rate (%)	-2.0	-0.46	-2.3	-2.4	-2.8	-2.6	-2.3	-2.5	-2.2	-2.0

NA = data not available.
Source: State Statistical Bureau, various issues (1984–95).

In the early years reported in Table 17 there are large differences in vegetable consumption across income groups, with the highest income group consuming about 70% more vegetables than the lowest income group. However, this gap is narrowing because although all income groups show a declining trend in vegetable consumption, the decline is relatively much smaller for the lowest income groups than for the middle and high income groups. As a result, the difference in vegetable consumption between the highest and lowest income groups in later years is only about 40%.

Despite the narrowing gap in consumption, there remains a question of quality. When there is strong pressure on prices, as is the case in China, the poor usually switch to low-quality vegetables. Quantity might increase, but quality might deteriorate (Darmawan and Pasandaran 2000).

Regional Variation in Vegetable Consumption

Vegetable consumption also varies from rural to urban areas, with rural people generally eating fewer vegetables than urban people. However, the difference is not as great as the difference across income groups, and across geographical regions.

Regional variation in vegetable consumption is quite high (Table 18). Across regions differences can be almost 100% among urban dwellers, and more than 170% for rural groups.

Table 18. Vegetable consumption (kg per capita) in selected provinces of China by rural and urban group, 1991

Province	Urban[1]	Rural[1]
China	132	127
Beijing	132	139
Tianjin	149	116
Shanxi	148	68
Liaonin	181	185
Shanghai	110	108
Fujian	99	153
Henan	122	81
Shaanxi	121	84

[1] Consumption among urban groups includes both fresh and processed vegetables; the figures for rural groups are only for fresh vegetables. However, the share of processed vegetables in the total is less than one percent.
Source: State Statistical Bureau (1993).

Summary and Conclusions

Over the past 13 years, the vegetable area in China has increased 58% and vegetable production has risen by 51%. Annual per capita availability of vegetables has reached 103 kg. However, survey data on household consumption indicate very different consumption figures, and an opposite trend; there has been a serious decline in annual per capita consumption of vegetables, from 156 kg in 1983 to 112 kg in 1994. Clearly, there is a need to validate these data on vegetable production and consumption.

Vegetable exports are very limited and come only from China's southern and coastal regions, which have started selling vegetables to USA and Japan, as well as to South Korea and other newly developed countries (or regions) in Asia.

Market supply of vegetables varies greatly throughout the year. How the gap between supply and demand can be adjusted in these peak and slack periods and across regions is a key issue. Developments of processed products and protected cultivation during the winter and early spring are long-term solutions. But it is also necessary to exploit the variation in climate across regions by building an efficient and extensive transportation system to move vegetables from areas with surplus to areas in deficit. This would establish a nationwide division of responsibility for year-round production and supply of vegetables, and allow a comprehensive adjustment of quantities and sales. The system would overcome vegetable production constraints due to climatic stresses, save energy, protect the environment, and reduce costs. Since 1979, vegetable farmers have had more freedom to grow and sell. The supply of vegetables to big cities and big industrial centers has increased and supply source and sale outlets are more diverse. This has enabled vegetable production bases to be located further away from markets. The policy of "local production and local sale", which was

followed for a long time, has been replaced by a policy of "production in suitable areas on competitive basis and purchase of products from competitive regions". For this policy to be effective, an efficient transportation system is essential.

China is now in transition, from a centrally planned economy to a socialist marketing system. There are many important issues to be considered: how to reform the vegetable production and sale system; how to transfer management of state-owned vegetable companies; how to establish vegetable wholesale markets; and how to develop strategies for the continuous supply of vegetables to big cities. These are urgent problems, which need to be researched in detail. Other questions that need to be answered are:

- What are the functions of wholesale markets?
- How can regional production be connected to national or international demand?
- How should national information networks best be established to serve the vegetable business in order to adjust macro-production and sales?
- How can the price system be improved to develop transparency between producers and consumers?
- How can investment mechanisms be set up for vegetable research and production?

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INDIA

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Introduction

India (Fig. 1) lies entirely in the northern hemisphere, extending between latitudes 8°4' and 37°6' north and longitudes 68°7' and 97°25' east. The country has four well defined regions: the great mountain zone of the Himalayas, the plains of the Ganga and Indus Rivers, the desert region, and the southern peninsula. It is divided into 26 states and six Union Territories. With a population of 896 million in 1993 and an area of 3.287 million km^2, population density in India was 273 people per km^2. With total cultivable land area of 139.5 million ha (1991–92), land availability was 0.16 ha per person. Average per capita income was US$317 in 1994.

About 175 types of vegetables are grown in India, including 82 leafy vegetables and 41 root (tuber and bulb) crops. India is the world's second largest producer of vegetables, following China (Shunmugavelu 1989). In 1994 the area under all vegetables (excluding tubers, but including onion and garlic) was 3.8 million ha (about 2.2% of the total cropped area), and vegetable production totaled more than 49.7 million t (at an average yield of about 13 t/ha); total production in 1980–81 was only 19.8 million t. The value of all vegetables in that period was INR 225 billion, equivalent to 20% of the value of cereal production. About 0.38 million t of vegetables are exported, leaving a daily per capita availability at the farm-level of around 149 g/day, compared to the recommended level of 200 g/day.

In 1990–91, average per capita food consumption was about 794 g/day, of which cereals constituted 51.5%, livestock products 17.6%, non-cereal plant food 11.5%, vegetables 10.6%, roots and tubers 5.7%, and fruit 3.1%. Staple foods in India are wheat in the north, rice in the south, and sorghum in the central part of the country.

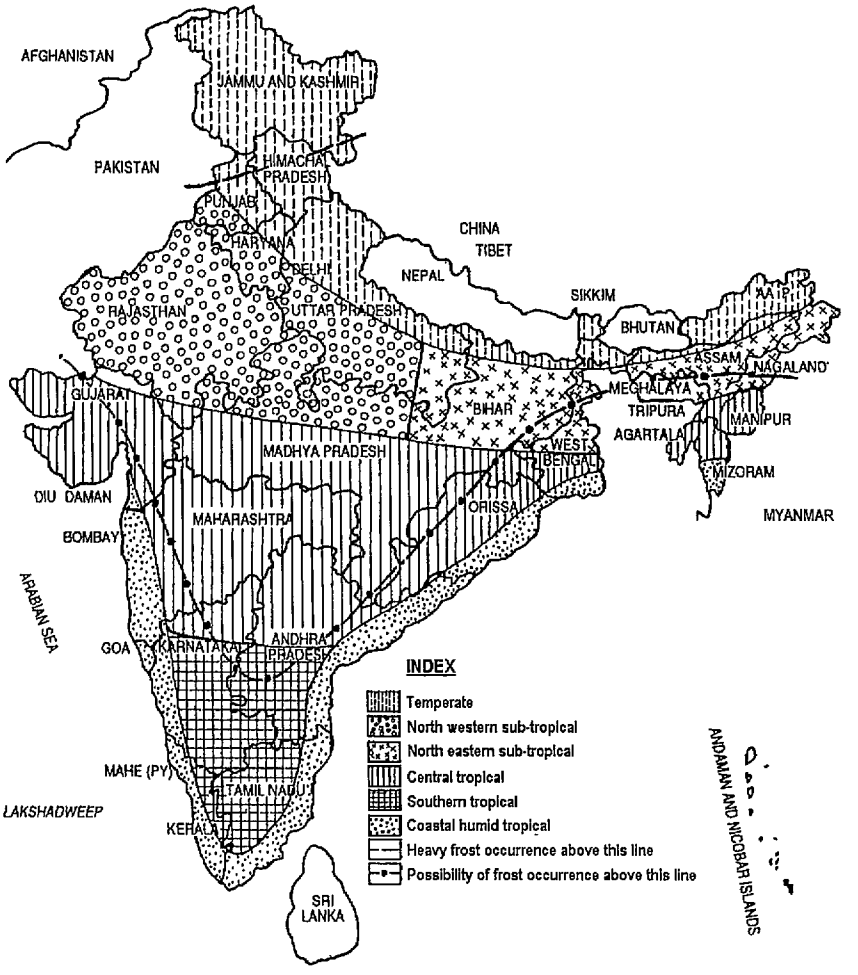

Fig. 1. Map of India

Vegetable production in India is unevenly distributed across the country (Table 1), with 57% of the total vegetable area being concentrated in just four states—Uttar Pradesh, Tamil Nadu, Orissa, and Bihar. At the national level, about 3.7% of the country's total area under all crops is devoted to vegetables (including potato, tapioca, and sweet potato). The percentage share of vegetables in the gross cropped area in 1992 was more than 7% in 11 out of 26 states and in the Union Territories combined.

Agroclimatic Zones

The climate of India can be broadly described as tropical with a few temperate areas. There are four seasons: winter (January–February); hot dry summer (March–May); south-west monsoon (June–September), and north-east monsoon (October–December).

The country can be divided into six ecoregions (Table 2), which can be grouped into three areas based on the possibility of frost (Fig. 1).

Table 1. Share of vegetables in gross cropped area in India, 1992

State/Union Territory	Area under all crops ('000 ha)[1]		Cropping intensity (%)	Vegetable area[2]		
	Net (cultivated)	Gross (cropped)		Area ('000 ha)*	% of gross area	% of total vegetable area
Andhra Pradesh	11022	13192	119.7	380.96	2.87	5.74
Arunachal Pradesh	149	247	165.8	18.95	7.73	0.29
Assam	2706	3797	140.3	222.44	5.93	3.25
Bihar	7702	10485	136.1	811.28	7.79	12.23
Delhi	48	76	158.3	5.47	7.70	0.08
Goa	131	151	115.3	7.38	4.76	0.11
Gujarat	9289	10361	111.5	133.14	1.36	2.01
Haryana	3575	5919	165.6	62.60	1.11	0.94
Himachal Pradesh	583	984	168.8	40.16	4.14	0.61
Jammu and Kashmir	731	1066	145.8	2.93	0.28	0.04
Karnataka	10381	11759	113.3	322.43	2.74	4.86
Kerala	2247	3020	134.4	217.14	7.19	3.27
Madhya Pradesh	19558	23880	122.1	253.89	1.13	3.83
Maharashtra	17941	21866	121.9	368.23	1.70	5.55
Manipur	140	180	128.6	11.71	6.36	0.18
Meghalaya	202	243	120.3	32.18	13.35	0.49
Mizoram	65	74	113.8	6.72	9.21	0.10
Nagaland	190	210	110.5	8.71	4.36	0.13
Orissa	8304	9594	152.2	827.21	8.91	12.47
Punjab	4218	7502	177.9	82.59	1.12	1.24
Rajasthan	16377	19380	118.3	112.11	0.63	1.69
Sikkim	95	152	160.0	10.91	7.42	0.16
Tamil Nadu	5579	6632	118.9	950.49	13.93	14.33
Tripura	270	445	164.8	33.46	7.99	0.50
Uttar Pradesh	17299	25480	147.3	1195.21	4.72	18.01
West Bengal	5334	8662	162.4	497.55	5.96	7.50
Union Territories	94	118	125.5	8.96	7.59	0.14
All India	142234	185477	130.4	6634.81	3.66	100

Source: [1] The Fertilizer Association of India, 1994 (Table III-10).
[2] Official files of Directorate of Economics and Statistics, New Delhi.
*Includes area of tuber crops, such as potato and tapioca.

Table 2. Ecoregions of India

Ecoregion		State covered
I	Temperate	Jammu and Kashmir, Himachal Pradesh, Garhwal and Kumaon, Uttar Pradesh (12%); Darjeeling region of West Bengal (18%); Sikkim, Arunachal Pradesh
II	North-western subtropical	Haryana, Punjab, Rajasthan
III	North-eastern subtropical	Uttar Pradesh (88%), Bihar, Northern West Bengal (51%), Assam, Manipur,Nagaland, Tripura (93%), and Mizoram (87%)
IV	Central tropical	Gujarat, Maharashtra (84%), Northern Andhra Pradesh (41%), Orissa (80%), Madhya Pradesh, West Bengal (23.5%)
V	Southern tropical	Karnataka (89%), Tamil Nadu (66%), Andhra Pradesh (38%), Kerala (33%)
VI	Coastal humid tropical	Maharashtra (16%), Karnataka (11%), Tamil Nadu (34%), Andhra Pradesh (21%), Kerala (67%), Orissa (20%), Tripura (7%), West Bengal (7.5%), Mizoram (13%)

Major Vegetables and Ecoregion Distribution

Table 3 shows the distribution of vegetable area by ecoregion. Tubers and bulbs are the largest group, accounting for 45% of the country's total vegetable area; the major vegetables in this group are tapioca, potato, and onion. All leafy and flower crops have a total share of only 12% in the total area under vegetables. Cabbage and cauliflower are the main vegetables in this group. The fruit group contributes about 28%, with eggplant at 8%, and lady's finger, tomato, peas, and beans each having a 5% share in the total vegetable area. Zonal and state distribution of major vegetables, varieties grown and cultivation periods are listed in Table 4.

Table 3. Area under vegetable crops by ecoregion, 1992

Vegetables	Vegetable area (000 ha) by ecoregions						All India	
	I	II	III	IV	V	VI	Area (000 ha)	%
Tuber and bulb	325.00	121.11	734.34	642.17	896.47	384.33	3003.42	45.27
Potato	180.16	63.12	500.73	260.23	-	61.71	1065.95	16.07
Tapioca	-	8.71	67.50	56.46	802.53	185.83	1121.06	16.90
Onion	6.38	25.91	74.74	166.84	80.61	61.46	145.99	6.27
Sweet potato	-	6.37	23.75	45 51	5.05	21.70	102.37	1.54
Carrot	16 77	4.29	23 29	26 78	3.34	6.81	81 33	1.23
Radish	9.83	4.57	24.81	35.56	3.00	15.06	92.93	1.40
Beetroot	3.65	6.83	16.95	23.95	-	0.55	51.93	0.78
Turnip	2.95	-	1.59	-	-	0.05	4.59	0.07
Yam	2.97	1.00	0.60	17.88	1.30	24.15	47.30	0 71
Others	2.89	0 30	0.38	8.94	0.64	7.01	20.19	0.30

Contd. Table 3.

Vegetables	Vegetable area (000 ha) by ecoregions						All India	
	I	II	III	IV	V	VI	Area (000 ha)	%
Leafy and flowery	112.05	12.46	247.51	286.30	29.48	96.17	783.97	11.82
Cabbage	74.73	3.80	105.16	77.76	1.50	42.39	305.34	4.60
Cauliflower	30.45	3.84	100.26	92.53	0.40	20.71	248.19	3.74
Greens	5.57	3.91	33.39	97.11	4.21	26.17	170.36	2.57
Drumstick	-	-	-	8.56	21.31	1.68	31.55	0.48
Others	1.30	0.91	8.70	10.34	2.06	5.22	28.53	0.43
Fruit	51.40	72.17	462.17	951.04	127.53	182.68	1846.99	27.83
Eggplant	2.60	10.79	120.33	296.89	34.21	73.47	538.29	8.11
Lady's finger (Bhendi)	4.45	12.71	116.81	148.63	14.74	23.76	318.10	4.79
Tomato	8.33	23.82	79.02	87.12	63.72	50.91	312.92	4.72
Peas	26.98	6.43	101.61	189.91	0.95	3.93	329.79	4.97
Beans*	9.04	12.00	38.15	213.78	5.32	19.53	300.83	4.53
Gourds, etc.	-	6.43	6.25	14.71	8.59	11.08	47.06	0.71
Spice crops	10.55	57.27	67.78	317.98	210.07	336.78	1000.43	15.08
Chili	2.65	45.90	46.25	233.45	190.80	327.25	846.30	12.76
Garlic	0.30	11.20	5.00	70.80	4.33	2.67	94.30	1.42
Ginger	7.60	0.17	16.53	13.73	14.94	6.86	59.83	0.90
Grand total	399.00	263.01	1511.80	2197.49	1263.55	999.96	6634.81	100.00
Share in total vegetable area (%)	6.01	3.95	22.79	33.12	19.04	15.08	-	100.00

Note: Region wise aggregation was made from the district level data.
*Beans include all varieties of beans, such as French beans, lab-lab, winged beans, cluster beans, and cowpea.
Source: Official files of Commissioner of Horticulture, New Delhi, 1993.

Table 4. Zonal and state distribution, varieties, and cultivation period of major vegetables in India

Crop	Ecoregion[a]	State[b]	Varieties	Growing period
Chili	VI	Northern AP (10.3), Orissa (9.8)	Pusa jwala, CO-1, CO-2,	February
	IV	MAH (9.9), North AP (7.9)	Pusa sadambhar, K-1,	Winter, Summer
	V	KAR (8.6), AP (8.1)	K-2, MDU-1.	Rainy season
Eggplant	IV	Central & southern UP (29.8),	Arkasheel, S-16, S-4,	Year round
		Orissa (18.0)	Arka kusumakar, P-8,	
	III	Bihar (12.1)	Arka shirish, H-4, MDU-1,	
	VI	Orissa (6.2)	Pusa Purple Long, PKM-1.	
Onion	IV	MAH (19.7),	Bellary, Pusa Red, Early	Rainy and dry winter
		Central & southern UP (6.0)	Grano, Pusa Madhvi,	seasons
	V	KAR (11.0), TN (5.7)	Pusa White Flat, Pusa White	
	III	Bihar (10.9)	Round, N-53 (summer onion),	
			Early Grano (green onion)	

Contd. Table 4.

Crop	Ecoregion[a]	State[b]	Varieties	Growing period
Peas	IV	Orissa (28.6), MP (6.7)	Asauji, Early Badger, Little	Year round,
	III	Bihar (12.1), Assam (11.3),	Marvel, Arkel, Early giant,	Early December in plains
		Eastern UP (6.5)	Meteor, NP-29, Bonneville, Sylvia	
Lady's finger	IV	Orissa (24.4),	Pusa Sawani, CO-1,	Year round,
		Central & southern UP (8.3)	Punjab Padminim CO-2,	Summer and rainy
	III	Bihar (22.2), Eastern UP (5.8),	MDU-1.	
Tomato	III	Bihar (16.8)	Pusa Ruby, CO-1, CO-2,	Year round,
	IV	Orissa (9.0), MP (6.5)	Pusa Early Dwarf, CO-3,	winter
	V	Southern AP (8.8), KAR (7.4)	PKM-1, Pusa Red Plum	
Cabbage	I	Darjeeling WB (21.9)		October-January
	IV	Orissa (16.1)		
	III	Bihar (12.1), Assam (8.3), North WB (7.2)		
	VI	WB (9.4)		
Beans	IV	Central & southern UP (42.5),	French bean (Tweed Wonder,	Summer and rainy
		Orissa (17.4), MP (6.2)	Premier)	season under moderate
	III	Bihar (6.2), Eastern UP (5.6)		temperature condition.
Cauliflower	III	Bihar (26.9), Assam (8.3)	Pusa Katki, Pusa Synthetic,	October-December
	IV	Orissa (19.7), Central & southern UP (10.8)	Pusa Early Synthetic, Pusa Shubhra.	
	I	Darjeeling WB (10.4)		Summer
Greens	IV	Central & southern UP (44.1)	-	Summer & rainy
	III	Eastern UP (10.8), Bihar (5.4)	-	Rainy season
	VI	WB (5.8)	-	Rainy season
Radish	IV	Orissa (26.9)	Pusa Desi, Pusa Reshmi,	July-September
	VI	Orissa (10.9)	Pusa Chetki.	
	III	Eastern UP (7.7), Bihar (6.9)		
	I	UP hills (5.4)		
Garlic	IV	MP (31.4), Orissa (20.6), Gujarat (15.4),	Ooty-1.	June-July,
		MAH (3.5), Central & southern UP (4.2),		
	II	Rajasthan (11.2)		October-November
Carrot	IV	Central & southern UP (25.2)	Local Red, Pusa Kesar,	Rainy season
	I	Darjeeling WB (14.5)	Pusa Meghali	Summer season
	III	Eastern UP (11.7), Bihar (10.1), Tripura (6.5)		Rainy season
Ginger	V	Kerala (20.2)	Thingpuri, Rio-de-janerio, Maran,	July-September
	IV	Orissa (16.2)	Burdwan, China Wynad local,	
	III	North WB (11.0), Meghalaya (10.6)	Jorhat, Nadia, Wynad manantoly	

Contd. Table 4.

Crop	Ecoregion[a]	State[b]	Varieties	Growing period
Beetroot	IV	Central & southern UP (37.6)		Summer
	III	Eastern UP (18.9), Bihar (7.8), Tripura (6.0)		October-January
	II	Rajasthan (9.0)		Rainy season
Turnip	I	UP hills (50.1), ARUP (10.0),	Pusa Kenchem,	August-September
	III	HP (4.1), Bihar (27.2), Meghalaya (7.4)	Pusa Sweti	
Yam	VI	Orissa (43.1), MAH (6.2)		Rainy season
	IV	Orissa (16.1), MP (15.1), MAH (6.7)		Rainy season
Calocasia	VI	Orissa (30.0), MAH (3.2)		Summer, rainy
	IV	Orissa (20.3), MP (15.4), MAH (6.7)		Rainy season
	I	HP (12.8)		Rainy season
Drumstick	V	Kerala (56.2), South AP (9.1)		Perenniel crop,
	IV	Gujarat (20.3), North AP (6.8)		October-January, July-August
Gourds	V	Southern AP (13.5)	Pumpkin(Pusa Visvas),	October-January
	II	Rajasthan (13.5)	Bitter gourd (Pusa Do	Rainy season
	IV	North AP (13.1), MAH (10.2)	Mausami, Pusa Visesh)	
	VI	AP (7.7)	Bottle gourd (Pusa Naveen, PSPL, Pusa Manjari, Pusa Meghdoot)	Rainy season
Total vegetables	-	UP (18.0), TN (14.3), Orissa (12.5), Bihar (12.2)	-	Mostly in October-January, in peri-urban year-round

[a] For definitions of ecoregions, see Table 2.

[b] ARUP = Arunachal Pradesh; AP = Andhra Pradesh; HP = Himachal Pradesh; KAR = Karnataka; MAH = Maharashtra; MP = Madhya Pradesh; TN = Tamil Nadu; UP = Uttar Pradesh; WB = West Bengal. Figures in parentheses are the percentage share of a state in total area under the vegetable.

Source: the percentage of vegetable area grown in each state is estimated from the state level data of area of vegetables; for the variety, see Gill et al. (1991). Varieties in some crops are from discussions of the authors with vegetable experts. The varieties available in each crop are at all-India level, not at ecoregion level.

Trend Analysis

Production

Potato, tapioca, and onion (among tuber/root and bulb crops), cabbage and cauliflower (among leaf and flower crops), eggplant, lady's finger, tomato, and beans (among fruit vegetables), and chili, garlic, and ginger (among spice crops) were selected for an analysis of trends in area, production, and yield (Table 5). These vegetables were chosen for two reasons:

- with the exception of ginger, they are major crops by area, accounting for more than 85% of the total area under vegetables in India.
- for these crops, time series data were available for the period 1980–93. Garlic and chili were not

major crops, yet they were included in the analysis to give some coverage of the vegetables used as spices.

Table 5. Trends in vegetable area, production, and yield in India, 1980–93

Vegetables	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
Potato	0.030	-	0.049	-	0.018	-
Tapioca	0.011	-	0.040	-	0.028	-
Onion	0.023	-	-	0.002	-	-
Cabbage	0.090	-0.005	0.320	-0.018	-	-
Cauliflower	0.038	-	0.116	-	0.078	-
Eggplant	0.022	-	0.241	-0.011	0.248	-0.013
Lady's finger	-	0.001	0.079	-	0.071	-
Tomato	0.029	-	0.235	-0.015	0.150	-0.010
Beans	0.041	-0.002	0.122	-0.006	0.021	-
Chili	-	-	0.032	-	0.097	-0.005
Garlic	-	0.003	-	0.003	-0.034	0.003
Ginger	0.069	-0.003	0.070	-	0.038	-
Other vegetables	0.174	-0.012	0.196	-0.010	0.044	-
All vegetables (excl. potato and tapioca)	0.032	-	0.189	-0.011	0.162	-0.110
Rice	-	0.0005	0.036	-	0.031	-
Wheat	-	-	0.036	-	0.032	-

Source: Estimated from data provided by Department of Economics and Statistics, New Delhi.
- implies that the coefficient is not significant at least at the 5% level.

Area under all vegetables is increasing at 3.2% per annum; yield and production increased in the early years of the study time frame, but stagnated in the later years, as seen from the negative quadratic terms. The main cause of stagnation was declining production of cabbage, eggplant, tomato, beans, and other vegetables. The stagnation in vegetable production and yield is a serious concern for policy makers and poses a challenge for researchers, as it will cause the per capita vegetable consumption to decline. For comparison, production of rice and wheat in India increased at about 3.6% annually during the same period as a result of rising yields; wheat area remained stagnant, and rice area increased quadratically, although the coefficient is small.

Prices

Semilog trends were estimated using time series (1980–91) of farm-gate, wholesale, and retail prices for 12 major vegetables. The compound growth rates are reported in Table 6.

The nominal weighted average wholesale prices of all vegetables increased more rapidly than the prices of rice and wheat. Weighted average vegetable prices deflated by the consumer price index

(CPI) had positive trends, and increased at 2.3% at the farm gate, 2.4% at the wholesale level, and 4.7% at the retail level. The increase at the retail level might have threatened vegetable consumption by low-income groups in India. The increase in farm-gate prices could have been expected to result in increased vegetable production, but, as shown in the previous section, this did not happen; instead, vegetable production has stagnated in India. This suggests that bottlenecks affecting vegetable supply are more fundamental, and high farm-gate prices will not solve the problem. (For more discussion, see the section on vegetable production constraints.)

Generally, vegetable prices rose faster at the retail level than at the farm gate or wholesale level. The increase in nominal prices of potato, onion, cabbage, cauliflower, chili, garlic, and ginger were modest at all levels, resulting in a negative or neutral trend in the deflated prices of these commodities. The highest increases were in tapioca, eggplant, and tomato prices at all the three levels, resulting in positive trends in the deflated prices of these vegetables.

Table 6. Compound growth rates (%) in the farm-gate, wholesale, and retail prices of selected vegetables in India, 1980–91

Crop	Farm-gate price		Wholesale price		Retail price	
	Nominal	Deflated	Nominal	Deflated	Nominal	Deflated
Potato	2.5	-5.4	3.3	-4.6	7.4	-
Tapioca	16.4	8.4	16.1	8.2	18.3	10.3
Onion	4.2	-3.7	-	-	6.1	-
Cabbage	3.1	-4.8	6.5	-	5.0	-
Cauliflower	8.6	-	5.9	-	9 1	-
Eggplant	14.8	6.9	10.2	-	14.3	6.4
Lady's finger	11.5	3.6	12.6	4.6	11.7	3.8
Tomato	13.0	-	15.3	7.4	16.7	8.8
Peas	9.1	-	8.2	-	9.6	1.6
Chili	9.1	-	8.8	-	7.7	-
Garlic	-	-5.4	-	-5.8	-	-6.9
Ginger	7.8	-	9.1	-	7.1	-
Weighted average prices of all vegetables	7.3	2.3	7.5	2.4	8.7	4.7
Rice	NA	NA	6.5	-1.5	NA	NA
Wheat	NA	NA	6.0	-	NA	NA

Note: NA = Data not available; - implies growth rates are not significant at the 5% level.
Source: Estimated from data provided by Department of Economics and Statistics, New Delhi.

Seasonal Variation in Prices

Using data for 33 major markets in India for the years 1990–91 to 1993–94, seasonal variation in prices was studied with the help of a seasonal price index constructed for major vegetables (Table 7).

Table 7. Seasonal price index of major and all vegetables in selected markets of India, monthly average for 1990–93

Vegetables/ Markets	Months 1	2	3	4	5	6	7	8	9	10	11	12	Seasonality (%)
Eggplant													
Bangalore	100	106	95	99	94	115	123	115	102	115	152	161	25
Bombay	100	93	83	86	86	103	76	102	115	89	109	91	51
Calcutta	100	94	204	127	159	175	229	215	260	309	187	145	228
Delhi	100	108	149	114	74	94	145	135	168	95	59	67	154
Madras	100	120	118	80	92	97	81	81	93	111	155	150	93
All India	100	100	141	106	101	121	133	136	148	128	118	106	41
Cabbage													
Bangalore	100	70	60	61	77	111	139	132	127	63	98	133	133
Bombay	100	91	88	131	136	162	179	196	166	144	153	111	124
Calcutta	100	98	140	135	185	339	336	324	339	356	397	248	307
Delhi	100	82	116	120	142	242	454	375	375	327	216	122	450
Madras	100	95	88	91	103	125	162	124	143	86	96	155	88
All India	100	88	99	115	126	161	188	177	171	149	159	144	114
Cauliflower													
Bangalore	100	64	66	104	119	109	119	129	93	101	125	120	96
Bombay	100	106	118	178	163	-	-	-	-	162	121	119	78
Calcutta	100	126	-	-	-	-	-	-	-	152	447	271	347
Delhi	100	73	149	156	162	-	1402	1047	489	201	131	109	1833
Madras	100	110	103	144	-	-	-	-	-	-	80	103	81
All India	100	69	92	122	231	244	157	119	141	128	105	87	166
Garlic													
Bangalore	100	89	64	59	67	76	81	88	83	90	93	82	69
Bombay	100	90	63	56	60	67	76	84	78	77	85	76	78
Calcutta	100	99	66	62	62	70	73	84	81	91	95	81	52
Delhi	100	94	59	46	55	64	73	81	84	78	84	71	115
Madras	100	106	80	82	74	76	86	83	91	78	80	75	43
All India	100	93	65	55	60	70	77	85	86	86	90	81	83
Ginger													
Bangalore	100	110	122	140	146	162	150	122	99	103	113	126	63
Bombay	100	100	102	105	128	139	142	120	94	100	103	105	51
Calcutta	100	101	108	123	146	150	144	186	196	149	125	123	96
Delhi	100	90	97	107	116	130	112	115	139	123	121	107	55
Madras	100	105	121	137	143	149	151	117	105	84	93	102	77
All India	100	103	111	120	133	138	138	148	135	128	118	114	48
Lady's finger													
Bangalore	115	125	128	106	109	100	93	95	96	97	138	174	88
Bombay	-	-	-	56	67	100	96	81	65	66	65	121	118
Calcutta	-	-	226	86	102	100	154	139	142	198	174	-	164

Contd. Table 7.

Vegetables/ Markets	Months 1	2	3	4	5	6	7	8	9	10	11	12	Seasonality (%)
Delhi	-	-	433	244	121	100	149	168	173	138	170	362	333
Madras	-	-	68	82	87	100	101	97	104	113	101	-	66
All India	109	99	152	124	91	100	113	104	94	101	113	136	67
Onion													
Bangalore	100	72	63	52	53	68	83	94	111	112	126	156	200
Bombay	100	75	64	53	59	77	83	105	129	132	172	169	223
Calcutta	100	98	95	86	75	73	87	106	123	149	178	172	142
Delhi	100	80	80	74	71	74	84	102	115	107	119	108	68
Madras	100	83	72	62	59	79	91	100	117	120	126	169	185
All India	100	84	73	61	59	70	87	104	126	132	160	167	186
Peas													
Bangalore	100	98	144	164	182	307	221	152	180	246	327	257	234
Bombay	100	83	118	254	-	-	-	-	-	373	345	112	349
Calcutta	100	79	122	-	-	-	-	400	464	394	318	196	490
Delhi	100	87	119	287	319	-	-	352	406	0	358	177	368
Madras	100	93	135	196	207	-	-	228	226	260	196	152	178
All India	100	117	152	232	207	323	279	278	301	328	283	172	228
Tomato													
Bangalore	100	72	52	55	98	156	182	111	72	99	178	175	248
Bombay	100	106	80	104	119	180	200	158	105	91	158	160	150
Calcutta	100	59	68	66	117	208	262	178	150	178	214	178	264
Delhi	100	96	110	98	55	89	164	154	117	96	141	132	197
Madras	100	83	80	77	102	137	183	131	99	122	188	200	160
All India	100	93	98	91	95	142	203	162	114	113	160	152	123
All vegetables													
All India	100	90	108	138	139	173	220	196	163	154	168	138	143

Note: Estimated from the monthly market arrival and price data for 34 major markets in India. Monthly prices were converted into indices (with January as a base) separately for every year. Then the average of the four years' monthly indices was calculated. Months with missing prices were excluded from the estimation. If January prices were not available (indicated by -) for all of the four years, June was taken as the base. Weighted average prices of a vegetable for India was calculated by weighing the individual monthly prices with the share of a market in the total monthly arrival of that vegetable in all India. Similarly, the weighted average price index of all vegetables in a month in India was calculated by weighing the relative share of all vegetables in a month.

Source: Unpublished data of National Horticultural Board, collected under the scheme "Market Information Services of Horticultural Crops", Ministry of Agriculture, Government of India.

At the national level, the weighted average monthly market price index of all vegetables (excluding onion) was highest during June–August, rainy months, and lowest during January–March, which are cooler months. Correspondingly, the vegetable arrival index to 34 markets in India is a mirror image of prices (Fig. 2). The increase in prices during the low supply period was about 120% of the lowest price during the highest supply period, and the corresponding difference in market arrival in the lean

supply period was about 55% of the highest supply period.

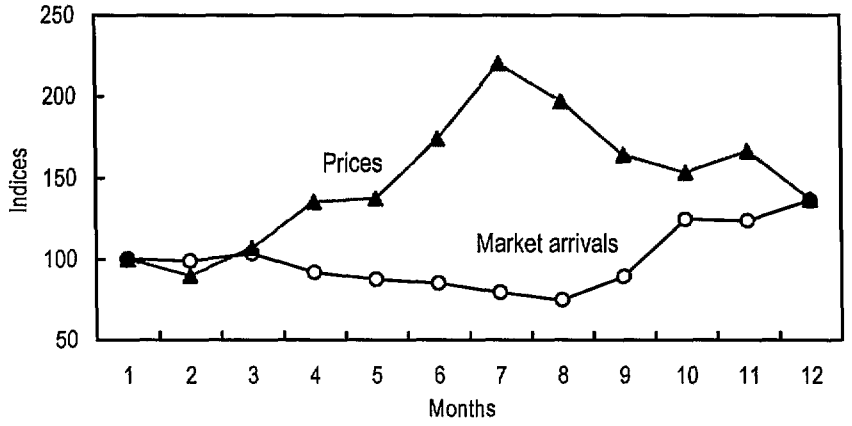

Fig. 2. Seasonality in vegetable prices and market arrivals (monthly average 1990–93)

Market Integration and Seasonality

Arora (1998) found that the markets in the hill region of Uttar Pradesh are well integrated. However, this situation is not found nationwide: Indian markets across states seemed relatively less integrated, as suggested by wide variability in seasonality of a vegatable across markets. For example, prices of eggplant in Calcutta were highest in October, while in the low range in the Delhi and Madras markets (Fig. 3). A similar situation was seen to prevail for other vegetables and markets. Therefore, integrating markets by providing information on market arrival and prices can help to reduce seasonality in Indian markets.

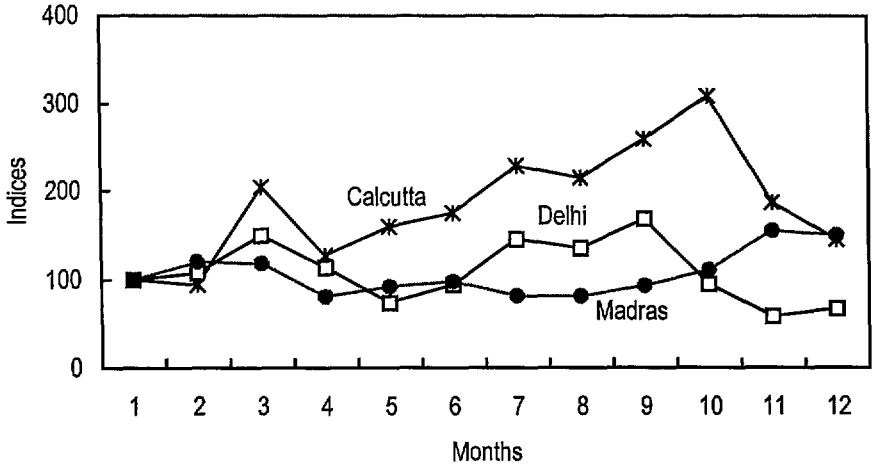

Fig. 3. Regional monthly price indices of eggplant prices, (average 1990-93)

Risk in Vegetable Production

Regional Variation in Yield

Average per ha yield of 10 major crops in each zone and the corresponding coefficients of variation (CV) are presented in Table 8. Yields were generally lowest in zone I, perhaps because this zone is mainly rainfed and experiences heavy frosts. The range of inter-zone variation was narrowest in yields of tapioca at 0.1%. It should be noted that percentage zonal differences in average yields of rice and wheat are equal or even higher compared to those for vegetables.

Table 8. Zonal average yields (t/ha) and CV (%) of major crops, 1991–92

Crop	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone CV*	State mean*	State CV*
Potato	16.6	20.4	13.2	15.7	16.1	17.0	1.7	16.03	56.6
Tapioca	-	18.5	-	17.5	19.1	-	0.1	18.7	11.3
Onion	7.5	18.0	9.7	16.2	17.3	16.4	8.1	14.2	56.8
Cabbage	14.2	23.4	26.7	30.7	34.6	38.5	7.9	28.0	64.3
Cauliflower	7.6	14.1	14.5	18.5	18.7	15.2	6.2	14.8	60.1
Eggplant	10.6	14.3	11.4	13.9	19.2	19.5	5.4	15.2	49.3
Lady's finger	6.3	12.0	8.3	7.3	8.7	8.5	4.3	8.5	39.7
Tomato	9.5	25.2	9.2	13.6	18.3	14.5	13.3	14.7	63.0
Peas (Green)	5.1	8.0	3.7	9.5	9.8	7.7	9.2	7.3	47.3
Beans	7.5	-	7.9	9.6	11.7	10.7	2.9	9.3	29.4
Chili	0.6	0.7	0.7	1.0	0.8	1.0	3.6	0.8	14.5
Garlic	-	2.4	2.5	3.7	2.2	2.7	3.8	3.3	5.6
Ginger	1.7	1.6	2.0	2.3	2.5	2.1	2.4	2.3	9.5
Rice	1.6	3.2	1.3	1.2	2.7	2.1	13.2	1.7	12.1
Wheat	1.4	3.3	2.1	1.5	-	-	13.3	2.0	12.2

*Zone CVs in yield are calculated from the mean yields of the zones. State means and state CVs in yield for all India are calculated on the basis of the actual mean yield for each state.

However, when coefficients of variation were estimated from the farm-specific yield (where differences in yield due to climatic conditions are averaged out), the CV in most vegetables was 2–5 times higher compared to rice. The only exceptions were ginger and garlic where the CVs were lower than rice, and tapioca and chili where CVs were almost equal. This implies that zonal variations attributed to climatic differences are less important, and farmer-to-farmer variation attributed to differences in farm management practices are more important, in vegetables than in cereals. Thus substantial improvements in production can be achieved even with the existing technology by bridging the gap between farm-level and experimental yields through extension, training, and educational programs.

Intertemporal Variation

Further analysis on variability in vegetable production was done by estimating the detrended coefficient of variation from the time series data for the period 1980–91. The results of the estimation for area, production, and yield of major vegetables and of all vegetables taken together are presented in Table 9.

Table 9. Detrended coefficient of variation in selected vegetables, rice, and wheat in India, 1980–91

Crop	Area	Production	Yield	Prices		
				Farm gate	Wholesale	Retail
Potato	3.4	6.2	6.1	5.0	14.3	16.4
Tapioca	9.2	12.0	5.5	50.6	26.5	24.8
Onion	4.9	7.8	4.0	16.3	26.8	17.4
Cabbage	9.4	25.8	21.8	9.9	28.7	23.1
Cauliflower	4.6	15.7	14.9	18.1	30.9	24.3
Eggplant	9.5	8.7	12.4	19.4	25.7	18.9
Lady's finger	5.7	11.3	10.6	9.9	19.0	15.3
Tomato	10.9	22.9	15.3	33.8	26.8	30.8
Peas	5.1	19.5	15.8	5.1	15.3	6.6
Chili	5.7	14.3	10.7	18.2	14.8	14.3
Garlic	11.1	14.8	5.3	24.5	22.2	19.6
Ginger	4.9	6.7	4.4	35.2	26.9	4.8
All vegetables	4.2	14.2	14.9	7.2	11.1	10.9
Rice	2.6	6.8	4.6	NA	7.5	NA
Wheat	2.9	4.8	3.3	NA	8.6	NA

Source: Estimated from official data provided by Department of Economics and Statistics, New Delhi.

All individual vegetables (except potato and ginger), as well as all vegetables as a group, have higher production CVs than do cereal crops, such as rice and wheat. High variation in vegetable production not only indicates that vegetable cultivation is more risky than cereal cultivation, but that this might also create intertemporal variation in vegetable consumption, unless production variation is cushioned by international trade.

It should be noted that variation in vegetable yields is much higher than variation in area for all crops, except tapioca, onion, garlic and ginger. Erratic rains contribute to high variation in vegetable yields because 50% of the cultivated vegetable area is rainfed. Stability in yield is more important in reducing overall variation in vegetable production than policy interventions designed to stabilize vegetable growing area in India. Researchers should focus on generating stabilizing technologies (e.g., stress-tolerant and pest-resistant varieties), and management practices (e.g., protected cultivation, increased irrigation) to counter environmental effects.

Instability in Vegetable Prices

Variation in vegetable production generally leads to unstable prices. This can be established from the detrended coefficients of variation for vegetable prices at the farm-gate, wholesale, and retail levels (Table 9). The CVs for individual and all vegetable prices were higher than those for rice and wheat at all three levels of marketing. Although production of tapioca and ginger was relatively stable, CVs of their prices were relatively high. The inverse was true for cabbage and peas. The CVs for the prices of potato, onion, cabbage, cauliflower, lady's finger, peas, and all vegetables were higher at the wholesale and retail levels than at the farm-gate level, indicating that wholesalers and retailers faced higher price fluctuations than farmers. The opposite was true in the case of tapioca, tomato, chili, garlic, and ginger. It is not clear from this analysis if the fluctuation in vegetable prices is helpful to stabilize farmers' overall incomes. There is a need to quantify the association between low production and high prices in a particular year, and vice versa. If such an association is strong, then variation in farm-gate prices is good for farmers in stabilizing their incomes, although it might cause high variation in consumer expenditures for vegetables and thus in vegetable consumption.

Economics of Vegetable Production

The scheme for estimating the cost of cultivation of principal crops (CCPC) was implemented by the Government of India in several states using a detailed cost accounting method. Through a cluster sampling method, 400 farms were selected in each state, and were visited at regular intervals by field investigators. The CCPC scheme has been in operation since 1971–72. After 1983–84, the sample size was increased (to 600 farms) and the coverage was extended to include non-principal crops.

Input Use

Vegetable cultivation concentrates more on irrigated area than does cultivation of cereal crops (Singh and Sikka 1992). Quantities of major inputs used in vegetable cultivation during 1990–91 are reported in Table 10. Data for cereal production are included for comparison. Wide variation in input use across crops and states was observed.

On average, cultivation of one hectare of vegetables requires about 10% more labor than cultivation of one hectare of rice; however, labor needs for vegetable cultivation are about twice those for cultivation of wheat. The small difference in labor use in vegetable and rice may be due to the exclusion of harvesting labor from both the crops in this comparison, which constitutes a major share of labor used in vegetables.

The amounts of fertilizer applied to vegetables (300–500 kg/ha) are two to three times those used on rice or wheat. Except for onion, fertilizer use is generally higher than the recommended level. For example, the recommended level of fertilizer for tomato, eggplant, and cauliflower for the Karnataka state is 275 kg/ha, whereas it is even lower for Tamil Nadu state (IIHR 1989). Pesticides, too, are used in far greater quantities on vegetables than on cereals. However, there is wide variation in fertilizer and pesticide use among vegetables grown in different states.

Table 10. Major input quantities (unit/ha) for the production of major vegetable crops in India during 1990–91

Crop	State	Seed (kg)[1]	Labor (labor hour)	Animal (pair hour)[2]	Fertilizer (kg nutrient)	Manure (t)	Pesticide (INR)	Irrigation (INR)
Potato	Bihar	1245	1473	173	46	1.9	-	208
	Himachal Pradesh	1202	868	134	63	7.0	6	4
	Tamil Nadu	1779	1682	-	1747	6.7	1781	-
	Uttar Pradesh	1647	1588	131	166	7.7	3	381
	West Bengal	2030	2332	408	542	14.0	59	242
Onion	Karnataka	(183)	998	88	60	5.5	-	131
	Maharashtra	(1116)	995	184	111	5.0	46	733
	Tamil Nadu	(298)	996	95	95	2.8	108	463
Cabbage	Himachal Pradesh	(1110)	988	214	431	10.0	675	322
	Karnataka	(835)	815	252	240	13.0	850	410
	Tamil Nadu	1	537	-	683	8.8	1478	-
Cauliflower	Haryana	(1250)	997	270	425	20.0	410	520
	Uttar Pradesh	(1305)	988	260	440	21.0	610	522
	Tamil Nadu	1	858	-	531	12.1	1258	-
Eggplant	Andhra Pradesh	(279)	486	72	489	4.5	327	280
	Tamil Nadu	1	644	57	525	13.0	750	387
Tomato	Karnataka	1	1530	130	420	7.5	410	365
	Madhya Pradesh	1	1640	19	489	15.8	804	670
	Tamil Nadu	1	1525	21	287	10.4	619	59
Chili	Andhra Pradesh	(367)	4139	260	301	4.5	2643	125
Garlic	Assam	(14473)	1031	402	180	7.0	559	2658
Ginger	Kerala	(13500)	1840	250	410	25.0	-	35
Average vegetables		(1634)	1350	131	395	11.3	589	306
Rice	Tamil Nadu	96	1220	206	149	3.3	270	289
Wheat	Haryana	110	680	82	140	1.0	143	385

[1] In the seed column, seed values in INR are given in parenthesis if data on seed quantities are not available.
[2] Includes equivalent machine power.
Source: Government of India (various issues 1981-1992).

Costs and Returns

Costs and returns of major vegetables in the major growing states are reported in Table 11; production costs for rice and wheat are included for comparison. Wide variation was observed in costs and returns of different vegetables grown in different states, depending upon the social and physical infrastructure, and policy environment. Despite these variations, however, the benefit-cost (B-C) ratio (net benefit/total cost) was positive and generally high for all vegetables in all states.

Table 11. Economics of vegetable production in India, 1990–91

Crop	State	Operational cost (INR/ha)	Fixed cost (INR/ha)	Total cost (INR/ha)	Yield (t)	Gross returns (INR/ha)	Net benefit (INR/ha)	B-C ratio	Cost/kg (INR)
Potato	Bihar	4286	3224	7510	11.9	9195	1685	0.22	0.63
	Himachal Pradesh	4020	2313	6333	7.8	8255	1922	0.30	0.81
	Tamil Nadu	7812	2476	10288	18.3	13750	3462	0.34	0.56
	Uttar Pradesh	6787	2147	8934	18.7	12627	3693	0.41	0.48
	West Bengal	7684	3295	10979	19.2	12000	1021	0.09	0.57
Onion	Karnataka	2169	2334	4503	8.3	6709	2206	0.49	0.54
	Maharashtra	5205	2560	7765	14.5	11729	3964	0.51	0.54
	Tamil Nadu	3368	2200	5568	8.2	8353	2785	0.50	0.68
Cabbage	Himachal Pradesh	9230	3250	12480	24.2	19844	7364	0.59	0.52
	Karnataka	7968	1782	9750	18.2	16380	6630	0.68	0.53
	Tamil Nadu	12882	2684	15566	27.1	24379	8813	0.57	0.57
Cauli-	Haryana	13540	2180	15720	11.2	36960	21240	1.35	1.40
flower	Uttar Pradesh	13011	1973	14984	14.8	48100	33116	2.21	1.01
	Tamil Nadu	17236	1763	18999	8.9	28587	9588	0.50	2.13
Eggplant	Andhra Pradesh	3254	1914	5168	10.0	12300	7132	1.38	0.52
	Tamil Nadu	6837	3965	10802	24.1	27844	17042	1.58	0.45
Tomato	Karnataka	5583	2527	8110	19.3	30880	22770	2.81	0.42
	Madhya Pradesh	16481	5039	21520	15.7	32467	10947	0.51	1.37
	Tamil Nadu	8436	2316	10752	14.9	31290	20538	1.91	0.72
Chili	Andhra Pradesh	9966	3000	13662	3.0	18453	4791	0.35	4.53
Garlic	Assam	22535	17059	39594	6.0	78783	39189	0.99	6.59
Ginger	Kerala	22540	636	26323	20.0	60000	33677	1.28	1.31
Average of all vegetables		9583	3211	12969	14.7	24949	11981	0.92	1.22
Rice		7440	2745	10185	3.9	13830	3045	0.30	2.61
Wheat		5658	2706	8364	4.0	14300	5936	0.71	2.09

Source: Government of India (various issues 1981-1992).

Vegetables generate higher net benefit than rice, except for potato production in Bihar, Himachel Pradesh and west Bengal, and onion in Karnataka and Tamil Nadu. On average, vegetable cultivation generates about four times higher net benefit than does rice cultivation, and about a 100% higher benefit than does wheat. The B-C ratio for vegetables is also generally higher than that of rice and wheat. The relative profitability of some vegetables would be even higher if the crop duration were taken into consideration, because some vegetables occupy land for a shorter time. The cost of producing 1 kg of any vegetable (except chili and garlic) is lower than producing the same quantity of rice or wheat.

Production Constraints

Yield Gap

The concept of yield gap can be used to quantify production constraints. The total yield gap is the difference between actual yield achieved by the majority of farmers (called the farmers' modal yield, or MY) and the potentially achievable yield (PAY). It represents the extent to which yield can be improved by alleviating socioeconomic and institutional constraints. The potentially achievable yield (PAY) is estimated as 90% of the best generally attainable yield on research stations, and in adaptive trials, if any (not the maximum yield achieved). Data on research station yields were collected from several publications, and data on actual yield of different vegetables achieved by the majority of the farmers were obtained from the CCPC scheme data.

The total yield gap is divided into two components:

- yield gap 1 is the deviation between the PAY and the highest yield obtained (HYO) at the sample farmers' fields (i.e., from CCPC data series)
- yield gap 2 is the difference between HYO and yield on most of the sample farms (MY)

Both gaps can be expressed in percentage of the PAY. Yield gap 1 largely refers to inefficiency in transferring technologies, while yield gap 2 is due to differences in management efficiency across farms, or to farm-specific constraints. Yield gap analysis is valid only for a given level of technology on research station and farmers' fields.

Yield gap estimates (both in t/ha and in percentage of PAY) for the major vegetables in 1990–91 are presented in Table 12. For all crops, the total yield gap between the PAY and the MY is substantial. Gap 1 is higher than Gap 2 for all crops. Gap 2 is relatively small, though still substantial.

Using slightly different definitions, Singh and Sikka (1992) observed a relatively bigger gap between the experiment yield and average yield at farmers' fields in Himachal Pradesh, ranging from 36% for tomato and 71% for beans. The gap was found to be higher under un-irrigated conditions. The main causes offered to explain the gap were farmers' ignorance about new technology, shortage of critical inputs at the right time and place, and lack of irrigation and institutional credit to small farmers.

Production Constraints

The yield gap observed in major vegetables is caused by several factors, simply called production constraints. Important constraints reported by studies on production of vegetables are listed in Table 13. The most important problems in the production of vegetables are: loss due to pests and diseases, and inadequate and/or unbalanced manuring. Many studies have reported farmers' perception of inadequate manuring as a constraint, although we have observed higher than recommended fertilizer use on most vegetables.

Marketing

In India 90–98% of vegetables are sold (the exceptions being root and tuber crops, where a large proportion is saved for seed). Therefore study of marketing systems is important to help farmers increase their income.

Table 12. Yield gaps in major vegetable crops of India, 1980–91

Crop	State	Variety	PAY	HYO	Gap 1[a]		MY	Gap 2[a]		Total gap[a]	
					t/ha	%		t/ha	%	t/ha	%
Potato	Uttar Pradesh	Great Scot	48.0	30.9	17.2	35.7	18.5	12.4	25.7	29.6	61.4
Tapioca	Kerala	CO 2	36.0	22.6	13.4	37.2	20.0	2.6	7.2	16.0	44.4
Onion	Andhra Pradesh	Bellary Red	35.0	24.0	11.0	31.4	17.3	6.7	19.1	17.7	50.5
Cabbage	Tamil Nadu	Early Autumn	63.0	36.4	26.6	42.2	29.5	6.9	11.0	33.5	53.2
Cauliflower	Maharashtra	Pusal Deepali	45.0	18.2	26.8	59.6	16.0	2.2	4.9	29.0	64.5
Eggplant	Tamil Nadu	CO 2	56.5	21.0	35.5	62.8	15.8	5.2	9.2	40.7	72.0
Lady's finger	Karnataka	Pusa Sawani	20.0	12.5	7.5	37.5	8.5	4.8	20.0	12.3	57.5
Tomato	Karnataka	Pusa Ruby	45.0	29.5	15.5	34.4	16.5	13.6	28.9	29.1	63.3
Peas[1]	Himachal Pradesh	Bonneville	12.0	9.3	2.7	22.5	7.4	2.0	16.3	4.7	38.8
Beans[1]	Tamil Nadu	CO 1	12.4	10.1	2.3	18.6	9.5	0.6	7.7	2.9	26.3
Chili	Tamil Nadu	MDU 1	2.3	1.0	1.3	57.8	0.8	0.2	8.4	1.5	66.2
Garlic	Tamil Nadu	Ooty 1	6.5	3.7	2.8	43.8	3.3	0.4	5.7	3.2	49.5
Ginger	Kerala	Waynad	4.5	2.5	2.0	44.9	2.3	0.21	4.7	2.2	49.6

[a]All percentages were estimated with respect to the PAY.
[1]In terms of fresh fruits (not dry seeds)
Note: PAY = Potentially achievable yield (t/ha); HYO = Highest yield obtained at the farm level (t/ha); MY = Modal yield (t/ha); Yield Gap 1 (t/ha) = PAY (t/ha) – HYO (t/ha); Yield Gap 2 (t/ha) = HYO (t/ha) – MY (t/ha); Total Gap = Gap 1 + Gap 2, or PAY – MY.
Source: Estimated from the primary data collected for Government of India (various issues 1981–1992).

Table 13. Constraints in vegetable production

Vegetable studied	Region[a]	Year	Constraints[b]										Reference
			1	2	3	4	5	6	7	8	9	10	
Cassava	Kerala	1973	*			*	*	*	*	*	*		Kumar & Hirishi (1973)
Cassava	T.N.	1973	*	*		*			*	*		*	Ramaswamy & Muthukrishnan (1980)
Cauliflower	-	1970					*						Madhur & Chauhan (1970)
Eggplant, Lady's finger	T.N.	1991	*	*		*			*	*		*	Banumathy (1991)
Onion	Haryana	1983			*						*		Madan & Sandhu (1983)
Potato	J& K	1972				*	*		*	*			Chohan (1972)
Sweet potato	Punjab	1970							*		*		Pandey & Jauhari (1970)
Tomato	N. India	1976					*	*					Khan & Mishra (1976)
Major veg.	T.N.	1971		*	*				*	*			Palanisamy et al. (1973)
Major veg.	All	1977		*	*				*	*			Premachandra et al. (1977)
Major veg.	Karnataka	1987						*					Edward & Iyengar (1987)

Contd. Table 13.

Vegetable studied	Region[a]	Year	Constraints[b]										Reference
			1	2	3	4	5	6	7	8	9	10	
Major veg.	All India	1989	*	*			*		*	*	*		Shunmugavelu (1989)
Major veg.	H.P.	1992		*	*	*							Singh and Sikka (1992)
Major veg.	H.P.	1994		*	*	*						*	Thakur et al. (1994)
All veg.	India	1975							*	*			Chaudhury (1975)
All veg.	India	1986	*				*	*	*	*	*		Bose & Som (1986)
All veg.	India	1991					*				*		Singh (1991)
All veg.	India	1992	*	*					*	*			Singh & Seshadri (1992)
All veg.	U.P.	1996	*	*		*				*			Arora (1998)

[a] H.P. - Himachal Pradesh; U.P. - Uttar Pradesh; T.N. - Tamil Nadu, J & K - Jammu & Kashmir.

[b] Production constraints are

1. Non-availability of location-specific recommendations; 2. Non-availability of quality seeds; 3. Water-scarcity; 4. Finance scarcity; 5. Inadequate and/or unbalanced manuring; 6. Micronutrient deficiency; 7. Loss due to pests; 8. Loss due to diseases; 9. High variation in yield; 10. High cost of production.

* Shows just that the problem has been reported; no measure of its intensity is available.

Marketing Channels

Seven market channels for vegetables can be identified (Fig. 4):

- I Producer→commission agent→shipper→secondary wholesale trader→retailer→consumer
- II Producer→commission agent→ primary wholesale trader→retailer→consumer
- III Producer→commission agent→retailer→consumer
- IV Producer→primary wholesale trader→retailer→consumer
- V Producer→cooperative (or regulated market)→ primary wholesale trader→retailer→consumer
- VI Producer→cooperative (or regulated market)→retailer→consumer
- VII Producer→cooperative (or regulated market)→consumer

Channel I, involving the shipper, is important for long-distance markets such as onion in Maharashtra, which serves the northern states and the export market, and potato in Haryana, which reaches the south. Commission agents usually buy on behalf of wholesale traders. Whenever a cooperative society or regulated market is successful, Channel V becomes important. Channels VI and VII are the least important because they serve only the immediate neighborhood of production areas.

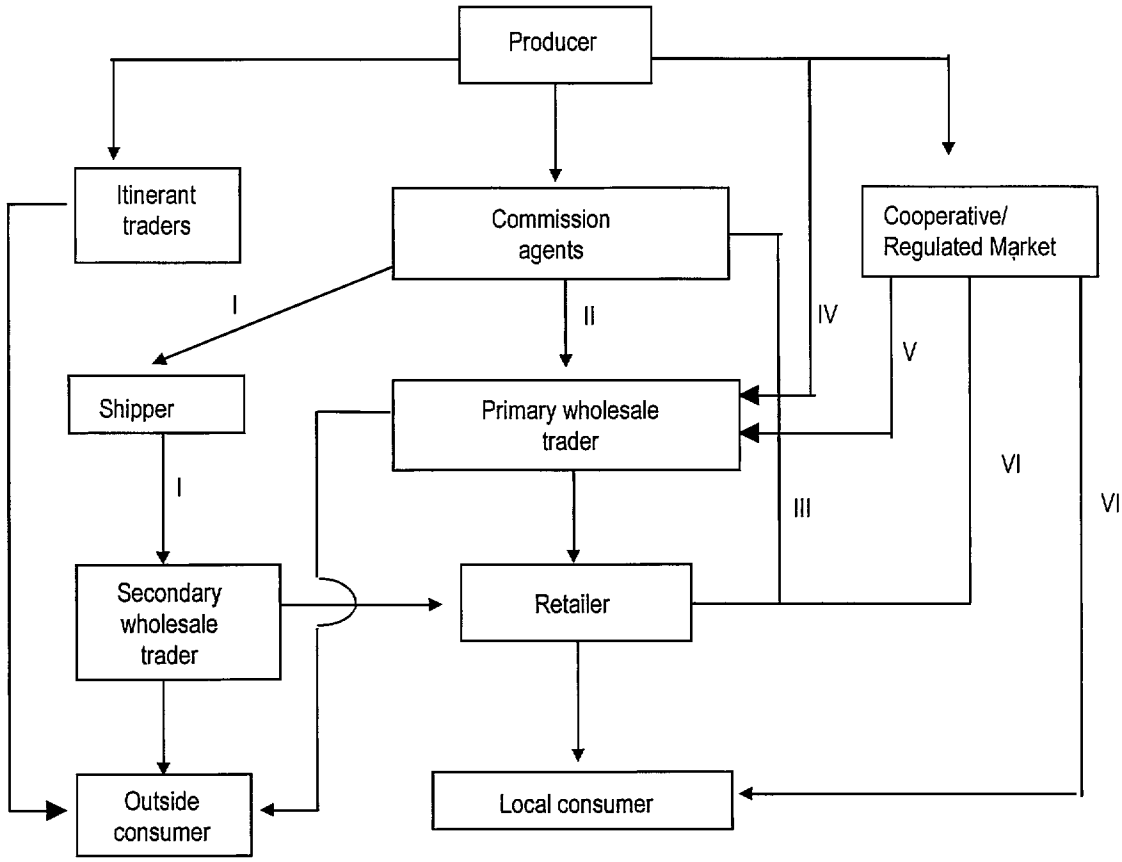

Fig. 4. Market channels for vegetables in India

The percentage of production of selected vegetable that goes through each marketing channel was studied by Jaffarulla (1977) in Karnataka and Chandran (1975) in Tamil Nadu (Table 14). Generally, Channels IV, VI, and VII are less important than Channels I, II, III, and V.

The Indian Institute of Horticulture Research (IIHR 1989) conducted a market study in Karnataka, Andhra Pradesh, and Tamil Nadu. About 92% of the vegetable farmers in Karnataka and 62% in Andhra Pradesh and Tamil Nadu sell their vegetables through commission agents. However, in Andhra Pradesh 22.6% of the farmers sell their output to wholesalers in markets and 15.4% sell their output to retailers in the fields. In Tamil Nadu, 21% of farmers have pre-harvest contracts (all farmers growing cabbage and carrot), one-tenth sell vegetables to retailers (all farmers growing cauliflower) who take the output from their fields, and 5% (farmers growing eggplant) choose wholesalers at the market. In Karnataka, only 3% of farmers make pre-harvest contracts, mostly for cabbage and cauliflower, and 5% (mostly lady's finger farmers) sell their output to retailers in their fields.

Table 14. Distribution or marketed vegetables among different marketing channels (% of output flow)

Channels	Karnataka		Tamil Nadu		
	Eggplant	Tomato	Cabbage	Potato	Tomato
I	-	8.7	0.3	-	28.5
II	3.6	6.0	6.6	7.3	39.7
III	60.2	17.8	21.2	18.9	9.1
IV	6.2	-	-	-	8.8
V	17.7	64.4	61.3	7.0	-
VI	6.2	-	10.5	3.8	4.5
VII	6.1	3.1	0.1	-	9.4
No. of sample farmers	150	200	120	60	250

Sources: Chandran (1975) for Tamil Nadu and Jaffarulla (1977) for Karnataka.

Market Efficiency

For perishable commodities, quick and efficient disposal of produce is very important in order to avoid loss of quality and value. In India, the marketing infrastructure is not developed sufficiently to avoid such losses, so vegetable production is mostly concentrated near consumption centers (so-called peri-urban areas), and is mostly for immediate sale. If any grading and processing is done, it is done by traders and packers, not by farmers (Singh and Sikka 1992). Cooperatives might do some grading on behalf of growers, but their role in the sale of vegetables is limited to a few isolated cases, such as the Nilgiris Vegetable Growers Cooperative Marketing Society, a cooperative in Maharashtra and Punjab. Marketing of vegetables is generally in the hands of private traders, and although they are believed to be extracting excessive profit, this was found not to be the case in Karnataka.

Technical and Price Efficiency

Market efficiency can be defined and measured in a variety of ways. Two interlinked measures are technical efficiency and price efficiency. Technical inefficiency (T) of a channel is defined by the expression (V/(W*d)), where V is variable marketing cost in INR, W is the final weight at delivery in t, and d is the total distance the commodity traveled in km. Price (or economic) efficiency (E) is the marketing agents' profits as a percentage of the variable marketing costs and is defined by the expression $(\Sigma S_k/V)*100$, where S_k is the profit of the *k-th* marketing agent involved in the marketing channel. Another measure of marketing performance is physical efficiency (Q), defined as the ratio of quantity of farm output to the quantity of the same commodity supplied to the consumer (Varadarajan 1993).

The lower the values of T and Q, and the higher the value of E, the greater will be the technical, physical, and economic efficiency, respectively, of the marketing operations. Although the use of any index individually is insufficient, together they may not provide a reasonable assessment of marketing efficiency.

Estimates of T, E, and Q were made for potato and cabbage, tapioca, tomato, onion, and eggplant (Table 15).

Table 15. Efficiency in vegetable marketing

Crop	Channel II[a]			Channel III[a]			Channel IV[a]			Channel V[a]		
	T	E	Q	T	E	Q	T	E	Q	T	E	Q
Potato	31.4	8.2	1.1	28.2	7.1	1.1	26.5	8.4	1.1	21.0*	6.1*	1.1*
Tapioca	47.2	8.2	1.1	37.0	6.4	1.0*	34.3*	3.1*	1.0	-	-	-
Cabbage	27.2	13.8	1.4	31.1	11.5	1.1	26.2	9.3	1.2	19.4*	4.3*	1.1*
Onion	28.9	9.8	1.1	29.6	14.4	1.1	26.0	10.3	1.1	21.7*	6.6*	1.0*
Tomato	37.8	14.2	1.3	32.5*	9.9*	1.1*	45.3	11.7	1.2	-	-	-
Eggplant	30.0*	11.3	1.1	38.3	10.0	1.0*	30.0	8.2*	1.1	-	-	-
Chili	27.2	6.7	1.7	28.0	5.4	1.8	25.4	4.2	1.3	20.2	3.9	1.1
Garlic	16.7	4.9	1.2	20.3	6.9	1.3	15.3	5.3	1.1	13.8	4.7	1.0
Ginger	14.3	4.1	1.3	-	-	-	-	-	-	6.7	1.0	1.1

[a] See section on market channels for the definition of these channels.
* Computed from price spread estimates and the estimate of market losses.
T=INR/t/km; E=(INR/INR)*100; Q=(t at the farm /t for the consumer)

Channel V operated only for potato, cabbage, onion, chili, garlic, and ginger. Whenever Channel V existed, it was the most efficient among the four channels studied. In the absence of Channel V, the most efficient channel was Channel IV for tapioca, potato, cabbage, onion, chili, and garlic, which satisfies all the three efficiency criteria, except one for tapioca. Channel III is most efficient for tomato. For eggplant, no channel could be given an overall ranking, because each of the three channels handling the crop was found to be efficient by one criterion but not by the other two.

Producers' Share in Retail Prices

Another way of defining market efficiency is to estimate the producers' share in the retail price (Table 16). Using macro statistics on prices received by farmers and prices paid by consumers for different vegetables, it can be seen that the producers' share decreased for potato, tapioca, onion, tomato, eggplant, and chili over the period. Producers' share of the consumers' Rupee was relatively high, ranging from 40 to 67% for tapioca, cabbage, cauliflower, pea, chili, garlic, and ginger. For all other crops, around 30% or less of the consumer's Rupee was seen going to producers. Thus, the value added in the marketing process exceeded the farmers' share of the retail price in all vegetables except chili and garlic.

A review of the literature on marketing margin also suggests a decline in producers' share of the consumer's price in all vegetables reviewed except peas (Singh and Kharwal 1995 and Dahiya 1995 in Table 17). Farmers who sold their vegetables directly to consumers received higher shares of the consumers' price than did those who sold their produce through agents. The farmers' share is higher in the off-season than in the harvesting season (Vasisht et al. 1995). The share only marginally differs for the places connected and not connected by a road (Yadav and Pant 1995). The farmers' share can be as high as 87% in onion, 68% in cabbage, and 62% in cauliflower, when they sell their output direct to consumers. But the share can fall to below 50% as more agents are involved in marketing (Mishra et al. 1995, and Baig et al. 1995, in Table 17).

Table 16. Producers' share of consumers' INR (%)

Crop	1980–81	1985–86	1991–92
Potato	27.92	28.42	23.87
Tapioca	44.94	46.22	42.24
Onion	29.76	28.57	27.76
Cabbage	39.74	44.72	41.65
Cauliflower	49.48	46.58	49.50
Tomato	39.09	38.98	33.29
Eggplant	37.50	21.21	26.87
Lady's finger	26.53	28.00	26.87
Pea	48.00	48.40	48.76
Chili	66.64	66.63	64.31
Garlic	51.47	54.40	50.82
Ginger	48.82	47.05	48.77

Source: Computed from data on farm-gate prices and retail prices provided by Department of Economics and Statistics, New Delhi.

Table 17. A review of the producers' share in the consumers' INR in vegetables

Reference	Area covered	Crop	Producers' share (%)	Remarks
Singh and Kharwal	Himachal	Chili	81 (44)	1970 (1994)
(1995)	Pradesh	Cauliflower	62 (47)	1970 (1994)
		Tomato	57 (44)	1970 (1994)
		Peas	80 (80)	1970 (1994)
Dahiya	Allahabad, Unno	Potato	77 (48)	1968 (1983)
(1995)	and Varanasi in UP			
Vasisht et al. (1995)	All India	Potato	35	Harvesting season
			69	Off season
Yadav and Pant	Alwar	Onion	31	Place connected by road
(1995)	Rajasthan		30	Place not connected by road
Mishra et al. (1995)	Kalahandi	Onion	87	Channel K1*
	in Orissa		40	Channel K2
			38	Channel K3
Baig et al. (1995)	Sardar Cuttack	Cabbage	68	Channel S1**
	in Orissa		52	Channel S2
			50	Channel S3
		Cauliflower	61	Channel S1
			48	Channel S2
			41	Channel S3

Contd. Table 17.

Reference	Area covered	Crop	Producers' share (%)	Remarks
Prasad and Krishna (1995)	Bihar	All vegetables	61	-
Jairath et al. (1995)	Rajasthan	Cabbage	81	-
		Cauliflower	62	-
Maurya et al. (1995)	Varanasi in UP	Bhendi	59	-
Dahiya (1995)	Bihar	Potato	42	1980
	All India	Potato	59	1980
Marothia et al. (1996)	Chattisgarh	Tomato	43	Shastri market
	Region of	Eggplant	41	Shastri market
	Madhya	Tomato	48	Subhash market
	Pradesh	Eggplant	54	Subhash market

*The three channels in Kalahandi are:
K1 - Producer-Consumer
K2 - Producer-Village trader-Consumer
K3 - Producer-Village trader-Wholesaler-Retailer-Consumer

**The three channels in Sardar block are:
S1 - Producer-Village trader-Consumer
S2 - Producer-Wholesaler-Retailer-Consumer
S3 - Producer-Village trader-Wholesaler-Retailer-Consumer

Marketing Cost

Marketing cost varies from place to place and among commodities. For example, marketing cost to bring vegetables (based on the average for all vegetables) from field to market place varies from 90.3 INR/t in Tamil Nadu to 212.5 INR/t in Karnataka. Similar variation is observed for individual commodities (Table 18).

Commission charges and transportation are the major marketing costs for farmers. On average these activities consume 39.7% and 34.0%, respectively, of the total marketing cost in Tamil Nadu, and 49.9% and 38.3% in Karnataka. In Uttar Pradesh, transportation, packaging, and commission charges are major costs (Table 18).

The marketing margins as a percentage of sale price were highest at the retail level only in cabbage, at the wholesale level in onion, carrots, and green pea, and at the contractor level in potato, tomato, ginger, cauliflower, radish, and capsicum. Profit in most cases is higher than marketing cost (Table 19).

Table 18. Vegetable marketing cost for cultivators (INR/t) in different states in India

Item	Crops							Average of all vegetables	
	Tomato	Eggplant	Lady's finger	Cabbage	Cauli-flower	Carrot	Beans[1] Gourd	INR	Percent
					Karnataka				
Transport cost	68.7	75.4	56.6	86.3	92.2	92.1	85.8	68.6	38.3
Loading/unloading	15.2	9.2	6.4	14.2	29.9	15.5	13.5	14.2	6.7
Commission charges	117.1	102.3	108.2	107.1	106.0	88.2	118.4	106.1	49.9
Packing charges	13.3	6.6	6.7	5.9	10.6	6.1	5.9	7.7	3.6
Tax and other costs	3.2	4.4	3.7	1.1	-	1.7	3.3	3.2	1.5
Total	217.5	197.9	181.6	214.6	238.7	203.6	226.9	212.5	
					Andhra Pradesh				
Transport cost	36.2	45.8	26.9	-	-	-	57.2	46.1	34.2
Loading/unloading	10.0	22.7	4.5	-	-	-	10.7	14.9	11.1
Commisssion charges	55.6	39.6	107.1	-	-	-	84.9	62.3	46.2
Packing charges	7.3	11.4	6.4	-	-	-	16.4	11.6	8.6
Tax and other costs	-	-	-	-	-	-	-	-	-
Total	109.1	119.6	144.9	-	-	-	171.2	134.9	
					Tamil Nadu				
Transport cost	28.0	25.4	24.8	45.7	70.0	76.0	NS[3]	30.7	34.0
Loading/unloading	6.2	5.1	8.2	8.7	5.0	3.2	NS	6.2	6.9
Commission charges	47.7	18.8	30.7	42.0	120.8	101.4	NS	35.8	39.7
Packing charges	1.6	1.0	25.6	48.3	1.3	2.4	NS	10.8	12.0
Tax and other costs	-	6.8	-	-	-	-	NS	6.8	7.5
Total	83.5	57.1	89.3	144.7	197.1[2]	183.0	NS	90.3	
					Uttar Pradesh				
Transport cost	32.7	-	-	44.5	27.6	70.7	-	43.8	30.0
Packaging	82.8	-	-	33.0	45.6	59.9	-	55.3	37.9
Commission charges	24.0	-	-	22.7	36.4	25.4	-	27.1	18.6
Grading	11.3	-	-	7.4	18.1	16.9	-	13.5	9.2
Tax and other costs	8.1	-	-	4.7	4.4	7.3	-	6.1	4.2
Total	158.9	-	-	112.3	132.1	180.3	-	145.9	

[1] French beans in Karnataka and ridged gourd in Andhra Pradesh.
[2] Based on only one sample, because the rest of all the selected cultivators had sold in the field.
[3] NS = Not studied.
Source: IIHR (1989) for Karnataka, Andhra Pradesh, and Tamil Nadu states.
Arora (1998) for Uttar Pradesh.

Table 19. Marketing cost (INR/t), profit (INR/t), and marketing margin (%) at various marketing stages, 1996

Crop	Contractor			Wholesaler			Retailer			Total [1]		
	Cost	Profit	Margin	Cost	Profit	Margin	Cost	Profit	Margin	Cost	Profit	Margin
Potato	517	845	26	284	670	16	537	533	16	1338	2048	40
Tomato	949	2204	43	683	984	24	765	3765	40	2397	6953	63
Onion	493	700	26	199	2194	57	429	1371	36	1121	4265	33
Ginger	2070	8460	52	357	1589	16	862	3278	25	3289	13327	41
Cabbage	700	230	21	296	507	19	725	1945	34	1721	2682	56
Cauliflower	757	2170	44	249	596	19	736	1454	29	1742	4220	51
Green pea	1365	-10	11	443	1896	21	903	-503	3	2701	1383	19
Carrots	994	1050	35	277	2511	38	562	1098	20	1833	4659	55
Radish	645	3770	69	309	186	20	356	884	42	1310	4840	34
Capsicum	1195	1360	25	527	700	12	820	1270	21	2542	3330	24

Note: Margin at each level was estimated as (sale price—purchase price)/sale price. The total margin was estimated as (cost+profit)/sale price at the retail level.

[1]This was estimated by assuming the commodity passes through the channel of contractor→wholesaler→retailer.

Source: Arora (1998).

International Trade

The quantity and value of vegetable and fruit exports are reported in Table 20. Traditionally, earnings from the export of vegetables significantly exceed those from fruit. Recently, however, increase in fruit exports has been more rapid than for vegetables, thus the share of vegetables in exports has declined. India's exports of fruits and vegetables accounts for only a very small part of world trade in these commodities.

Table 20. Fruit and vegetable export quantities (thousands t) and values (millions INR), and India's share (%) in the world vegetable and fruit trade during 1980–91

Year	Fruits		Vegetables			Total value of fruits & vegetables	Share (%) in world trade
	Value	%	Quantity	Value	%		
1980–81	109.8	25.1	195.3	327.5	74.9	437.3	-
1981–82	125.0	24.9	174.1	377.3	75.1	502.3	-
1982–83	170.1	22.5	188.8	586.7	77.5	756.8	-
1983–84	174.2	23.0	187.4	584.7	77.0	758.9	-
1984–85	501.9	39.8	280.3	758.7	60.2	1260.6	0.70
1985–86	204.4	30.1	211.4	474.3	69.9	678.7	0.60
1986–87	309.4	30.0	266.4	722.2	70.0	1031.6	0.40
1987–88	435.2	43.2	141.5	571.1	56.8	1006.3	0.61
1988–89	369.5	29.0	288.2	905.0	71.0	1274.5	0.45
1989–90	419.3	27.0	360.4	1136.4	73.0	1555.7	0.45
1990–91	1528.2	53.9	302.4	1305.4	46.1	2833.6	0.74
1991–92	2121.7	46.9	381.2	2400.9	53.1	4522.6	0.81

Note: Percentages of vegetables and fruits show the share of these in the total value of fruits and vegetables.

Source: Indian Journal of Marketing 5 (1), 1991, p.31, for years up to 1989-90, and APEDA for the other two years.

The average annual growth rates for exports of vegetables in quantity and value are 6.0% and 13.8%, respectively, largely due to a considerable increase in export value after 1988–89. However, the coefficient of variation is also large. The detrended coefficients of variation in vegetable quantities and value were 28% and 10%, respectively, which indicates the unstable nature of India's vegetable exports and a relatively unsuccessful vegetable export policy. Statistics on vegetable imports are not available, so perhaps India imports no vegetables. However, some exchange may be going on through the porous borders of Nepal, Bangladesh, and Pakistan.

For the period 1990–92 more disaggregated data are available on vegetable exports (Table 21). Onion is the most important vegetable crop exported by India, accounting for about 33% of the total fruit and vegetable exports and for about 70% of the total vegetable exports. Exports of processed vegetables grew from 8% of the total value of vegetable exports in 1990–91 to 14% in 1991–92.

Table 21. Vegetable exports from India by category in 1990–91 and 1991–92

Commodity	1990–91		1991–92	
	Value	%	Value	%
Fresh and frozen vegetables				
Potato	0.74	0.26	0.87	0.19
Onion	90.88	32.07	149.59	33.08
Tomato	0.07	0.02	0.13	0.03
Carrot, turnip, radish	1.51	0.53	0.88	0.19
Cucumber	-	-	0.09	0.92
Legume vegetables	0.02	0.01	0.07	0.02
Processed	4.54	1.60	12.38	2.74
Frozen vegetables	10.62	3.75	12.10	2.68
Sub-group total	108.38	38.25	176.11	38.95
Processed vegetables				
Processed and canned	12.82	4.52	5.81	1.28
Dehydrated onion	1.07	0.38	4.49	0.99
Other dried vegetables	7.45	2.63	12.22	2.70
Other dehy. vegetables	0.82	0.29	41.46	9.17
Sub-group total	22.16	7.82	63.98	14.14
Fruits				
Fresh	72.02	25.42	118.37	26.17
Processed	80.80	28.51	93.80	20.74
Sub-group total	152.82	53.93	212.17	46.91
Total	283.36	100.00	452.26	100.00

The major importers of Indian chili are Canada, Germany, Japan, Russia, Singapore, Sri Lanka, the United Arab Emirates and other Arab countries, the UK, and the USA. A small quantity of chili oleoresin is also exported, but the quantity varies widely between years; the average is 53,000 t per year. The export of dry chili also varies widely, from 1250 to 12,888 t, the average being 6000 t. The export of chili powder started only recently.

India is the world's second largest exporter of garlic. The pungency of Indian garlic is preferred. However, exports are less than 2% of domestic production and probably could be increased substantially if special efforts were made for product promotion.

In the 1960s, India exported between 4000 and 6000 t annually of whole and powdered ginger. Exports had reached 11,485 t by 1980, but declined again to just 2628 t by 1988, and have fluctuated around this level since then. New markets need to be explored. The higher fiber content of Indian ginger compared to its competitor, Jamaican ginger, and the high cost of production, are the major constraints to ginger exports. Ginger oil, ginger oleoresin, dehydrated ginger, bleached ginger, and vitaminized effervescent ginger powder, for use in soft drinks, all have export potential. Therefore, research on high-yielding, low-fiber-content varieties, and on post-harvest technology for processing ginger would help solve problems associated with export of ginger.

Vegetable Processing

Most vegetables produced in India are sold fresh (GOI 1989), and of the total annual output only about 5000–6000 t are used for commercial processing. Fruit and vegetable processing is fairly well spread throughout the country, largely because most processing plants are located close to the production areas. The number of licensed processing units in the country increased from 3629 to 4132 between 1989 and 1993. Total installed capacity of the fruit and vegetable processing industry increased steadily from about 275,000 t in 1980 to 800,000 t in 1990, and 926,000 t by 1993. The important processed vegetable products include canned whole vegetables, pickles and chutneys, preserved and candied vegetables, dehydrated vegetables, and tomato products (puree and ketchup).

Recently, frozen vegetables and tomato pastes have found a market. The quantity of fruit and vegetables being frozen increased from 231,000 t in 1989 to 360,000 t in 1993. Output of the entire processing industry was expected to be around 560,000 t in 1994, showing a compound annual growth rate of 19.4% during the period 1989–94. The growth rates in value of some important processed vegetables during 1989-94 are reported in Table 22.

Table 22. Compound growth rate (%) of processed fruit and vegetable products in India, 1989–94

Product	CGR (%)
Pickles, preserves, and chutneys	22.0
Dehydrated vegetables and fruit	52.0
Frozen fruit and vegetables	3.0
Tomato products	30.3

Source: Indian Food Industry, official files, New Delhi.

However, local processing of vegetables is expensive, hence the very low utilization rate–only about one-third–of fruit and vegetable processing capacity. The fruit and vegetable processing industry has long been dominated by small-scale units. In recent years (after 1989–90), however, several large-scale units have been built, some with foreign collaboration. In 1994, an investment of about 2.5 billion INR was expected to flow into this industry. Up to September 1993, about 90 projects were approved, among them 53 projects planned as Export Oriented Units.

Supply and Demand

Availability

Vegetables play an important role in increasing farmers' incomes and improving the nutritional status of consumers. Most Indians (more than 58%) are vegetarian, in the sense that they consume no animal products other than milk and milk products. In recent years consumption of poultry, eggs, and fish products has increased, but most Indians remain dependent on vegetables as their primary source of vitamins and minerals.

Total annual vegetable production, excluding potato and tapioca, increased at the rate of 6.39% between 1980 and 1994. Although exports increased at 6.11%, the level of exports is so small as to make little difference to net availability of vegetables in India. Population has increased at an annual rate of 2.1%, and annual per capita availability of vegetables has grown at 4.32%; most of the increase occurred between 1981 and 1984. Availability changed little during the late 1980s and early 1990s, but there was another small increase in 1992. Per capita availability of vegetables at the farm gate (excluding potatoes and tapioca) has been around 54 kg/year, or 148 g/day (Table 23).

Table 23. Per capita availability of vegetables in India, 1980–94

Year	Total production[1] (million t)	Exports[2] (million t)	Net availability (million t)	Population (million)	Per capita availability (kg/year)
1980	19.79	0.195	19.59	688.86	28.45
1981	20.65	0.174	20.48	697.79	29.35
1982	21.38	0.189	21.19	711.66	29.77
1983	29.18	0.187	28.99	732.26	39.59
1984	35.15	0.280	34.87	746.74	46.70
1985	38.16	0.211	37.95	766.85	44.49
1986	35.31	0.266	35.04	785.93	44.59
1987	35.05	0.142	34.91	802.70	43.49
1988	38.90	0.288	38.68	819.48	47.20
1989	41.54	0.360	41.18	836.34	49.24
1990	39.09	0.302	38.79	846.19	45.84
1991	41.83	0.381	41.45	862.75	48.04
1992	48.16	0.381	47.77	880.44	54.27
1993	50.55	0.381	50.17	898.50	55.84
1994	49.72	0.381	49.34	916.93	53.81
Growth rate	6.39	6.11	6.99	2.1	4.32

[1] Total vegetable production excludes potatoes, tapioca, and sweet potato, but includes spice vegetables such as onion, garlic, etc.

[2] Due to non-availability of figures, exports for 1992–94 are assumed to be the same as in 1991.

Consumption Level and Pattern

Diet surveys reveal that cereals constitute the bulk of the Indian diet. On average, per capita food consumption in India was 794 g/day in 1990–91, up from 721 g/day in 1977–78. There are differences in consumption levels in rural and urban areas (Table 24), although the patterns of consumption are similar: cereals for the largest part of the diet, followed by livestock products, non-cereal plant foods and vegetables and fruit.

Table 24. Per capita daily food consumption (g) in India, 1978 and 1991

Commodity	1991 Rural	1991 Urban	1991 Overall	1978 Rural	1978 Urban	1978 Overall	Overall change (%)
Cereals and millets	414 (53.2)	401 (48.4)	419 (51.6)	361 (51.6)	352 (47.8)	366 (50.8)	14.5
Non-cereal plant food	86 (11.1)	102 (12.4)	91 (11.5)	74 (10.4)	83 (11.2)	78 (10.8)	16.7
Pulses	39 (4.9)	41 (5.0)	39 (4.0)	33 (4.6)	35 (4.7)	33 (4.6)	18.2
Sugar and jaggery	32 (4.2)	35 (4.2)	33 (4.2)	24 (3.4)	25 (3.4)	24 (3.3)	37.5
Fats and oils	15 (2.0)	26 (3.2)	19 (2.4)	17 (2.4)	23 (3.1)	21 (2.9)	-9.5
Vegetables	83 (10.7)	88 (10.6)	84 (10.6)	74 (10.3)	78 (10.5)	73 (10.1)	15.1
Leafy vegetables	43 (5.6)	47 (5.6)	44 (5.5)	22 (3.2)	23 (3.1)	22 (3.1)	100
Other vegetables	39 (5.1)	42 (5.0)	40 (5.0)	50 (7.1)	54 (7.4)	51 (7.1)	-21.6
Roots and tubers	44 (5.6)	45 (5.5)	45 (5.7)	58 (8.3)	60 (8.1)	59 (8.2)	-23.7
Fruit	23 (3.0)	28 (3.4)	25 (3.1)	22 (3.1)	24 (3.3)	23 (3.2)	8.7
Livestock products	128 (16.4)	163 (19.7)	139 (17.6)	114 (16.3)	140 (19.1)	122 (16.9)	13.9
Milk	110 (14.2)	140 (16.9)	120 (15.2)	98 (14.1)	121 (16.4)	105 (14.6)	14.3
Flesh foods	17 (2.1)	23 (2.8)	19 (2.4)	16 (2.2)	20 (2.7)	17 (2.4)	11.8
Total	778	829	794	699	737	721	10.1

Source: Official files of the National Sample Survey Data.
Figures in parentheses are percentages of the column totals. The last column shows percentage change in the overall consumption of a commodity over the periods.

The diet surveys indicate changes in the consumption patterns of Indian people over this period. There was a drop in consumption of fats and oils, roots and tubers, and other vegetables, while the consumption of leafy vegetables doubled. Overall vegetable consumption increased by only 15%. So the increase in vegetable consumption shown by the diet surveys is far less than suggested by the vegetable production figures.

Demand Elasticities

A sound knowledge of income and price elasticities of demand for vegetables is needed to evaluate the potential effects of policy-induced change on consumption of vegetables. Own-price and income elasticities of demand were estimated by a log-log function of the form:

$$\ln Q_i = \beta_0 + \beta_1 \ln P_i + \beta_2 \ln P_j + \beta_3 \ln Y + e$$

where: Q_i is quantity of vegetable consumed in kg per week per household; P_i is the price (INR/kg) of vegetable $_i$; P_j the price (INR/kg) of a close substitute vegetable $_j$; Y is income (INR per week) of the household; e is random error term; and β is the parameter to be estimated.

The equation was estimated by the Ordinary Least Square (OLS) method. Tomato is taken as a substitute for potato and other vegetables, potato for tapioca, cabbage for cauliflower, and beans (lab-lab) for peas (and vice versa in each case). The estimated parameter values of B_1 and B_2 directly give own- and cross-price elasticities, and B_3 income elasticities of demand. The estimated elasticities are presented in Table 25.

Table 25. Estimated vegetable demand elasticities

Vegetables	Own-price	Cross-price	Income
Potato	-0.4410*	0.2460 *	0.3833*
Tapioca	-0.1506	0.0983	-0.3273*
Onion	-0.3673*	0.1387*	0.4471*
Cabbage	-0.4137*	0.2889*	0.3917*
Cauliflower	-0.3133*	0.3891	1.6991*
Eggplant	-0.5601	1.3210*	0.2028*
Lady's finger	-0.0893	1.4213*	0.4240*
Tomato	-0.4132*	1.9876*	0.6793*
Pea	-0.5713*	0.6983	1.6768*
Bean	-0.5212*	0.5671	1.3291*
Others	-0.3786*	1.3857*	0.8119*

* Indicates statistical significance at 5% level or better.

Own-price elasticities are all negative, as expected, and range from –0.0893 to –0.5713. Their absolute numerical values are less than unity (i.e., price inelastic).

Cross-price elasticities are positive, revealing close substitutability among the various vegetables. However, the coefficients for the cross-price elasticities of demand for tapioca, cauliflower, peas, and beans are not statistically significant, implying that these commodities are not linked in consumption. Substitutions between eggplant and lady's finger, and tomato and other vegetables are significant and coefficient values are higher than unity.

Income elasticities of demand for vegetables are statistically significant and positive for all crops except for tapioca, for which the elasticity is negative and significant. Thus, tapioca is an inferior good. Demand for cauliflower, peas, and beans is highly income elastic, showing that these vegetables are preferred by the relatively rich. The share of income spent on spices is very small, so no separate demand function is estimated for this vegetable category. However, the group of 'other vegetables', where spices are merged, shows a relatively low own-price elasticity, and a positive but inelastic response to income changes. Improvement in marketing efficiency to reduce vegetable retail

prices, without significantly reducing price received by farmers, would be an effective strategy to encourage consumption of vegetables and to simultaneously increase their supply.

Demand elasticities estimated by other studies are reviewed in Table 26. For all vegetables, price elasticities vary within the range –0.21 to –0.57. The price elasticities are higher for urban consumers than for rural consumers (Srinivasan 1987).

Table 26. Review of vegetable demand elasticities in India

Reference	Place/group	Vegetable	Price elasticities	Income elasticities
Ramamurthy (1974)	Orisa	Tomato	-0.3968	0.6977
		Eggplant	-0.6083	0.2364
Banumathy (1991)	Karnataka	Lady's finger	-0.1387	0.4713
Mani and Varadarjan	Tamil Nadu	Eggplant	-0.2961	0.3116
(1989)	(Coimbatore	Lady's finger	-0.0589	0.4965
	District)	Tomato	-0.7231	0.2322
		Carrot	-0.9814	1.3671
		Cauliflower	-0.9876	1.1823
		Beans	-0.1085	1.0746
	Low income (<INR 9,000)	Amaranth	-0.2135	0.9835
	High income (>INR 15,000)	Amaranth	-0.6713	-0.4713
Srinivasan (1987)	All India, rural	All vegetables	-0.2138	0.3836
	All India, urban	All vegetables	-0.4030	0.9654
Nagarajan (1994)	Tamil Nadu State	All vegetables	-0.5658	0.9907

The demand for most vegetables is inelastic with respect to increase in consumers' income (income elasticities are less than one), except for carrot, cauliflower, beans, all vegetables for urban consumers, and all vegetables in Tamil Nadu. Especially, demand for vegetables in rural areas, where most Indians reside, is inelastic with respect to income increases, indicating the relatively small role that higher income might play in enhancing vegetable consumption among the rural people.

Government Policies

Projection of Vegetable Production

An estimate from the Indian Government's Eighth Plan (GOI 1989) showed that in 1988 the total area under all vegetables in the country was 4 million ha, production was 45 million t, and average productivity was 11.5 t/ha. Area, production, and productivity of vegetables in 1995 was projected to be 6 million ha, 75 million t, and 12.5 t/ha, respectively. Corresponding projections for the year 2000 are 8 million ha, 120 million t, and 15 t/ha, respectively. However, these projections were not achieved. More precise supply and demand parameters are required to make such projections more accurate in the future.

Chemical Use in Vegetable Production

There is a general belief among farmers, consumers, and even scientists that the use of large quantities of chemical fertilizers in vegetable production adversely affects the quality of vegetables and spoils their taste. This has encouraged wide appreciation for the concept of organic farming.

To achieve the required increase in yield, the proposal of Singh (1991) to increase nutrient management should be carefully evaluated, as fertilizer use in vegetable production is high. Perhaps soil nutrient efficiency, rather than nutrient levels, is now more important. The optimum application rates vary among different regions because soil fertility varies, so fertilizer recommendations need to be location specific and based on soil tests. Although there are 450 soil testing laboratories in the country, they are little used by vegetable growers. In the compendium of fertilizer recommendations developed by the soil test crop response correlation project of the Indian Council of Agricultural Research (ICAR), more than 100 fertilizer prescriptions are documented, but only a few deal with vegetables.

Vegetable productivity is affected by the infestation of many pests and diseases. Available chemical plant protection methods do not reduce damage and losses due to such pests as shoot and fruit borers in eggplant, Lady's finger, and tomato, and fruitflies in cucurbits. At the same time, the problem of pesticide residues is acute because of the indiscriminate use of often inappropriate pesticides. Pest and disease tolerant/resistant varieties are available only for a limited number of vegetable crops. A detailed crop-specific review of causes of low yield can be found in Singh and Seshadri (1992).

Seed Quality

The Indian Council of Agricultural Research (ICAR), and agricultural universities recommend nearly 100 varieties of different vegetable species for growing in India. However, the National Seeds Corporation cannot handle the multiplication and distribution of certified seeds of such a large number of varieties. Yields of vegetable crops could be dramatically increased if pure seeds of guaranteed quality, or seeds of improved varieties, could be made available. Use of improved varieties alone could increase vegetable yields by up to 30% (Chaudhury 1975).

Infrastructure

Vegetables are bulky and perishable commodities, so post-harvest handling costs are high. Seasonality in production causes further instability in prices if adequate storage facilities are not available. Traders' manipulations result in low prices to the growers and high prices for the consumers. Traders encourage pre-harvest contracts and advance credit or input supplies as part of tied sales agreements. Very little of the surplus produce is processed, because modern methods of preservation are expensive, and consumers prefer fresh vegetables to processed vegetables. In recent years a few cooperative markets have been organized to facilitate vertical integration and cost-effectiveness of the marketing system. There have been only a few success stories (Noga, Kissan, Apna, Mandi, others).

The ICAR (1987) implemented a Coordinated Research Project on Post-Harvest Technology of Horticultural Crops, with five main objectives:

- improvement of pre-harvest and harvesting techniques

- improvement of systems of pre-cooling, packaging, and transport of vegetables and fruit
- development of appropriate storage techniques
- processing
- utilization (recycling) of wastes.

Research

With the launch of the All India Coordinated Crop Improvement Project in 1970–71, research on vegetable crops was streamlined. Under the project, many research centers across the country have been working on yield improvement, resistance to pests and diseases, and adapted varieties for different soil conditions. More attention is now being paid to the development of F_1 hybrids that are more stable and tolerant to major diseases under varied agroclimatic conditions. A major breakthrough has been made in the production of F_1 hybrid tomato and other major crops.

Government Support

The quest for self-sufficiency in staple foods has long dominated the Indian agricultural development scene. Policy-makers shifted their attention to the quality of food to overcome the problems of malnutrition, and vegetable production received special attention from the Fourth Five-Year Plan onwards. In 1981, the Government of India set up a study group on Perishable Agricultural Commodities. Important recommendations made by the group were that:

1. an institutional framework should be set up consisting of a National Horticultural Board (under the Societies Act, 1960);
2. priority should be given to major vegetable crops for yield improvement; among these are potato, onion, tomato, cauliflower, and cabbage;
3. the National Dairy Development Board should assume responsibility for restructuring vegetable oil production and processing along cooperative lines;
4. arrangements should be made for the production and distribution of quality seeds.

Most of these recommendations have been put into practice with success, and vegetable production and distribution improved, although slowly, up to the late 1980s.

Under a scheme for fruit and vegetable processing (F&VP), assistance is provided to state government organizations, cooperatives, and others to set up food processing units and to develop facilities for post-harvest handling and storage of vegetables. To ensure adequate supplies of raw materials to the processing units, contract farming is encouraged. According to the guidelines of the commerce ministry, agro-based export units in the primary production of fresh fruit, vegetables, floriculture, horticulture, etc., are eligible to sell 50% of their produce in the domestic tariff area. The government has delicensed the industry and has also permitted 51% equity participation by foreign investors.

Specific Implications

Discussions and literature reviews in the earlier sections of this paper have some implications for future policy and research.

The following areas of research need priority:

1. screening and identification of vegetables for improved production, processing, disease and pest resistance, and stress tolerance (and conservation and utilization of genetic resources)

2. development of varieties for specific vegetable-growing zones, for processing and export

3. breeding for resistance to major diseases and pests

4. use of biotechnology for the transfer of genes for resistance, root modulation, and some other specific traits, and for clonal multiplication of hybrid cultures

5. development of region-specific packages of cultivation practices for major vegetables

6. water management technology for humid and dryland conditions for major vegetable crops

7. determination of maturity standards for harvesting for processing and the fresh market

8. development of low-cost technologies for processing and preservation

9. standardization of seed production technology for self- and cross-pollinated vegetables and hybrid seed production

10. systematic study of the effect of fertilizers on crop quality and post-harvest shelf-life under farmers' conditions

11. in view of the increasing price of chemical fertilizers, particularly P and K, extensive research on foliar fertilization needs to be undertaken, particularly on broad-leafed, densely planted crops.

Export Push

1. There is strong demand in international markets for some high-value vegetables. Due to low labor costs and diverse agroclimatic conditions, India can produce many vegetables at costs that are well below those in developed countries. The following vegetables need greater attention from an export point of view:

    - French bean and lima bean: fresh for the domestic and Gulf markets, and processed and frozen for European markets

    - sweet corn: fresh for domestic and Gulf markets, and processed for world markets

    - asparagus: fresh for domestic and Gulf markets

    - bell pepper: fresh for domestic and Gulf markets

- brussels sprouts: fresh for European markets
- broccoli: fresh for European markets.

Development of high-yielding varieties, cost-effective post-harvest technologies, promotion of products suitable for export (such as low-pungency chili, and ginger with low fiber content), identification of potential markets, compulsory quality control, and policies to stabilize production and export are suggested in order to improve production and export of spice vegetables.

2. Adequate protection of breeders' and farmers' rights must be established in sui-generis legislation on vegetable breeding and seed production.

3. Food and nutritional policies should pay attention to the problem of malnutrition and aim at achieving nutrition security at the household level.

4. With the policies listed above, it is possible to remain self-sufficient in vegetable production at higher consumption levels. The real challenge is in achieving more efficient vegetable processing, and generating additional vegetable demand. This would require:

   - maintenance of growth in the number of processing units
   - improved capacity utilization of the processing industry
   - strict quality control to retain overseas markets
   - cost reduction to make processed products available at reasonable prices to domestic consumers
   - nutrition education to increase awareness among consumers regarding the importance of balanced diets, with special emphasis on child nutrition.

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INDONESIA

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Introduction

Indonesia extends from latitudes 6° N to 11° S and from longitudes 95° W to 141° E. The greatest distance from west to east is 5110 km, and the greatest distance north to south is 1888 km. The Indonesian archipelago comprises 13,000 islands, the five largest being Sumatra, Java, Borneo (Kalimantan), Sulawesi, and Irian Jaya (Fig. 1).

The country's 1990 census counted 179.4 million people. Between 1970 and 1993, overall gross domestic product (GDP) and agricultural GDP grew at 3.8% and 2.3%, respectively, while the population grew at 2.1% annually. Per capita income was about US$740 in 1993 (CBS 1994a). In 1993, about 65% of the population lived in rural areas, down from 78% in 1980 (CBS 1993a).

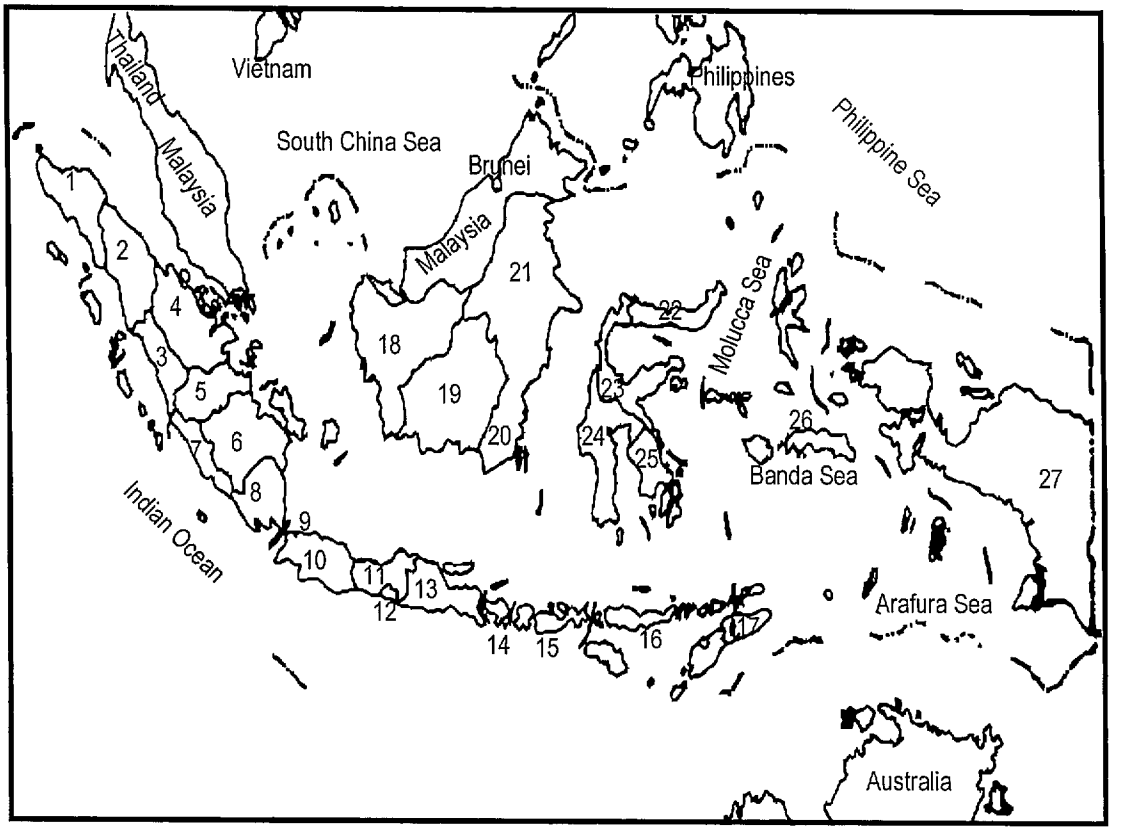
The population is dispersed unevenly throughout the country's 27 provinces. About 60% of the population resides on Java, but Kalimantan, which accounts for 28% of Indonesia's total land area, is home to only 5% of the population. The population density on Java is 814 people per km^2, but Irian Jaya has only 7 people per km^2. Average availability of cultivable land is about 0.467 ha per household on Java and 1.92 ha per household on Kalimantan (CBS 1993a).

The agriculture share in GDP has steadily declined from 37% in 1969 to 18% in 1992. There has been an absolute increase in agricultural employment, from 27 million people in 1971 to 41 million people in 1989, but over the same period agriculture's share of the labor force gradually fell from 64% to 54%. Within the agricultural sector, the food crop subsector employed about 28 million people, or 81% of agricultural labor force, in the 1980s, but by 1990 this figure had decreased to about 27 million, or 75% of the agricultural labor force (CBS 1992a).

The major crops grown in Indonesia are rice, maize, soybean, peanut, cassava, and chili. The area under vegetable cultivation during 1993, excluding potato and sweet potato but including onion, garlic and chili, was 775,000 ha, or about 3.7% of the total cropped area. This produced 4.3 million t of vegetables, worth more than US$1 billion. Average yields of vegetables were in the neighborhood of 5.6 t/ha. This translated into per capita availability of vegetables (excluding potato, sweet potato, and export of vegetables) of about 22 kg per annum, or 60 g per day, which is only 30% of the recommended vegetable consumption of 200 g per day. The main vegetables grown in the country are chili, yard long bean, shallot, cabbage, kidney bean, cucumber, Chinese cabbage, green mustard,

leek, spinach, French bean, eggplant, garlic, and carrot. Vegetable cultivation is concentrated on Java.

In 1993–94, average per capita food consumption was about 712 g per day, of which cereals and tubers made up 41.6%, oils and fats 38.3%, vegetables 5.3%, fruits 3.3%, livestock products 3.6%, legumes 2.6%, and miscellaneous other foods the remaining 5.3%. (CBS 1993a).



1. Daerah Istimewa Aceh
2. Sumatra Utara
3. Sumatra Barat
4. Riau
5. Jambi
6. Sumatra Selatan
7. Bengkulu
8. Lampung
9. DKI. Jakarta
10. Java Barat
11. Java Tengah
12. Daerah Istimewa Yogyakarta
13. Java Timur
14. Bali
15. Nusa Tenggara Barat
16. Nusa Tenggara Timur
17. Timor-Timur
18. Kalimantan Barat
19. Kalimantan Tengah
20. Kalimantan Selatan
21. Kalimantan Timur
22. Sulawesi Utara
23. Sulawesi Tengah
24. Sulawesi Selatan
25. Sulawesi Tenggara
26. Maluku
27. Irian Jaya

Fig. 1. Map of Indonesia

Indonesia has two seasons: the dry season and the wet or rainy season. The seasons are closely related to wind direction: from June to September dry winds coming from the direction of Australia bring the dry season, and in December to March, winds from Asia and the Pacific Ocean create the rainy season.

The temperature in Indonesia varies depending on altitude and distance from the sea; average temperatures are 28°C near the coasts and around 22°C in the mountainous areas.

Production Systems

The vegetable planting area in Indonesia can be divided into three categories: lowland (altitude 0–200 m), medium land (altitude 201–800 m), and highland (altitude above 800 m). Of the 16.6 million ha of cultivated land, about 30% is in the highlands (Bahar 1992).

Six situations can be distinguished regarding horticultural production and cropping systems. In the following general classification, temperature (as related to altitude) and commercialization (indicated by proximity to urban consumption centers) are the main variables.

In the highlands one can distinguish between:

i. Intensive and commercialized farming systems. These are located in relatively homogeneous production areas such as the mountainous areas around Bandung, Malang and many others places

ii. Less intensive farming systems, often in the remote highlands. Here there is commercial production of horticultural crops, often in combination with perennial crops, fruit trees, and secondary food crops.

In the medium altitude areas the following major vegetable production system can be distinguished:

i. Farms close to urban markets. These fully commercialized systems produce large volumes of high-value horticultural crops. Some crops (including potato, cabbage, and onions, which came from temperate zones and are usually grown in the highlands) have been adapted to the somewhat higher temperatures of medium altitudes. Other crops, such as peppers and leafy vegetables, are more typically tropical horticultural commodities, and some of them can be grown in the medium altitude areas.

ii. Farms further away from urban markets. These farms grow relatively fewer perishable crops because of increasing transportation costs, risk, and other reasons.

In the rainfed lowland areas, horticultural commodities have to compete with less labor intensive crops such as rice, cassava, soybean, corn, and peanut. In the lowlands one can distinguish between:

i. Intensive, highly commercialized systems, including the production of leafy vegetables, such as kangkong.

ii. Less intensive systems, in combination with cereals.

Regional Distribution

The major vegetable-producing areas of Indonesia are in west, central, and east Java (Table 1).

Table 1. Regional distribution of vegetable area and production in Indonesia, 1980–1993

Year	Area (000 ha)							Production (000 t)						
	W.Java		C.Java		E.Java		Total	W.Java		C.Java		E.Java		Total
	Area	%	Area	%	Area	%		Prod.	%	Prod.	%	Prod.	%	
1980	172.3	25.6	125.2	18.6	114.6	17.0	673.0	769.9	36.2	312.0	14.7	196.3	9.2	2127.0
1981	171.8	26.2	122.8	18.7	119.9	18.3	655.8	424.9	23.2	140.8	7.7	81.0	4.4	1833.5
1982	217.0	27.2	108.6	13.6	143.0	17.9	797.4	644.9	33.9	172.2	9.0	126.4	6.6	1903.4
1983	188.8	25.6	126.4	17.1	125.3	17.0	737.9	783.5	31.7	403.8	16.3	299.8	12.1	2473.5
1984	298.5	28.6	232.7	22.3	195.8	18.8	1043.0	1044.0	32.2	575.4	17.8	400.7	12.4	3238.6
1985	278.2	26.1	202.4	19.0	196.8	18.5	1065.0	1081.1	30.3	651.0	18.3	517.4	14.5	3562.3
1986	302.1	24.6	224.3	18.2	208.0	16.9	1230.0	1254.5	30.1	752.2	18.0	506.5	12.1	4170.1
1987	164.1	17.1	118.3	12.3	107.6	11.2	958.9	1452.2	34.9	740.3	17.8	1099.6	26.4	4164.8
1988	340.5	27.5	162.5	13.1	209.5	16.9	1237.1	1600.3	38.5	614.7	14.8	639.0	15.4	4160.7
1989	321.6	20.5	232.0	14.8	208.6	13.3	1566.9	1590.2	32.7	864.4	17.8	673.1	13.8	4868.1
1990	197.7	24.3	151.9	18.6	113.9	14.0	815.2	1348.3	29.4	1103.0	24.1	511.6	11.2	4580.8
1991	178.0	21.5	149.2	18.1	115.0	13.9	826.4	1191.9	26.7	885.7	19.9	556.7	12.5	4461.0
1992	200.8	23.6	142.5	16.8	122.5	14.4	849.7	1619.6	32.0	981.0	19.4	658.7	13.0	5055.6
1993	197.5	23.9	192.9	23.4	114.2	13.8	825.9	1551.2	30.1	1133.1	22.0	651.2	12.7	5146.1
Growth rate (%)	0.5	-1.4	2.2	0.3	-0.6	-2.5	1.9	8.0	-0.12	13.6	5.4	13.1	5.0	8.1

Figures are for all vegetables, including potatoes
Source: CBS (1993a).

Between 1980 and 1993, Java's overall contribution to total vegetable area and production in Indonesia remained steady at around 60%, indicating that this area still supplies most of the country's vegetables. This dependency on Java's performance has been attributed to the concentration of irrigation investment in Java.

Cultivation Period, Ecology, Cropping Regions, Cropping Patterns, and Varieties

Table 2 shows cropping patterns, cultivation times, varieties, and regional distribution of major vegetables in Indonesia. Most vegetables are grown during the dry season (March–April) and harvested before the start of monsoon in July–August; a few vegetables are grown year-round. This strong bias for growing vegetables in the dry season, combined with the short shelf life of most vegetables, creates serious shortages in supply during the hot rainy season. Most of the farmers grow traditional varieties of vegetables, although some commercial varieties are also used.

Table 2. Cropping pattern, cultivation time, varieties, and regional distribution of major vegetables in Indonesia

Vegetable	Cultivation month	Harvesting month	Ecology	Variety	Cropping pattern	Province/Region (Production share in %)
Bean	March/ April	May/ June	Upland Lowland	Local variety: Surakarta Rich green Manoa wonder Hawaiian wonder	Monoculture/ diversified	West Java (19.1) Central Java (30.7) East Java (11.9) North Sumatra (11.8) Bengkulu (6.8)
Cabbage	March/ October	June/ January	Upland	Yoshin, Pujon, Saigon, KK. cross Ky. cross	Monoculture	West Java (27.6) Central Java (26.8) East Java (13.1) North Sumatra (12.3) Bengkulu (7.6)
Carrot	March/ April	July/ August	Upland	Local variety: –Cipanas –Lembang	Monoculture/ diversified	West Java (56.0) Central Java (15.9) East Java (9.3) North Sumatra (11.0) Bali (3.1)
Chili	April	August	Lowland	Capsicum annuum Capsicum fru-tescens	Monoculture/ diversified	West Java (18.9) East Java (17. 7) Central Java (17.4) North Sumatra (12.8)
Garlic	March/ April	July/ August	Upland Lowland	Local variety: –Lumbu Hijau –Lumbu Kuning –Tawangmangu –Layur	Monoculture	Central Java (48.6) East Java (19.9) Bali (10.6) Nusa Tenggara Barat (7.0) North Sumatra (4.7)
Gourd/ pumpkin	March/ April	June/ July	Lowland Upland	Local variety: Bandung	Diversified	West Java (43.6) Central Java (7.8) Riau (6.1) Bali (4.6) North Sumatra (4.0)
Leek	March/ April	July/ August	Upland	Local variety: Lembang	Monoculture/ diversified	West Java (53.7) East Java (13.7) Central Java (13.6) North Sumatra (4.2) North Sulawesi (3.3)
Onion	May/ June	August/ September	Lowland Upland	Local variety: Sumenep, Medan, Maja	Monoculture	Central Java (35.5) East Java (24.4) West Java (17.2) Nusa Tenggara Barat (7.9) North Sumatra (4.7)
Petsai	March/ October	May/ December	Upland	Hybrid naga oka Naga oka king	Monocul-ture	West Java (31.7) Central Java (17.7) East Java (6.4) North Sumatra (11.1) Bali (5.0)

Cont. Table 2.

Vegetable	Cultivation month	Harvesting month	Ecology	Variety	Cropping pattern	Province/Region & (Production share in %)
Potato	March/ April	July/ August	Upland	Granola Cipanas Cosima Segunung	Monoculture	West Java (27.4) Central Java (25.4) East Java (16.5) North Sumatra (17.8) West Sumatra (3.4)
Tomato	April	July/ August	Upland Lowland	Mutiara Precious F-1 Gondol	Monoculture/ diversified	West Java (30.7) East Java (4.9) Central Java (4.3) North Sumatra (27.3) Bengkulu (7.9)

Source: 1) Directorate for Production Development, Ministry of Agriculture.
2) Nusa Tengara Agricultural Research Development Project, AARD (Agency for Agricultural Research Development).

Trend Analysis

Production

Between 1980 and 1994, the planted area of all vegetables, excluding potato but including chili, onion, and garlic, increased from about 649,000 ha to about 775,000 ha, and production increased from about 1.9 million t to 4.3 million t. This is explained mainly by the near doubling of yield of all vegetables over this period, from 2.9 t/ha in 1980 to 5.6 t/ha in 1994, which was largely a result of increases in the proportion of area devoted to multi-harvestable vegetables. The area peaked at 1.5 million ha in 1989. Since then it has declined to just over half of this level. However, total production has remained at around 4 million t in the 1990s.

The results of the trend analysis on area, yield, and production of major vegetable crops are given in Table 3. For all individual vegetables, except Chinese radish, area increased significantly in the 1980s, then declined and stayed at a low level during the 1990s. This is reflected by a negative coefficient of the square term for area. The same is true for production, although the coefficient of the square term is relatively small, which indicates a stagnation rather than a decline in vegetable production during the 1990s. There was a general increase in vegetable yields. Yields of Chinese cabbage, carrots, chili, French beans, and yard long bean increased linearly. On the other hand, the yields of kidney beans, tomato, eggplant, cucumber, swamp cabbage, and spinach increased quadratically, as only the square term is positive and significant in these cases. However, shallots, leeks, potato, cabbage, Chinese radish, and garlic yields increased in the 1980s, and then stagnated during the 1990s, indicated by the negative square term. Despite the achievements during the 1980s, yield levels are still low. As an example, the average national yields of tomatoes and eggplant in Indonesia in 1993 were 4.65 and 2.46 t/ha, respectively, compared to 8.5 and 6.4 t/ha in the Philippines (Librero and Rola 2000).

Table 3. Trend analysis (%) in total and individual vegetable area, production, and yield during 1980–93

Crop	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
All vegetables	0.1970	-0.0118	0.1782	-0.0064	_	0.0042
Cabbage	0.0517	_	0.1901	-0.0051	0.1736	-0.0076
Carrot	0.1042	_	0.1391	_	0.0340	_
Chinese cabbage	0.0595	_	0.1100	_	0.0490	_
Chili	0.2029	-0.0137	0.2395	-0.0132	0.0420	_
Chinese radish	-0.1667	0.0117	-0.0937	0.0103	0.1043	-0.0032
Cucumber	0.1804	-0.0105	0.1534	-0.0072	_	0.0019
Eggplant	0.2502	-0.0187	0.1896	-0.0140	_	0.0011
French bean	0.2140	-0.0112	0.2305	-0.0110	0.0220	_
Garlic	0.3088	-0.0127	0.4875	-0.0210	0.1787	-0.0083
Leek	0.0435	_	0.1118	_	0.1804	-0.0079
Potato	0.0541	_	0.1063	_	0.1095	-0.0035
Pumpkin	0.4592	-0.0388	0.5994	-0.0473	_	_
Red/kidney bean	0.0281	_	0.0449	_	_	0.0017
Shallot	0.0264	_	0.0898	_	0.1344	-0.0048
Spinach	0.2323	-0.0167	0.2412	-0.0149	_	0.0024
Swamp cabbage	0.3435	-0.0288	0.3065	-0.0235	_	0.0026
Tomato	0.2037	-0.0107	0.0748	_	_	0.0026
Yard long bean	_	-0.0054	0.2372	-0.0177	0.0720	_

– implies that the coefficient is not significant at the 5% level.

Prices

During 1983–94, nominal vegetable prices (except for onion) in Indonesia rose as fast as, or faster than, the consumer price index (CPI) for food (Table 4), indicating that, on average, vegetables have become more expensive compared to other food items. This is true for both the producer and retail prices. Leek and eggplant prices increased more sharply than did prices for other vegetables.

Table 4. Trend in nominal and deflated prices of selected vegetables (% per annum) in Indonesia, 1983–94

Vegetable	Nominal		Deflated[1]	
	Producers' price	Retail price	Producers' price	Retail price
All vegetables[2]	9.81	9.92	2.04	2.01
Cabbage	10.66	10.47	2.23 ns	2.04 ns
Carrot	9.31	9.64	0.88 ns	1.21 ns
Chili	10.19	10.32	1.76	1.89
Consumer price index (food)	-	8.43	-	-
Eggplant	12.95	13.02	4.52	4.59

Contd. Table 4.

Vegetable	Nominal		Deflated[1]	
	Producers' price	Retail price	Producers' price	Retail price
Leek	14.01	13.81	5.57	4.98
Onion	7.58	7.48	-0.86 ns	-0.95 ns
Potato	9.49	8.61	1.06ns	0.18 ns
String bean	10.21	9.96	1.78	1.53
Tomato	8.25	8.21	-0.18 ns	-0.22 ns

[1] Deflated prices were estimated by dividing the nominal prices with the consumer price index for food.
[2] All-vegetables price was developed from the individual prices using Layspeyres Index, instead of using the CBS vegetable price index, because the latter includes potato and bean prices.
All trend coefficients, except those bearing the "ns" sign, are significant at least at the 10% level.
Source: CBS (1994b), data processed

The increase in nominal prices, at a rate higher than the CPI, leads to an increase in the deflated or real prices of many individual vegetables and vegetables as a group. The deflated prices for eggplants, leeks, string beans, and chili increased in real terms during 1983-94, and no vegetable price showed a significant negative growth rate during this period. The deflated price of vegetables as a group increased at about 2% per annum. The pressure on prices increased, especially during 1992-94 when prices drifted up by about 20% (Fig. 2).

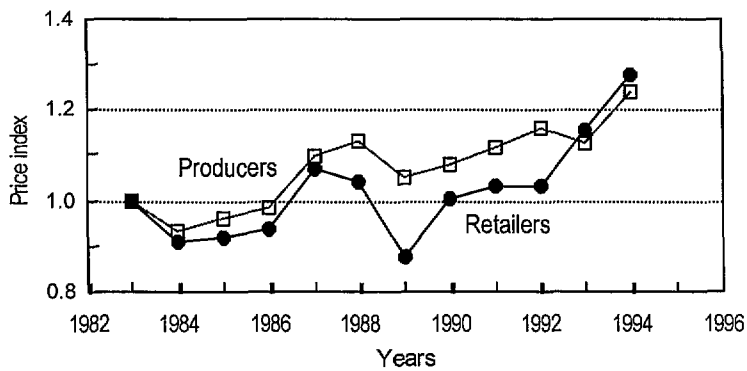


Fig. 2. Producers' and retailers' deflated price trend of vegetables in Indonesia, 1983–94

Risk in Vegetable Production

Detrended coefficient of variation (CV) in area, production, and yield of different vegetables are reported in Table 5. Variability in vegetable area, production, and yield was higher than the corresponding coefficients in rice in all cases, indicating that vegetable production is many times more risky than rice production. This might be because rice is considered a political crop, and its stability is supported by government policies such as an assured minimum price. Vegetable growers enjoy no such policy support.

In most vegetables, except for leeks, potato, cabbage, and kidney beans, variability in area is much higher than variability in yield. This suggests that government policies aimed at stabilizing area can

help more to stabilize vegetable production than can technologies which help to reduce variability in yield. However, the detrended CV in yield is also quite high (compared to rice), suggesting that technologies, such as resistant and tolerant varieties and improved management practices (e.g., protected vegetable cultivation) can also substantially reduce production variation by stabilizing yields.

Table 5. Detrended CV in area, production, and yield of selected vegetables in Indonesia during 1980–93

Name of vegetable	Area	Production	Yield	Prices	
				Producers	Retail
Shallot	7.4	9.3	6.0	NA	NA
Leek	7.2	12.7	13.1	58.5	44.3
Potato	9.2	14.7	9.5	29.9	25.3
Cabbage	7.5	9.4	9.6	26.8	42.9
Chinese cabbage	6.1	11.8	5.7	NA	NA
Carrot	10.8	17.4	8.9	20.4	35.5
Chinese radish	20.9	25.1	10.4	NA	NA
Red/kidney bean	15.7	22.7	20.0	NA	NA
Chili	39.6	25.3	26.4	8.6	12.9
Tomato	24.9	10.8	16.9	16.3	18.7
Eggplant	36.1	22.9	20.5	5.4	8.5
French bean	28.2	20.2	12.7	5.0	5.9
Cucumber	27.2	14.3	12.7	12.9	NA
Garlic	13.3	12.8	9.9	NA	NA
Onion	NA	NA	NA	20.5	21.6
Yard long bean	34.6	25.5	19.7	NA	NA
Pumpkin	62.1	66.3	36.5	NA	NA
Swamp cabbage	45.5	33.8	17.1	NA	NA
Spinach	25.4	17.8	12.1	NA	NA
All vegetables	25.9	9.9	17.1	15.3	11.0
Rice	2.3	2.1	1.7	4.9	12.1

NA implies that data are not available.
Source: CBS (1993b). Data Processed.

The high variability in the production of pumpkins, swamp cabbage, yard long beans, chili, Chinese radish, eggplant, kidney beans, and French beans is mainly due to high variability in area. Yield is most unstable in pumpkin, chili, eggplant, kidney beans, and yard long beans.

High variability in production generally leads to high, unstable prices (Table 5). Variability in producers' price is higher in each vegetable, and also higher for vegetables as a group, than producers' price variability of rice. With few exceptions, this is also true at the retail level, although variability in rice price is also high.

Seasonality in Vegetable Prices

Each vegetable experiences a peak price period (Table 6). Although prices for individual vegetables reach peaks at different times of the year, still there is seasonality in all vegetables as a group.

Table 6. Seasonality in the retail prices of vegetables, fruits, meat, and rice in Indonesia (average 1983-94)

Commodity	Month												Seasonality
	1	2	3	4	5	6	7	8	9	10	11	12	
Shallot	100	119.0	153.8	168.5	173.6	154.4	143.8	127.8	107.1	105.3	122.6	128.3	73.6
Carrot	100	97.3	91.4	87.6	102.3	118.9	117.6	119.0	123.5	140.3	133.5	130.7	60.2
Potato	100	104.3	111.3	116.2	124.4	137.1	144.5	140.5	141.0	135.4	128.9	121.9	44.5
Tomato	100	104.1	107.1	109.8	119.6	115.6	112.4	89.5	93.8	99.4	103.4	123.3	37.8
Leek	100	107.9	110.1	111.9	121.6	130.3	135.8	133.2	129.3	133.6	136.6	136.5	36.6
Citrus	100	101.3	102.4	102.3	103.0	101.3	99.1	103.0	113.0	133.4	134.3	119.4	35.5
Cabbage	100	95.0	107.2	111.3	125.5	128.5	116.4	104.1	105.6	110.0	115.6	117.7	35.3
All vegetables	100	105.5	114.3	118.9	126.7	129.3	127.3	117.5	115.3	117.1	119.8	123.8	29.3
Mustard greens	100	115.1	125.9	126.9	127.6	129.2	128.2	109.2	110.0	104.9	110.3	124.0	29.2
Garlic	100	101.7	108.0	119.2	118.7	120.2	120.1	116.5	112.4	108.0	107.9	108.1	20.2
All fruits	100	101.7	102.1	103.6	105.2	104.8	104.6	106.1	109.4	117.3	117.7	112.3	17.7
Rice	100	102.0	98.4	95.3	93.9	93.7	98.0	98.3	99.7	102.8	105.4	107.3	12.6
Banana	100	103.4	103.2	106.0	108.5	108.7	108.4	108.3	108.5	111.1	111.4	110.8	11.4
Meat	100	102.0	102.3	105.4	106.4	106.3	106.7	106.0	106.1	106.5	108.2	109.6	9.6
Papaya	100	100.3	100.7	102.5	103.9	104.5	106.3	107.0	106.8	107.3	107.4	106.8	7.4

Note: Due to lack of monthly vegetable supply data, the indices of 'all vegetables' and 'all fruits' are estimated as simple average of the individual commodity price index in each group, rather than the weighted average prices index.
Source: Estimated from the monthly retail prices published by CBS (1994b).

The price seasonality for each vegetable is much higher than is the price seasonality of rice, meat, or even some fruits, such as papaya and banana, although citrus prices exhibit quite high seasonal fluctuations as well.

Generally, vegetable prices start increasing in February and reach their highest levels in May–July. Rice prices show an opposite trend: they are lowest in May-June and highest in December. Fruit prices are highest in October-November, mainly because of high citrus prices. There is almost no seasonality in meat prices (Fig. 3). Both fruit and vegetable prices are high in July and December.

Economics of Vegetable Production

Existing data sets on input use, production cost, and profitability of vegetable production in Indonesia do not cover a large variety of vegetables and levels of farm technology. In this section, the results of a few studies and informal surveys are reviewed. The authors believe that the conclusions derived from this review are generally valid for other crops in other regions. However, they stress the importance of conducting a comprehensive study on the economics of vegetable cultivation for various crops across different regions to identify the most suitable areas for cultivation.

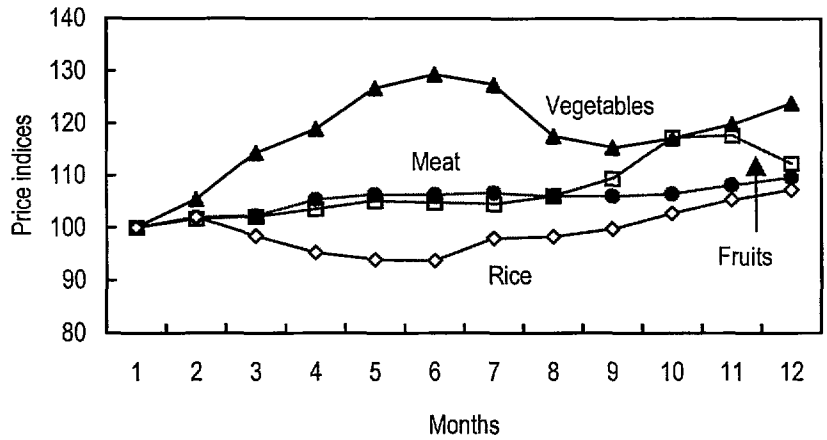


Fig. 3. Seasonality in the prices of major food items in Indonesia (average of monthly index for 1983-94)

Input Use

Vegetable cultivation needs major investment in terms of various inputs (Table 7). However, input levels often exceed recommendations or requirements, particularly in the case of fertilizer and pesticides. For example, for shallot, fertilizer guidelines issued in 1986 recommend 150–200 kg N, 90 kg P, 100 kg K, and 100 kg S, combined with 5 t/ha compost. Farmers have been found to apply 200 kg N, 110 kg P, 396 kg K, 337 kg S, and 100 kg MgO/ha, with 12 kg organic manure (Hilman et al. 1990). Similarly, pesticide use was found to be higher than recommended. An agronomic survey in 1986 showed that pesticides accounted for 30–50% of the cost of production of chili. Farmers applied 54–97 kg/ha on shallot, whereas the recommendation is only 22.4 kg/ha (On Farm Client Oriented Research 1990). Thus, fertilizer and pesticide use is cost-ineffective and environmentally unsound. But despite high commercial input use, vegetable production generates considerable employment opportunities, more so than does rice cultivation. Tomato and chili cultivation are the most labor intensive among the vegetables studied.

Table 7. Input use (per ha) on selected vegetables

Vegeta-	Seed	Fertilizer (kg)					Manure	Pesticide		Labor (person days)			Reference
ble	(kg)	Urea	TSP	KCL	ZA	All	(kg)	(kg)	(l)	Family	Hired	All	
Cabbage	0.22	294	641	378	475	1784	167	7	7	24	235	259	Hutabarat et al. (1992)
Chili	1.40	268	510	225	167	1170	63	12	26	104	206	310	Agri. Service**
Potato	954*	44.3	1313	643	631	2632	56	12	28	30	168	198	Hutabarat et al. (1992)
Rice	-	-	-	-	-	1483	-	-	-	128	48	176	IRRI (1995)
Tomato	0.63	111	163	1133	-	1408	82	4	5	191	116	307	Agri. service

* Tuber
** Unpublished survey data from Agricultural Service Lampung during 1996.
– implies that data are not available.

Factor Share

Vegetable cultivation is a capital-intensive farm business. However, factor share of different inputs

varies across vegetables (Table 8). For example, seed and pesticides are the major cost items in potato cultivation. On the other hand, seed is a minor cost item in tomato and cabbage; the highest cost item in tomato production is labour. Fertilizer and labor are the highest cost items for cabbage, each claiming about one third of the total cost.

Table 8. Factor share in selected vegetables

Crop	Region	Year	Seed	Manure	Fertilizer	Pesticide	Labor	Fixed cost
Cabbage	Lembang	1991	7.6	16.2	29.9	13.9	28.5	3.9
Garlic	Cianjur	1992	28.2	4.5	1.6	4.8	23.6	37.4
Potato	Pangalengan	1989	26.2	7.5	7.7	26.4	13.7	18.5
Shallot	Brebes	1992	12.2	3.1	7.3	7.4	56.0	14.0
Tomato	Lembang	1992	4.3	8.6	7.4	26.8	49.2	3.7

Source: Directorate of Food Crops (1995a).

Profitability

Most commercial vegetables are expensive to produce; as mentioned above, this is partly due to excessive application of fertilizers and pesticides. But despite the high input use, the benefit–cost ratio is about 2.5 for cabbage and 1.62 for garlic. However, the ratios for most vegetables are comparable to, or lower than, the benefit–cost ratio for rice (Table 9).

Table 9. Cost and return (000 IDR/ha) in the cultivation of selected vegetables

Crop	Region	Year	Variable cost	Total cost	Gross return	Net return	B–C ratio
Cabbage	Lembang	1991	2082	2166	5407	3241	2.50
Garlic	Cianjur	1992	3665	5856	9494	3638	1.62
Potato	Pangalengan	1989	2601	3192	4301	1111	1.34
Rice	Indonesia	1987-89	490	835	1326	490	1.59
Shallot	Brebes	1992	4352	5061	7689	2627	1.52
Tomato	Lembang	1992	5576	5788	7698	1910	1.33

Source: Estimated from Directorate of Food Crop (1995a); The data related to rice were taken from IRRI (1995) under irrigated environment, and converted into Rupiahs.using an official exchange rate (1842.8 IDR = 1 US$) in 1990 also reported in IRRI (1995).

Farm management practices and cultivation cost vary across eco-regions. For example, Suherman and Basuki (1990) found the production cost of growing shallot in the lowlands of West Java to be lower (IDR 314/kg) than in the highlands (IDR 427/kg).

Production Constraints

Despite high input use, farmers fail to achieve potential yields. One study on shallots (Hidayat et al. 1992) found that yields from experiments conducted in farmers' fields ranged from 13 to 23 t/ha in the wet season to 8 to 14 t/ha in the dry season, but that farmers themselves realized less than two-thirds of these yields.

Among the constraints that prevent farmers from achieving potential yields are pests and diseases, poor seed quality, lack of varieties, cultural practices, bureaucratic problems related to land and seed permits, small land holdings, lack of market information, post-harvest losses due to poor infrastructure, institutional factors, such as lack of an industrial policy for horticulture, and lack of credit.

Various production constraints and their relative intensity are shown in Table 10. Most research finds disease and insect pests to be the main constraints limiting production. Lack of quality seed (or seed deterioration due to improper storage) is also a major constraint to production. Generally, vegetable varieties grown by farmers are introduced from subtropical countries; they are only suited to the highland areas, and are usually susceptible to environmental stress and attack from pests and disease. In lowland areas, farmers usually use local varieties.

Table 10. Constraints to vegetable production in West Java, Indonesia

Vegetable	Vegetables production constraints							Reference
	1	2	3	4	5	6	7	
Cabbage	-	+++	-	-	-	-	-	Djatmika 1991
	-	-	-	+++	-	-	-	Permadi et al. 1992
	-	-	-	-	INS	-	-	Laksanawati et al. 1992
Garlic	+++	+++	+	+++	++	+++	++	Abidin and Karti 1989
	-	+++	-	-	-	-	-	Asandhi and Gunadi 1985
	-	+++	-	-	-	-	-	Duriat 1989
	-	+++	-	-	-	-	-	Suryaningsih 1991
	-	-	-	+++	INS	-	-	Yusdar 1992
	-	-	-	-	-	-	INS	Hilman and Ameriana 1992
	-	-	-	-	-	-	INS	Sinaga and Hastuti 1992
Potato	+	++	+	+++	++	+	+	Duriat et al. 1991
	-	-	-	+++	-	-	-	Asandhi 1992
Shallot	-	+++	-	-	-	-	-	Dibyantoro 1988
	-	+++	-	-	-	-	-	Suhardi 1991
	-	-	++	-	-	-	-	Abidin and Asandhi 1992
	-	-	-	+++	-	-	-	Ameriana 1989
	-	-	-	+++	-	-	-	Permadi et al 1992
	-	-	-	-	+++	-	-	Sinaga and Hastuti 1991
	-	-	-	-	+++	-	-	Asgar and Sinaga 1992
Tomato	+	+++	+	++	+	+	++	Kartapradja 1989
	-	+++	-	-	-	-	-	Hanudin 1989
	-	+++	-	-	-	-	-	Hanudin and Purwati 1990
	-	+++	-	-	-	-	-	Marwotto 1992
	-	-	-	++	-	-	-	Purwati and Asghar 1990

Note: 1 = Insect loss; 2 = Disease loss; 3 = Weeds; 4 = Non availability of good quality seed; 5 = Post harvest loss; 6 = Flooding or heavy rains; 7 = Marketing; + = Low; ++ = Moderate; +++ = High; INS = Mentioned, but intensity not specified. – implies the constraint was not studied.

Marketing

Marketing Channels

Vegetable marketing channels in Indonesia are shown in Fig. 4. A distinct feature of the system is the clear separation of the channel for local consumption from the channel for shipment to other regions. Another feature is the specialization of the inter-village collectors and market retailers. Vegetables destined for metropolitan markets are assembled by village-collectors (pengepak), and then shipped via inter-village collectors; normally no vegetable is diverted for local consumption. In the marketing of vegetables for local town consumers, the most important agent is the 'bazaar vendor' (pedagang kaki lima). Bazaar vendors are usually village women who collect vegetables in quantities of about 100-200 kg from nearby farmers and then transport them by minibus to the bazaar for sale in the open space. Their customers include housewives, as well as peddlers and keepers of small grocery stores (warung) in town.

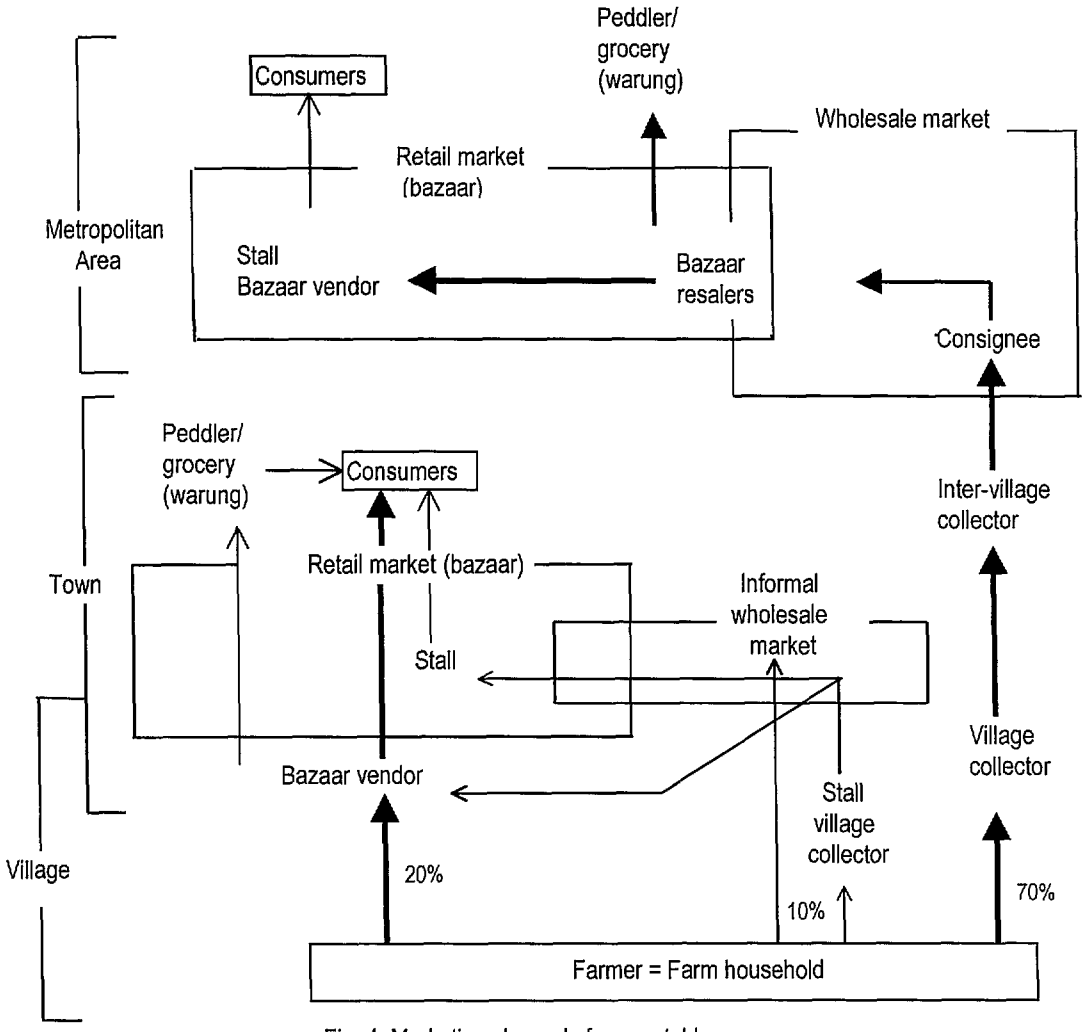


Fig. 4. Marketing channels for vegetables

It is estimated that about 70% of vegetables produced in villages is handled by village collectors and inter-village collectors, 10% is sent to the informal wholesale market by small collectors, and 20% is carried by bazaar vendors to local towns (Hayami and Kawagoe 1992).

In Indonesia, 99% of vegetables produced are sold in markets, mainly in large cities (Hayami and Kawagoe 1992). There is no doubt that a shift away from traditional farming systems to new farming systems (commercial vegetable production) has greatly strengthened the integration of villages with markets.

The Indonesian Government believes that shorter marketing channels would improve income to farmers and reduce costs to consumers. It therefore promotes the establishment of horticultural cooperatives, which are believed to reduce marketing costs. However, cooperatives tend to be poorly managed, and farmers are reluctant to support them.

The establishment of designated marketing areas where farmers and consumers can trade direct might help to reduce the transaction costs of vegetable marketing. Such "farmers' markets", very common in Southeast Asia, need to be popularized in Indonesia.

Marketing Efficiency

Marketing Margins

Table 11 reports marketing margins estimated from macro level data on monthly retail and producers' prices (both collected at the provincial level by Biro Pusat Statistik (BPS)).

The marketing margin is sometimes negative, suggesting that marketing people sometimes incur losses and indicating the risk involved in vegetable marketing. On average, the margin added by marketing agents on all vegetables was about 33%.

More perishable vegetables, such as tomato and leeks, had lower average marketing margins, but more variation in their margins, than less perishable ones, such as carrots and onions.

Table 11. Marketing margins (%) of selected vegetables in Indonesia, 1989–93

	Cabbage	Carrot	Leek	Onion	Potao	Tomato
Average	45	53	41	43	20	42
Maximum	175	129	182	117	43	158
Minimum	-19	6	-28	- 8	1	-26
SD	41	25	42	25	10	37

Source: Estimated from the monthly consumer and producer price statistics, CBS (1993c).

Marketing margin varies across regions for the same vegetable. For example, cabbage farmers in East and West Java received a higher percentage of the price paid by consumers than farmers in Central Java (Table 12). Prices vary more in West and Central Java than in East Java, as evidenced by the higher standard deviation (SD).

Table 12. Percentage of cabbage retail price received by producers in Java, 1987–1991

	West Java	Central Java	East Java
Minimum	52.7	33.8	54.3
Maximum	222.1	249.8	229.0
Mean	86.1	77.3	116.1
SD	37.3	37.7	23.1

Note: A more than 100% farmers' share in the retail price indicates a negative margin.
Estimated from the monthly consumer and producer prices for 1989–92.
Source: CBS (1993c).

A micro-level study of marketing margins of potato, cabbage, and leek at different stages in the marketing channel showed that the highest margin is added at the collector and retail levels, and that the added margin is relatively low at the wholesale level. This might be because of the low volume of vegetables handled and the high losses at the collector and retail levels. The profit share of total margin is high at the collector level and low at the retail level in potato and leek, but is high at all levels in cabbage. The share can be as low as 6%, or as high as 57% of the added margin (Table 13).

Table 13. Marketing margin at different marketing stages for selected vegetables in Indonesia, 1992

Vegetable	Region	Items	Collector I	Collector II	Wholesale	Retail	Total margin
Cabbage	Lembang	Buying price (IDR/kg)	200	-	278	319	-
		Selling price (IDR/kg)	278	-	319	414	214
		Added margin (%)	39.0	-	14.7	29.8	107
		Profit as % of margin	33.3	-	42.5	52.6	43.5
Leek	Cipanas	Buying price (IDR/kg)	550	600	650	750	-
		Selling price (IDR/kg)	600	650	750	900	350
		Added margin (%)	9.1	8.3	15.4	20.0	63.6
		Profit as % of margin	38.0	38.0	15.0	12.7	20.6
Potato	Medan	Buying price (IDR/kg)	374	-	439	497	-
		Selling price (IDR/kg)	439	-	497	621	247
		Added margin (%)	17.4	-	13.2	25.0	66.0
		Profit as % of margin	56.9	-	45.6	6.5	28.7

Source: Directorate of Food Crop (1995b).

Another detailed study of vegetable marketing in different regions indicated that profit, as a percentage of total marketing cost, varies across regions and vegetables, but rarely exceeds 20% of the total marketing cost (Table 14). This nullifies the common notion that middlemen enjoy excessive profits at the expense of producers and consumers. Physical losses during marketing were highest (up to 10% of the selling price) in tomato and leek, and lowest in carrot, shallot, and chili. Transportation cost is highest in cabbage, potato, and carrot, but generally less than 1% in tomato, shallot, and chili. Overall marketing costs are generally high in cabbage and carrot.

Table 14. Marketing margins for selected vegetables

Vege-table	Market level	Region	Year	% of selling price			% of total cost		Selling price (IDR/Kg)
				Transportation	Market cost	Losses	Profit	Marketing	
Cabbage	Retail	LEM,WJAV	1992	4.3	2.5	4.1	12.1	87.9	414
	Wholesale	LEM,WJAV	1992	-	3.6	3.6	5.5	94.5	319
	Retail	UPAN,SSUL	1992	1.9	10.4	-	27.4	72.6	530
	Wholesale	UPAN,SSUL	1992	4.5	13.2	-	10.2	89.8	215
Carrot	Retail	MED, NSUM	1993	0.6	1.6	0.5	20.0	80.0	600
	Wholesale	MED, NSUM	1993	1.6	2.2	0.5	9.0	91.0	465
	Retail	MAN,NSUL	1993	-	3.7	-	17.7	82.3	350
	Wholesale	MAN, NSUL	1993	3.6	5.5	-	36.4	63.6	275
Chili	Retail	SAK, LOM,WNTE	1993	0.1	0.02	1.9	5.0	95.0	4500
	Wholesale	SAK, LOM,WNTE	1993	0.1	0.1	1.9	3.0	97.0	4188
	Retail	TAR, NSUM	1992	0.3	0.9	0.2	5.1	94.9	1338
	Wholesale	TAR, NSUM	1992	0.8	1.1	0.2	16.8	83.2	1250
Garlic	Retail	KIN, BAL	1994	0.2	0.2	2.7	6.1	94.9	4550
	Retail	SRM,CJAV	1994	0.1	-	2.0	4.6	95.4	4500
	Wholesale	SEM,CJAV	1994	0.6	-	4.5	4.4	95.6	4200
Leek	Retail	CIP, WJAV	1993	0.4	0.4	7.6	5.9	94.1	1050
	Wholesale	CIP, WJAV	1993	1.5	0.4	9.3	2.1	97.9	750
	Retail	PAN,WJAV	1993	0.2	0.4	6.0	15.1	84.9	1150
	Wholesale	PAN,WJAV	1993	2.3	0.8	10.0	9.1	90.9	900
	Retail	TKAR, NSUM	1993	0.6	1.4	0.8	12.4	87.6	608
	Wholesale	TKAR, NSUM	1993	3.0	1.7	0.3	9.9	90.1	516
Potato	Retail	JAK,WJAV	1992	1.5	0.3	0.9	8.0	92.0	650
	Wholesale	PEN,WJAV	1992	4.4	0.8	4.8	2.1	97.9	580
	Retail	UPAN, SSUL	1992	1.9	5.9	-	12.8	97.2	635
	Wholesale	UPAN, SSUL	1992	6.3	4.7	-	18.4	81.6	450
Shallot	Retail	LAM,SSUM	1993	0.2	0.6	0.3	3.4	96.6	1100
	Wholesale	LAM,SSUM	1993	0.7	0.5	0.5	5.9	94.1	1050
	Wholesale	BRE, CJAV	1993	0.9	1.1	1.3	30.1	69.9	789
	Retail	TAR, NSUM	1993	0.3	0.8	0.3	15.9	84.1	1460
	Wholesale	TAR, NSUM	1993	0.7	1.5	0.2	12.1	87.9	1208
Tomato	Retail	UPAN,SSUL	1993	0.7	0.7	7.9	12.4	87.9	700
	Wholesale	UPAN, SSUL	1993	0.9	2.7	7.3	16.4	83.6	500

- implies figures are not available. Bali = BAL; Brebes = BRE; Central = C; Cipanas = CIP; Jakarta = J; Java = JAV; Karo = TKAR; Kintamani = KIN; Lampung = LAM; Lembang = LEM; Lombok = LOM; Manado = MAN; Medan = MED; North = N; West = W; Nusa Tenggara = NTE; Padang = PAN; Pengalengan = PEN; Sakra = SAK; Semarang = SEM; Sulawesi = SUL; Sumatra = SUM; Tanah South = S; Tarutung = TAR; Ujung Pandang = UPAN.

Source: Official files of Directorate of Food Crop Economics and Post Harvest Processing , Directorate General of Food Crops (1995).

Integration of Vegetable Markets

Integration of markets is an indication of efficiency. If a high proportion of production passes through markets (Hayami and Kawagoe 1992), vegetable production is said to be integrated with markets. If vegetables move freely in different regions in response to changing prices, markets are

said to be integrated across regions. In Indonesia vegetable production is integrated with markets. But vegetable markets are not integrated across regions, as indicated by the differences in the movements of monthly prices. Cabbage prices provide an example (Fig. 5). They are highest in South Sulawesi and Jakarta in May, when they are low in North Sumatra; in August the opposite is true. Moreover, the extent of seasonal variation is much higher in North Sumatra than in Jakarta, indicating difficulties in moving cabbage from low-price regions to high-price regions.

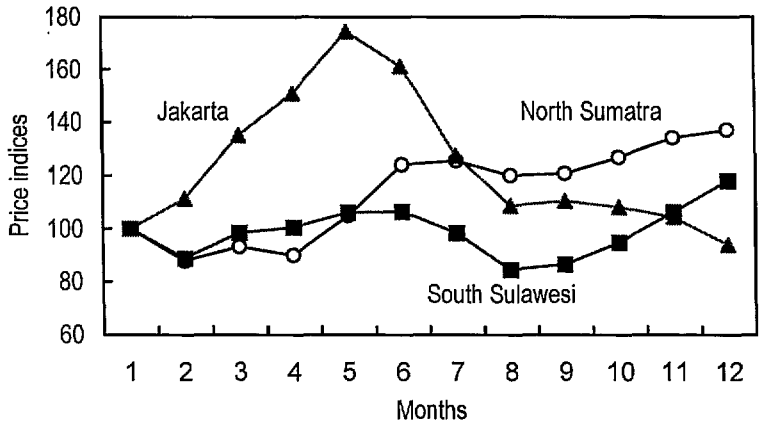


Fig. 5. Movement in seasonal cabbage prices across markets in Indonesia (average of monthly index for 1983-94)

Market Information Services

Since 1979, Indonesia has been developing a vegetable market information service (MIS). Price information is provided by the National Agricultural Market Information Service, established within the Subdirectorate of Marketing Information, which is responsible for publishing and broadcasting market price information from important production and consumption areas.

The MIS provides daily price information for farmers and traders. It covers vegetable and secondary food crop prices in production and consumption centers in 14 provinces. The data are sent to the provincial MIS office, which checks the information and passes it to local radio stations and newspapers, and to the MIS central office in Jakarta by telephone. In Jakarta, the data are checked and transferred to the Price Broadcasting Forum and then to the Radio of the Republic Indonesia (RRI) for broadcast to the entire country every evening.

The MIS system provides adequate market information for producers, traders, and consumers. This information service can:

1. Improve the bargaining position of farmers (weaker elements of the marketing system) and help them to get a fair share of the consumer price.

2. Stimulate competition between traders dealing in vegetables, thereby contributing to the technical and allocative efficiency of the marketing system for vegetables.

3. Create new demand so that new supplies can be absorbed continuously.

However, farmers and small assembly traders usually obtain price information through more informal means, from colleagues, friends, and traders, or by observing transactions at the assembly market(s), if it is nearby.

International Trade

Because all crops can be grown year-round in Indonesia, vegetables hold great export potential. Horticulture could be developed or expanded on nearly 200,000 ha of previous estate-crop lands currently not used to capacity. Moreover, as pointed out previously, more than 30% of the cultivated land in highland environments is suitable for vegetable cultivation (Bahar 1992).

With its naturally fertile land and its low wages, Indonesia can produce vegetables much cheaper than can neighboring countries. The landed price of Indonesian vegetables in Singapore and Kuala Lumpur is lower than the landed price from other countries (Godoy 1989).

Data on Indonesia's international trade in vegetables between 1980 and 1993 are summarized in Table 15. Over this period the value of fresh vegetable exports rose sevenfold (annual growth rate of 13.6%), and up to 1992 the export volume showed a fivefold increase (at 11% per year). Despite these increases, however, exports amounted to only 4% of vegetable production in 1992.

Table 15. International vegetable trade of Indonesia, 1980–1993

Year	Export		Import		Trade surplus	
	Quantity (000 t)	Value (M US$)*	Quantity (000 t)	Value (M US$)*	Quantity (000 t)	Value (M US$)*
1980	33.1	3.0	32.0	18.9	1.1	-15.9
1981	37.4	6.3	32.7	18.5	4.7	-12.2
1982	36.8	4.3	33.2	20.8	3.6	-16.5
1983	46.8	5.3	21.5	13.4	25.3	-8.1
1984	55.1	6.3	30.6	19.1	24.5	-12.8
1985	58.5	6.5	34.6	16.8	23.9	-10.3
1986	52.7	5.6	39.4	17.7	13.3	-12.1
1987	56.7	6.9	45.1	17.9	11.6	-11.0
1988	95.7	12.8	94.9	32.9	0.8	-20.1
1989	116.0	16.5	47.7	24.7	68.3	-8.2
1990	118.5	17.1	46.6	24.2	72.5	-7.1
1991	154.9	39.5	54.4	30.2	100.5	9.3
1992	174.3	32.6	57.5	33.1	116.8	-0.5
1993	119.1	21.1	31.3	14.6	87.8	6.5

Source: Official files of Directorate of Food Crops Economics and Post Harvest Processing, Directorate General of Food Crops, 1995.
* M = 1,000,000

Although Indonesia enjoys a trade surplus in vegetables, the country has been facing a deficit in balance of payments in the vegetable trade since 1980 (Table 15). This indicates that the quality and price of imported vegetables far exceeds those of exported vegetables. Recently, fast growth in both

the quantity and value of vegetable exports has widened the trade surplus and reduced the deficit in payments.

Indonesia's international trade in vegetables is dominated by just a few types of vegetables (Table 16): in 1992 cabbage, cauliflower, and potato accounted for 90% of the total volume and 70% of the value of exports, and garlic and shallot were the main imports, accounting for 85% of the total volume of vegetable imports. Most of Indonesia's fresh vegetable exports go to Singapore and Malaysia (Table 17). North Sumatra is the largest exporter. It accounted for 89% of total vegetable exports in 1992. Vegetable production in Java is mostly for domestic consumption (Table 18).

Table 16. Individual commodity share (%) in total vegetable exports and imports, 1990-92

Vegetable	Export						Import					
	Quantity			Value			Quantity			Value		
	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
Cabbage/ Cauliflower	23.3	20.0	33.5	22.0	16.9	22.6	0.0	0.5	0.5	0.1	1.7	0.7
Dried scallion	-	-	-	-	-	-	10.5	11.3	-	6.6	7.5	-
Garlic	-	-	-	-	-	-	51.6	48.6	55.0	67.6	59.8	64.2
Gourd	-	-	-	-	-	-	-	0.3	-	-	0.8	-
Leek	1.1	0.8	1.5	1.8	0.9	1.4	-	0.1	0.2	-	1.9	0.5
Lettuce	-	-	-	-	-	-	-	0.1	-	-	0.1	-
Mushroom/ Asparagus	0.1	0.5	2.2	1.1	5.2	16.7	-	-	0.0	-	0.1	0.1
Onion	0.1	-	-	0.2	-	-	1.0	1.1	1.6	3.8	3.4	4.9
Other dried vegetables	0.0	0.5	0.3	0.0	1.1	0.7	1.9	2.0	2.2	4.2	4.3	4.7
Potato	70.2	69.5	56.8	66.5	61.7	48.8	-	0.2	0.3	-	0.7	0.4
Shallot	3.7	7.3	4.1	6.3	12.2	7.3	34.9	35.8	39.8	17.6	19.4	24.1
Tomato	1.3	1.3	1.6	1.7	1.9	2.2	-	0.1	0.4	-	0.2	0.4

Source: CBS (1992b).
- implies the share is less than 0.1.

Table 17. Quantity (000 t) and value (000 US$) of Indonesian vegetable exports by importer country, 1990-1992

Country	Quantity			Value		
	1990	1991	1992	1990	1991	1992
Malaysia	70.7 (59)	98.6 (67)	103.7 (59)	8.5 (48)	12.0 (53)	14.1 (43)
Singapore	41.4 (35)	40.1 (27)	54.5 (31)	7.2 (41)	8.8 (39)	11.5 (35)
Taiwan	4.1 (3)	4.3 (3)	10.7 (6)	0.0 (0)	0.0 (0)	3.0 (9)
Hong Kong	2.2 (2)	1.5 (1)	2.7 (2)	0.6 (4)	0.9 (4)	1.9 (6)
USA	0.0 (0)	0.0 (0)	2.2 (1)	0.8 (4)	0.3 (1)	0.5 (1)
Others	0.1 (1)	10.4 (1)	0.3 (1)	0.3 (2)	0.7 (3)	1.8 (6)
Total	118.5 (100)	154.9 (100)	175.6 (100)	17.1 (100)	22.8 (100)	32.8 (100)

Figures in parentheses are relative share (%) of total vegetable exports from Indonesia.
Source: CBS (1992b).

Table 18. Provincial share in vegetable export and production in Indonesia, 1992

Province	Exports (000 t)	Regional share (%)	Production (000 t)	Regional share (%)	Export value (000 US$)	Regional share (%)
North Sumatra	156.08	88.9	468.99	12.7	22.696	69.1
Jakarta & W. Java	14.18	8.1	1288.89	35.0	5.269	16.0
Central Java	0.93	0.5	768.83	20.9	0.492	1.5
East Java	3.98	2.3	452.60	12.3	4.281	13.0
Others	0.12	0.1	705.20	19.1	0.110	0.3
Indonesia	175.64	100.0	3684.50	100.0	32.848	100.0

Source: Official files of Directorate of Food Crop Economics and Post Harvest Processing, Directorate General of Food Crops, 1992.

Supply and Demand

Per Capita Availability

Vegetable production, excluding potatoes, increased from 1.9 million t in 1980 to 4.3 million t in 1993 (an annual growth rate of 7.8%), and annual per capita availability of vegetables increased from 13 kg (36 g/day) to 22 kg (60 g/day) over the same period (Table 19). Despite this achievement, annual per capita availability is still less than one third of the recommended level of 73 kg (200 g/day).

Table 19. Per capita availability of vegetables in Indonesia

Year	Production (000 t)	Exports net of imports (000 t)	Net availability (000 t)	Population (000)	Per capita availability (kg/capita/annum)
1980	1896.59	1.1	1895.49	146600	12.93
1981	1616.79	4.7	1612.09	149500	10.78
1982	1738.58	3.6	1734.98	153032	11.34
1983	2223.51	25.3	2198.21	155564	14.13
1984	2867.00	24.5	2842.50	162167	17.53
1985	3189.47	23.9	3165.57	166440	19.02
1986	3723.82	13.3	3710.52	169356	21.91
1987	3795.79	11.6	3784.19	172323	21.96
1988	3742.55	0.8	3741.75	175109	21.37
1989	4308.68	68.3	4240.38	177893	23.84
1990	3952.09	72.5	3879.59	178200	21.77
1991	3935.13	100.5	3834.63	187758	20.42
1992	4353.01	116.8	4236.21	191170	22.16
1993	4336.62	87.8	4248.82	194617	21.83

Source: CBS (1993d).

Per Capita Consumption

The latest household consumption survey (from 1993) indicates that Indonesians eat more than they did in 1981 (Table 20). Vegetable consumption has increased over the period, but still accounts for only 5.3% of food expenditure. (The differences between the availability and consumption figures are due to the losses suffered in bringing vegetables from farmers' fields to consumers' tables.)

Table 20. Daily per capita consumption (g) and expenditure share (%) of major food items for 1981 and 1993

Item	1981		1993	
	Consumption (g)	Expenditure share (%)	Consumption (g)	Expenditure share (%)
Cereals	251	37.2	238	33.5
Tubers	44	6.5	58	8.2
Oils and fats	269	40.1	273	38.3
Vegetables	26	3.8	38	5.3
Legumes	18	2.7	18	2.5
Fruits	18	2.6	24	3.3
Eggs and milk	5	0.8	6	0.9
Meat	2	0.3	4	0.5
Fish	12	1.8	15	2.1
Miscellaneous items	25	3.7	21	3.0
Prepared food	4	0.5	17	2.4
Total	674	100	712	100

Source: CBS (1993e).

Consumption by Urban and Rural Groups

Data from the National Socioeconomic Survey (SUSENAS) provide a more detailed picture of consumption patterns in urban and rural areas and by expenditure class. However, data seem to estimate the availability rather than the consumption of vegetables at the household level.

No significant difference in vegetable consumption across urban and rural groups has been observed in any household survey, except in 1990 when rural people consumed more vegetables than their urban counterparts. Compared to rural residents, people in urban areas eat more less-perishable vegetables, such as potato, garlic, shallot, etc. (Table 21).

Table 21. Average per capita consumption of vegetables (kg/annum) in rural and urban areas

Vegetable	1981			1984			1987			1990			1993		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
All vegetables	18.8	16.4	16.7	20.4	21.0	20.8	22.4	23.9	23.6	20.3	24.4	24.7	20.8	21.3	22.2
Aubergine	1.04	1.56	1.56	1.04	2.60	2.60	1.56	3.12	3.12	1.56	3.12	2.60	1.56	2.08	2.08
Beans/peas	0.88	0.52	0.52	0.52	0.52	0.52	1.04	0.52	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Cabbage	2.08	2.08	2.08	2.60	2.08	2.08	2.08	2.60	2.08	1.56	2.08	2.08	1.56	2.08	2.08

Contd. Table 21.

Vegetable	1981			1984			1987			1990			1993		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Carrot	0.52	0.05	0.21	0.52	0.16	0.36	0.52	0.21	0.42	0.52	0.21	0.42	1.04	0.26	0.52
Cassava leaves	1.56	4.16	3.64	2.08	5.20	4.68	2.60	5.20	5.20	2.60	5.20	5.20	2.08	5.20	4.68
Cayenne pepper	0.52	1.04	1.04	0.52	1.04	1.04	0.52	1.04	1.04	0.52	1.04	1.04	0.52	1.04	1.04
Chili	0.52	2.60	2.08	1.04	0.52	0.52	1.04	0.52	0.52	1.04	1.04	1.04	1.04	0.52	0.73
Cucumber	1.56	0.52	1.04	2.08	1.56	1.56	1.56	1.56	1.56	2.08	2.08	2.08	2.08	1.56	1.56
Garlic	0.16	0.10	0.10	0.26	0.16	0.16	0.31	0.21	0.21	0.31	0.26	0.26	0.47	0.31	0.36
Kangkong	4.68	3.64	3.64	4.68	4.16	4.16	5.20	4.68	4.68	4.68	5.20	5.20	4.68	4.16	4.68
Mushroom	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.16	0.21	0.42	0.21	0.26	0.42	0.21	0.31
Mustard greens	1.04	0.21	0.36	1.56	0.52	0.52	1.56	0.52	0.52	1.04	0.52	0.52	1.04	0.52	1.04
Potato	1.04	0.52	0.52	2.08	1.04	1.04	2.60	1.04	1.56	2.60	1.04	4.16	2.6	1.56	1.56
Radish	0.05	0.05	0.05	0.10	0.05	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.05
Shallot	1.56	1.04	1.04	1.56	1.56	1.56	2.08	1.56	1.56	2.08	1.56	1.56	2.08	1.56	1.56
Spinach	4.68	3.64	3.64	4.68	4.16	4.16	5.20	5.20	5.20	4.68	5.20	5.20	4.68	4.68	4.16
String bean	3.12	3.64	3.64	3.12	4.68	4.16	3.64	4.16	4.16	3.12	4.68	4.16	3.64	4.68	4.68
Tomato	1.56	0.52	0.52	1.04	0.52	0.52	1.56	0.52	0.52	1.04	0.52	1.04	1.56	0.52	1.04

The category of total vegetables does not include potatoes and beans.
Source: CBS (1993e).

Consumption by Income Group

During 1980-93, vegetable consumption within the low-income group increased (Table 22). However, most of the increase came from low-quality vegetables, such as cassava leaves, and consumption of the high-quality vegetables, such as tomatoes, declined. This shift towards low-quality vegetables may be a response to increasing overall vegetable prices. Consumption by the medium- and high-income groups has changed little.

Table 22. Average per capita annual consumption (kg) of vegetables by expenditure classes, 1980–1993

Vegetable	1980			1984			1987			1990			1993		
	low	medium	high	low	medium	high	low	medium	high	low	medium	high	low	medium	high
Aubergine	0.73	2.91	2.76	1.61	2.45	1.30	0.94	2.65	1.82	1.72	2.34	0.83	0.57	1.82	1.35
Beans/peas	0.10	0.87	3.12	0.16	1.12	2.81	0.73	1.30	3.38	0.62	1.30	2.18	0.83	1.25	2.60
Cabbage	0.42	2.34	5.82	0.47	2.54	4.06	1.66	2.81	4.16	2.29	2.18	2.18	0.16	2.03	3.22
Carrot	0.00	0.31	2.39	0.05	0.75	3.38	0.16	0.88	3.59	0.05	1.04	3.33	0.10	1.02	3.59
Cassava leaves	3.22	3.59	3.33	5.51	4.54	3.12	8.22	5.18	3.12	13.94	5.04	1.20	11.23	4.47	2.50
Cayenne pepper	0.97	1.39	1.34	1.14	1.20	1.00	0.72	1.06	1.13	1.34	1.12	0.82	0.77	1.02	0.97

Contd. Table 22.

Vegetables	1980			1984			1987			1990			1993		
	low	medium	high	low	medium	high	low	medium	high	low	medium	high	low	medium	high
Chili	0.11	1.09	2.85	0.10	1.20	2.79	0.07	1.25	2.32	0.24	1.42	2.17	0.04	1.30	2.58
Cucumber	0.05	1.92	5.25	0.31	2.39	5.41	0.21	2.08	4.73	0.26	2.39	2.86	0.05	2.08	4.63
Garlic	0.08	0.21	0.63	0.55	0.21	0.63	0.07	0.48	0.77	0.17	0.37	0.61	0.10	0.47	1.05
Mushroom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.34	0.00	0.05	0.19	0.00	0.04	0.42
Mustard greens	0.00	0.00	0.00	0.10	1.12	2.60	0.00	1.25	3.48	0.00	1.19	3.17	0.00	1.14	3.22
Potato	0.21	2.55	7.33	0.16	2.28	7.12	0.00	2.39	8.58	0.16	2.68	8.53	0.16	2.76	9.15
Radish	0.00	0.00	0.00	0.00	0.10	0.31	0.00	0.16	0.52	0.05	0.10	0.31	0.00	0.05	0.16
Shallot	0.60	1.92	4.02	0.66	1.98	3.79	0.64	2.28	3.67	0.81	2.22	3.17	0.62	2.18	3.60
Spinach	2.76	5.30	8.53	3.69	5.04	7.70	3.85	5.98	8.27	5.72	5.41	7.75	3.07	5.04	7.12
String bean	1.30	4.35	6.14	1.92	4.57	5.62	1.14	4.06	4.78	2.29	4.47	3.90	0.99	4.47	5.15
Swamp cabbage	1.25	4.52	6.71	1.66	4.37	5.88	1.98	4.99	5.82	0.78	4.89	4.99	0.47	4.32	4.52
Tomato	0.21	1.81	5.77	0.12	1.25	3.02	0.12	1.45	3.49	0.14	1.52	2.51	0.05	1.66	3.63
Total*	10.4	27.3	49.4	15.5	29.1	45.0	18.6	32.5	47.3	27.5	31.3	36.1	17.2	28.7	42.6

Data from CBS (1993e); From each survey reported, the first three income categories have been grouped as low income, the next five as medium income, and the remaining as high income.
* The category of total vegetables does not include potatoes and beans.

Expenditure Share

People in rural areas spend around 5–6% of their total expenditure on vegetables and 3% on fruits; in urban areas, the respective shares are 4% and 3%. The share of consumption expenditure for vegetables and fruits has increased (Table 23), suggesting that preference for vegetables is increasing and that demand pressure generated by higher incomes will increase.

Table 23. Fruit and vegetable expenditure (% of total expenditure) in rural and urban areas, 1987 and 1990

Area	Vegetables		Fruits	
	1987	1990	1987	1990
Rural	5.09	6.16	3.40	3.40
Urban	4.39	4.32	2.96	3.22
Average	4.82	5.35	3.22	3.32

Source: CBS (1987 and 1990).

Vegetable Processing

In comparison to fresh vegetables, the consumption of processed vegetables is rather low. The Food Balance Sheets do not take into account processed vegetables, which is an indication of the relatively small quantities of vegetables that are processed.

However, the processing industry in Indonesia is developing quickly. At the end of the Fourth Five-Year Plan in 1987–88, the installed processing capacity was 249,000 t. It was projected to reach 396,000 t in 1988–89, and 733,000 t by the end of the Fifth Five-Year Plan (Table 24). Figures were not available to test this projection. To fulfil the need for vegetable raw material for the processing industry, production must be coordinated between farmers and industry. Government control over installation of the processing industry needs to be relaxed.

Table 24. Position and projection of established capacity (000 t) of vegetable processing industry in the Fifth Five-Year Plan (FYP)

Kind of industry	Fourth FYP		Projected for the 5th FYP	
	Established	Utilized	1988/1989	1993/1994
Fruit canning	64	29	99	205
Fruit juice	63	3	90	109
Vegetable juice	24	10	35	62
Tomato paste	12	9	16	34
Pepper sauce	48	38	69	143
Mushroom processing	38	30	55	113
Red kidney bean	-	-	2	4.2
Yard long bean	-	-	2.4	5
Chayote	-	-	21	44
Eggplant	-	-	6.6	13.8
Total	249	119	396	733

Source: Official data from Directorate General of Miscellaneous Industry.

The fruit and vegetable processing industry is operating below the installed capacity. For example, at the end of the Fourth Five-Year Plan, less than half of the installed capacity was utilized. The reasons for this include insufficient supply of raw material, unsuitability of produce for processing, and the long distance between production and processing points.

Income Elasticities

Usually, demand for horticultural produce increases with income. There are, however, large differences in demand behavior across different horticultural products and population strata.

Estimates of income (or expenditure) elasticities made by Roche (1988) and Hukum (1989) are presented in Table 25. Except for spinach in both rural and urban areas, eggplant in urban areas, shallot in urban areas, and kangkong in Indonesia as a whole, elasticities of most vegetables are reasonably high (in most cases higher than or almost equal to one.) In contrast, the elasticity for cereal is 0.2–0.3. The high elasticities suggest that strong vegetable demand will be generated with economic development.

Table 25. Expenditure elasticities for vegetables in Java and all Indonesia

Vegetable	Java (1980)[1]		Indonesia (1990)[2]		Indonesia[3]
	Urban	Rural	Urban	Rural	(1984)*
Beans	-	-	-	-	1.41
Cabbage	1.184	0.979	0.670	0.952	1.28
Carrot	1.437	1.809	-	-	-
Chili	0.717	1.091	1.087	1.175	0.60
Cucumber	0.991	1.620	-	-	-
Eggplant	-0.165	0.632	-	-	-
Garlic	0.568	0.623	-	-	-
Kangkong	-	-	-	-	0.40
Potato	1.585	1.985	1.269	1.081	
Shallot	0.470	0.716	0.965	1.072	0.69
Spinach	0.254	0.283	-	-	0.61
Tomato	0.909	1.823	-	-	-

Source: [1]Roche (1988); [2] Estimated by the authors; [3] Hukum (1989).
* Income elasticities.

The income elasticities for most vegetables are higher in rural areas than in urban areas. As level of vegetable consumption among the two groups is not significantly different (Table 23), it is difficult to explain these differences in income elasticities. More study is needed to clarify the reason for and the consequences of these differences.

Price Elasticities of Demand

Goods that represent a very small portion of a person's total expenditure tend to have low price elasticities of demand. Indonesian per capita expenditure on vegetables during the period 1976–1990 remained around 5.5% of total expenditure, which explains low price elasticities. SUSENAS data show that the proportion of income spent on vegetables is higher in rural areas, pointing to higher price elasticities of demand in rural areas than in urban areas. However, no estimates are available on the own- and cross-pricing elasticities of vegetable demand.

Demand Projection

A short-term projection of production, harvested area, and yield of vegetables and fruits for the Sixth Five-Year Plan is presented in Table 26. It is projected that production, harvested area, and yield of vegetables will increase by 5.1%, 2.42%, and 2.68% per annum, respectively, during the planning period. For fruit, the growth projection of production, harvested area, and yield are 4.10%, 2.08%, and 2.02% per annum.

Table 26. Projection of production, harvested area, and yield of horticulture crops (vegetables and fruits) in Sixth Five-Year Plan

Commodity	End of Plan V 1993	Plan VI 1994	1995	1996	1997	1998	Growth (%/year)
Vegetable							
Production (000 t)	4377	4600	4835	5081	5341	5613	5.10
Harvested area (000 ha)	1126	1153	1182	1210	1240	1265	2.42
Yield (t/ha)	3.89	3.99	4.09	4.2	4.31	4.44	2.68
Fruits							
Production (000 t)	5388	5609	5839	6078	6327	6587	4.10
Harvested area (000 ha)	653	666	680	694	708	723	2.08
Yield (t/ha)	8.25	9.42	8.58	8.76	8.93	9.11	2.02

Source: Ministry of Agriculture (1993).

A long-term projection for vegetable demand was made by the World Bank (1992) assuming 6% per annum growth in real incomes and 1.9% per annum increase in population. Under these assumptions, the share of staples (grains and root crops) in food expenditure is expected to fall from 73% in 1988 to 59% in 2010. The shares of animal products, fruits, and vegetables will each rise from 4.6% in 1988 to 8.9% in 2010.

The demand for fruits and vegetables in Indonesia is growing fast because of rapid economic development and high income elasticities of demand. This rapid growth is expected to continue. Consumption of vegetables is projected to grow at 3.9% per annum between 1995 and 2010.

It was estimated that by 2010, almost 200,000 ha of additional land would be required to meet the incremental increase in urban demand for fruits and vegetables; this is a little more than 2% of the arable land base in 1995. The availability of suitable land, therefore, will not constrain the growth of fruit and vegetable crops.

Summary and Conclusions

Vegetables are grown on 775,000 ha, about 3.7% of the total cropped area in Indonesia. Despite efforts to diversify vegetable cultivation across the country, it is still concentrated on Java. Vegetables are produced mainly in the dry season, but in some cases year-round. This results in seasonality in vegetable prices, which are normally high in May and June and low in January.

Vegetables are grown along with other main crops, such as rice and corn, but commercial vegetables are normally grown in more intensive monoculture systems. More perishable vegetables are grown in the lowlands near cities, and less perishable vegetables are grown in the uplands, away from the large consumption centers.

Vegetable production increased from 1.9 million t in 1980 to 4.3 million t in 1993. Area under vegetables increased from 649,000 ha to 775,000 ha and yield doubled from 2.92 t to 5.6 t during this period. Annual per capita availability increased from 13 kg to 22 kg. Vegetable consumption, however, is still far below the recommended level of 73 kg per annum. A more serious concern is the

stagnation in vegetable production at around 4 million t, and the upward drift in real vegetable prices during recent years.

There are indications that higher than recommended levels of fertilizer and pesticides are being applied to vegetable crops. This inflates cost, reduces benefits, creates pollution, and kills beneficial organisms, such as the natural predators of crop pests. Despite high investment in vegetable cultivation, the benefit-cost ratio is relatively low. Ways must be found to reduce cultivation cost so that vegetables can become an economically viable option for small resource-poor farmers, and also to minimize damage to the environment. In particular, more effort should be focused on reducing chemical use, as this is generally the major cost item.

Although per-ha yield of most vegetables has doubled since 1980, yields are still far below their potential, and far below the yield levels attained in neighboring countries. Major constraints include diseases and insects, lack of high-quality seed, and high post-harvest losses. These create high variability in yield. However, lack of policy support creates even higher variation in the area under vegetables. Both area and yield variations cause cyclical fluctuation in vegetable production and prices. This seriously affects the nutrition of the poor people.

Vegetable marketing has high marketing margins. About half of the consumers' price, or up to two-thirds of the producers' price, is added in the marketing stage. Highest margins are added at the collector and retail levels. Even so, there is little evidence that brokers and agents make excessive or exploitative profits. Despite an intensive effort by the public sector to integrate the information system reporting on prices and trade flow of agricultural commodities, vegetable markets seem to be poorly connected. This and high margins might be due to poor infrastructure which inhibits the flow of commodities from low-price to high-price regions.

Per capita vegetable consumption is higher in urban areas than it is in rural areas, although the difference is not great. A larger difference was observed across income classes. The consumption and relative share of vegetables in the food basket have increased for rural and urban groups and across income classes, but consumption is still far below the recommended level. Moreover, most of the increase in the poor income group has come from relatively low-grade vegetables, and the consumption of high-grade vegetables has decreased. As income elasticities for vegetables are high, rising incomes and population are expected to create much additional demand. Unless this demand is met by increased production, it will simply result in higher vegetable prices, as has been the case in recent years.

Indonesia has great potential to export vegetables. Until recently, however, the country's balance of payments in the trade of vegetables was in deficit. Potatoes and cauliflower are major export vegetables, and garlic and shallots are major import vegetables. North Sumatra accounts for most of the exported vegetables, and Singapore and Malaysia are major export markets. A serious effort is needed to exploit the export potential of other high-priced vegetables, especially to the next-door markets of Singapore and Malaysia.

The processing industry in Indonesia is developing fast. Processing is expected to reduce both seasonal and cyclical price fluctuations at the retail as well as at the producers' level. However, there is a need to study the constraints preventing full utilization of existing capacity before allowing additional capacity. Moreover, the private sector should be encouraged to enter the vegetable processing industry.

Achievements of Past Research

Information is available on the seasonal and cyclical movement of vegetable prices and consumption across regions, income groups, rural and urban areas, etc. However, seasonal vegetable availability is unknown. Marketing margins by market level and activity have been quantified for certain vegetables. Income elasticities for certain vegetables are available, although, to the knowledge of the authors, no substantial effort is made to estimate price elasticities of demand.

Not enough information is available on the relative cost and profitability of different vegetables in different ecoregions. Such information would be useful in determining region-specific optimum input use. The domestic resource cost of various vegetables, which can tell how competitive a crop is vis-a-vis the international market, is not known. Therefore, it cannot be determined which vegetables should be promoted for export. Information on farm management practices, as they relate to the extent of potential yield achieved, is lacking. Why farmers use high inputs despite the negative implications for profitability is not known. Little is known about the product characteristics demanded by domestic and international consumers.

Future Research Priorities

Vegetable production can generate employment, supply raw material for the development of agroindustry, and earn foreign exchange. For this, however, investment in vegetable research should be given high priority. The absolute and relative share of horticulture research should be increased substantially.

The upward shift in the vegetable yield frontier will probably come from:

- development and adoption of newer varieties, including the use of hybrid seed
- changes in plant architecture in the long term
- incorporation of pest resistance and other characteristics through the use of advanced techniques, such as biotechnology and gene mapping
- improvement of crop management practices, i.e., direct seeding, higher plant populations, judicious use of pesticides, better placement of fertilizer, incorporation of organic matter to improve soil health, and improved crop rotation practices.

To improve cultural practices, further study will be needed to assess existing farm management practices in various farming systems.

Further in-depth studies should include:

- evaluation of the economics of vegetable cultivation in different ecoregions and farming systems
- assessment of commercial varieties to gauge ecoregional yield potential and the gap between potential and actual yield

- assessment of the constraints to vegetable production, in particular, quantification of the losses due to insects, disease, and management practices
- evaluation of inter- and intra-island trade restrictions and local monopolies
- analysis of the protection structure for the processed commodities
- evaluation of export market requirements and the potential for vegetable export
- assessment of the impact of higher wages, mechanization, and changes in land holdings
- identification of pockets of poverty and the requisite ameliorative measures involving vegetable cultivation.

Research on input supplies and support services might best look at the impact of pesticide, fertilizer, and seed subsidy phase-outs. The various roles of the public and private sectors in seed production and marketing need to be redefined, and policy guidelines conducive to private-sector involvement need to be developed. The government must monitor the vested interests of and abuses by the private sector in promoting pesticides, which have adverse environmental and health effects. Assessment of the impact of integrated pest management (IPM) training should be given priority. Extension workers need training in input-intensive but sustainable production technologies for horticultural crops.

There is little formal research being conducted on the market situation of horticultural crops, especially vegetables. No effort has been made to study consumer preference. Carrots, for example, are already popular in the Singapore market, but because of the irregular form and size of Indonesian carrots, they fetch a lower price than do Australian carrots. For the domestic trade, some basic facilities must be provided for efficient marketing, i.e., terminal handling and packing houses near the production centers and cool storage located at the central market. Availability of these facilities must be synchronized and made known to farmers. Study of marketing facilities and the establishment of a marketing institution for vegetables would improve development of the horticulture subsector.

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KOREA

Hong-Woo Chung and In-Soo Kim

Introduction

The Republic of Korea is located in the monsoon area of northeast Asia with four distinct seasons: spring (March-May), summer (June-August), fall (September-November), and winter (December-February). Total average annual rainfall amounts to 1300 mm, 60% of which comes in the summer. On average, frost occurs on 205 days annually in the mountainous areas, but on only 125 days annually in the inland areas. Temperatures can go below -10°C in the central region in winter and can rise to above 30°C in the southern region in summer. In 1990, population density was about 438 people/km^2. Korea is divided into nine political regions, called do (Fig. 1).

In 1990-91, average per capita total food availability in the country at the household level was about 1.35 kg/day, of which cereals constituted 35.8%, non-cereal plant food 7.4%, fruit and vegetables 33.4%, and livestock products 12.9% (Korea Rural Economic Institute 1993b). Rice is the major staple food, making up 24.2% of total food consumption (in weight terms).

Rice, the country's major crop, occupies half of the total cropped area. Other major crops include barley, soybean, chili, apple, sesame, Chinese cabbage, watermelon, and garlic. Various kinds of vegetables are cultivated on around 350 thousand ha, which is 15.4% of the total cropped area, or one third of all the cereal area. The value of vegetable production amounted to about US$5.0 billion in 1993, or more than 40% of the value of all cereal production in the country. In the same year, vegetable exports were US$26 million, while imports amounted to US$45 million. Annual per capita vegetable availability at the farm level was 229 kg. The Republic of Korea experienced a spectacular increase in vegetable production during the 1970s and 1980s.

Major Vegetables

Chili, Chinese cabbage, watermelon, garlic, and radish are the most important vegetables in Korea, occupying about two-thirds of the total vegetable-growing area. The relative share of different vegetables in Korea, however, has changed over time. For example, chili was grown on 16% of the total growing area during 1971-75, which increased to 34% during 1981-85. Thereafter, the crop's share steadily decreased to about 21% in the 1990s. Nevertheless, chili remained a major vegetable crop in the 1980s and 1990s. The next most important vegetable is Chinese cabbage, which occupied about 13% of the total vegetable area during the 1980s and 1990s, down from 27% in the early

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1970s. The relative importance of radish declined from second to third or even fourth position. The area under garlic increased, and the relative position of watermelon also improved (Table 1).

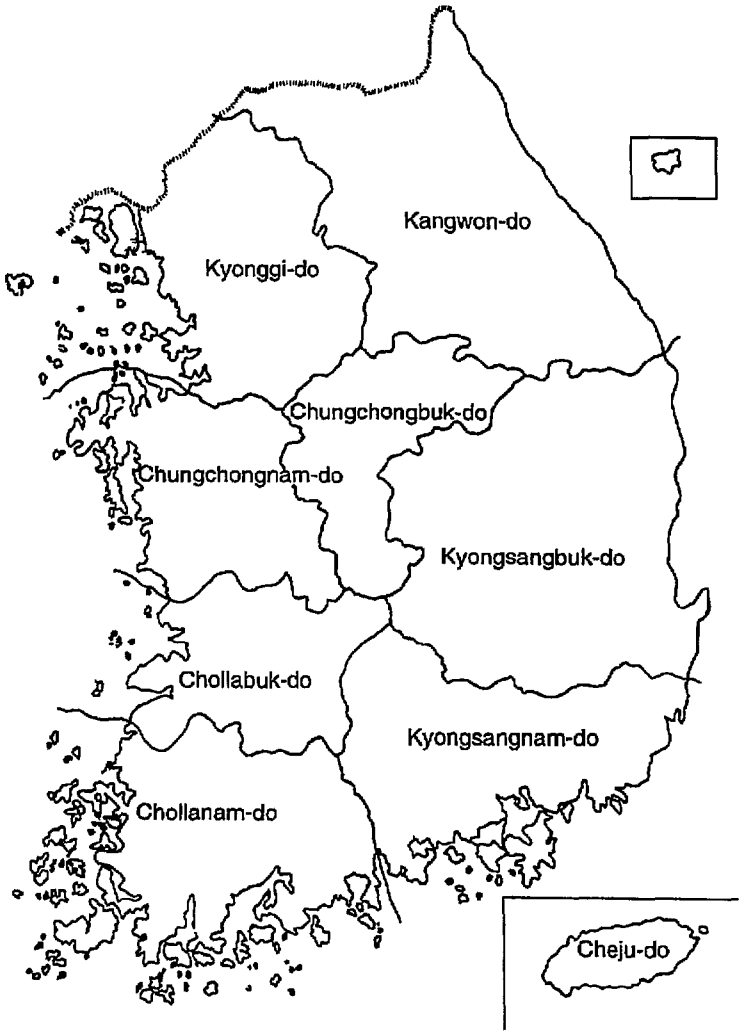


Fig. 1. Map of Republic of Korea by province

Table 1. Area under major vegetables (% of the total) in the Republic of Korea (1971-94)

Crop	Years				
	1971-75	1976-80	1981-85	1986-90	1991-94
All vegetables	(262.8) 100	(296.2) 100	(363.3) 100	(350.7) 100	(349.6) 100
Carrot	0.2	1.1	1.3	1.5	1.5
Chili	16.3	32.8	34.1	28.8	21.2
Chinese cabbage	26.7	16.2	14.0	12.5	13.2
Cucumber	3.4	2.0	1.7	1.9	2.3

Contd. Table 1.

Crop	Years				
	1971-75	1976-80	1981-85	1986-90	1991-94
Garlic	6.2	7.6	9.0	12.1	12.3
Onion	1.7	2.6	2.8	3.1	3.0
Radish	24.5	15.7	12.9	11.3	10.2
Tomato	1.5	0.9	0.8	0.8	0.8
Watermelon	3.3	3.6	4.6	6.9	9.1
Welsh onion	2.3	4.3	4.8	6.2	6.1
Other vegetables	13.8	13.2	13.8	15.0	20.3

Source: Ministry of Agriculture, Forestry and Fisheries (1994).
Note: Figures in brackets are total area (annual averages for the period in thousand ha).

Regional Distribution

The cultivation of vegetables is influenced by various agroclimatic factors, the most important of which include rainfall, frost, and temperature. The main production areas for different vegetables are reported in Table 2.

Table 2. Regional distribution of major vegetables, 1994

Vegetable	Region (Area share %)
Spicy vegetables	
Garlic	Chollanam-do(42.2), Kyongsangnam-do(15.6), Kyongsangbuk-do (13.7), Chungchongnam-do (13.5)
Red pepper	Kyongsangbuk-do (25.0), Chungchongbuk-do (15.7), Chollanam-do (14.3), Chollabuk-do (12.7)
Onion	Chollanam-do (47.9), Kyongsangbuk-do (18.9), Kyongsangnam-do (24.5)
Welsh onion	Chollanam-do (22.8), Kyonggi-do (17.4), Kyongsangbuk-do (11.8), Chungchongnam-do (11.2)
Fruit vegetables	
Cucumber	Kyonggi-do (23.0), Chollanam-do (20.0), Kyongsangnam-do (14.5)
Pumpkin	Kyonggi-di (24.0), Kyongsangnam-do (16.2), Chollanam-do (11.8), Chungchongnam-do (10.1)
Sweet melon	Kyongsangbuk-do (54.4), Kyonggi-do (10.2)
Tomato	Kyongsangnam-do (19.5), Chollanam-do (14.3), Kyongsangbuk-do (13.7)
Watermelon	Kyongsangnam-do (24.7), Chollanam-do (19.4), Kyongsangbuk-do (14.1), Chollabuk-do (13.8), Chungchongnam-do (12.1)
Leafy and stem vegetables	
Cabbage	Cheju-do (32.5), Chollanam-do (20.0), Kangwon-do (17.9)
Chinese cabbage	Kangwon-do (20.0) , Chollanam-do (15.8), Kyonggi-do (12.6), Chollabuk-do (10.6), Chungchongnam-do (10.5)
Lettuce	Kyonggi-do (46.5)
Spinach	Kyonggi-do (32.2), Chollanam-do (30.7), Kyongsangnam-do (10.3)

Contd. Table 2.

Vegetable	Region (Area share %)
Root vegetables	
Carrot	Cheju-do (39.8), Kyongsangnam-do (20.9)
Radish	Kyonggi-do (19.4), Chollabuk-do (16.2), Chollanam-do (14.1), Chungchongnam-do (12.0) , Kangwon-do (11.3)

Source: Ministry of Agriculture, Forestry and Fisheries (1994).

Vegetable Cultivation

Two types of vegetable cultivation can be identified in the Republic of Korea, i.e., protected and open cultivation. In protected cultivation, the seeding spans from about the end of October to January of the following year, while harvest spans from December to May of the following year. In open cultivation, radish and Chinese cabbage are largely seeded during late summer and harvested in late fall. Garlic and onions are seeded in the fall and harvested in late spring of the following year. Other vegetables are usually seeded in the spring and harvested in the fall (Table 3).

Table 3. Distribution of production by ecology, cropping pattern and cultivation time.

Crop	Seeding month*	Harvest month*	Ecology/ region	Cropping pattern	Percentage of production
Chili	3	6-10	Kyongbuk,Chungbuk	single crop	100.0
Garlic	9	5-6	Chunnam, Kyongnam	garlic-rice	67.0
	10	6-7	Chungnam, Kyongbuk	"	33.0
Onion	8	5	Chunnam, Kyongnam	onion-rice	19.0
	9	6	"	"	81.0
Chinese cabbage	1-3	3-5	Chunnam, Kyongnam	rice-C. cabb.	12.7
	3-4	5-6	nation wide	"	15.9
	5-7	7-10	Kangwon	rye-C. cabb.	9.1
	8-9	10-11	nation wide	w. melon-C. cabb.	62.3
Radish	1-3	3-5	Chunnam, Kyongnam	rice-radish	2.6
	3-4	5-6	nation wide	rice-radish	14.6
	5-7	7-10	Kangwon	rye-radish	9.2
	8-9	10-11	nation wide	watermelon-radish	73.6
Cucumber	11-2	2-5	Chunnam, Kyonggi	cucumber-cucumber	68.2
	4-5	6-8	Kyonggi, Chungnam	cucumber-cucumber	20.6
	7-8	9-10	Kyonggi, Chungnam	cucumber-cucumber	11.2
Water-melon	11-12	4-5	Kyongnam	rice-watermelon	25.2
	3-4	7-8	Chunbuk	w.melon-radish, C. cabb.	74.2
	6	9-10	Chunbuk	C. cabb.,radish-w. melon	0.6

*1 to 12 denotes the months January-December.
Source: Rural Development Administration (RDA) (1993).

Chili is harvested once a year as a single crop, while garlic and onions are cultivated after the harvest of rice. Chinese cabbage and radish are planted as second crops after watermelon or rice. Cucumber

is cultivated year-round in succession two times per year. Onion and garlic are cultivated both in the tropical and temperate regions after the harvest of rice. Chinese cabbage and radish are cultivated year-round, but about two-thirds of the cabbage and three-fourths of the radish are cultivated in the fall, grown after watermelon, while the winter and spring crops are grown after rice. Watermelon can be cultivated any time of the year, though three-fourths of the production is concentrated in summer when it is cultivated in a watermelon-radish/Chinese cabbage cropping system. The remaining one-fourth is grown in winter after the rice harvest (Table 3).

The varieties of vegetables grown in Korea are shown in Table 4.

Table 4. Varieties used by farmers

Vegetable	Cropping method/period	Variety
Cucumber	forcing	Chungjang, Nakhap
	semi-forcing	Banback
	open	Hukchinju, Banback, Backchim
Spinach	Spring	Minsterland, Pioneer, Nobel
	Summer	Kingoffdenmak, Woosung, Samboosangrok
	Fall	Woosung, Pungsung, Minsterland, Yipchugarak
Garlic	frozen zone	Seosan, Eusung, Danyan
	subtropical	Jeju, Haenam, Namdo
Onion	open	Paechong, Chunjuwhang, Chalwhangwhang, Yeoeujuwhang
Welsh onion	open	Eunchang, Sangryong, Jangsuhan, Backjinju, Bullambakeunju, Backchu
Watermelon	open	Palbo, Mirak, Changhae, Daeborum, Olrimpia,
	semi-forcing	Keummedal, House 1 ho
Radish	Spring	Seoul, Daehyung
	Summer	Minongchosang
	Fall	Jinjudaepyung, Younghyum, Seoul
	protected	Daehyung
Chinese cabbage	Spring	Manchun, Daekwanryung
	Summer	Manchun, Daekwanryung, Wallbok
	Fall	Chunseung, Chosangmiho, Tamra
	forcing	Housebom, Seoul
Cabbage	Spring	Copenhagen market, Succession
	Summer	Sakye
	Fall	Succession
Tomato	forcing	Kangyuk, Poongsang
	semi-forcing	Kangyuk'
	tunnel	Seokyang, Kangyuk
	open	Youngkwang, Daehyungboksu, Kangyuk
	early	Poongsang, Kangyuk

Source: AFMC (1994).

Trend Analyses

Area, Production, and Yield

During 1970-93, the total cropped area in the Republic of Korea decreased by some 10%, while total area in vegetable production increased by about 40%. Vegetable production increased by more than 20% in this period. Yields show an increasing trend for most vegetables due to improved varieties, proper fertilization, introduction of protected horticulture, adoption of new technology, and other improvements.

However, the increase in total vegetable area under all vegetables has slowed, evidenced by the significant negative quadratic terms in the trend data for area. The same holds true for yield and total production of vegetables (Table 5).

Table 5. Trends in area, production, and yield in the Republic of Korea, 1970-93

Crop	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
Chili	0.0869	-0.0031	-0.4450	0.0021	0.0186	-
Chinese cabbage	-0.0242	0.0006	0.1228	-0.0037	0.0986	-0.0031
Cucumber	-0.0333	0.0013	0.0175	-	-	0.0007
Garlic	0.0484	-0.0009	0.0113	-	0.0355	-
Onion	0.0584	-0.0016	0.0207	-	0.0401	-
Radish	-0.0114	-	0.0838	-0.0024	0.0679	-0.0220
Tomato	-0.0263	0.0008	0.0143	-	-	0.0004
Watermelon	0.0303	-	0.0036	-	0.0339	-
Welsh onion	0.0718	-0.0018	0.0458	-0.0011	0.1177	-0.0028
Total vegetable	0.0243	-0.0008	0.0515	-0.0014	0.0758	-0.0022

Source: Estimates from data reported in Ministry of Agriculture, Forestry and Fisheries (1994).
- implies that the coefficient is not significant at the 5% level.

The cultivated area under radish has a linear decreasing trend, while the area under watermelon exhibits a linear increasing trend. The area equations for carrot, garlic, onion, chili, Welsh onion, and total vegetables have significant positive linear but negative quadratic coefficients, indicating that the area of these vegetables increased in the early years, but started declining in later years. However, the opposite is true for Chinese cabbage, cucumber, and tomato where the cultivated area decreased in the early years but picked up in later years (Table 5).

Yields of garlic, onion, chili, and watermelon increased linearly. Yields of cucumber and tomato increased quadratically suggesting that the rates of increase were higher in later years. The yield of radish, Chinese cabbage, carrot, Welsh melon and total vegetables increased in the early years but started declining in the later years (Table 5).

Production of garlic, onion, cucumber, tomato, and watermelon increased linearly. The production of radish, Chinese cabbage, carrot, Welsh onion, and total vegetables increased linearly in the early

years under study but experienced a decline in the later years. However, the opposite is true for chili, where production decreased substantially in the early years but started picking up in the later years, although very slowly (Table 5).

Protected Vegetable Cultivation

The area under protected cultivation of different vegetables in Korea is reported in Table 6. The relative importance of protected cultivation has increased substantially in recent years. In 1993, about 16% of the total vegetable area was classified as protected cultivation. Lettuce and fruit vegetables, such as tomato, cucumber, and sweet melon, are some of the most important crops grown under protective structures.

Table 6. Area of protected vegetables (% of total protected vegetable area) in the Republic of Korea, 1983-94

Crop	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Veg. total (ha)	21456	23066	25123	26412	25398	24442	32156	35279	43852	45833	54640	64286
Chili	7.8	7.0	8.4	10.3	7.7	7.5	5.9	5.2	5.2	6.3	5.7	6.4
Chinese Cabbage	16.6	15.2	12.7	11.8	9.6	11.5	7.7	9.2	9.6	8.2	9.4	7.3
Cucumber	9.0	8.4	8.5	8.8	9.3	9.3	9.4	9.8	9.7	9.9	9.4	8.2
Lettuce	6.5	6.8	6.6	6.1	5.8	4.2	6.6	6.0	7.1	6.5	7.3	7.3
Radish	10.4	10.1	8.7	7.2	6.3	6.2	7.0	6.2	6.3	6.1	6.3	6.0
Sweet melon	16.5	16.2	15.1	14.2	14.1	12.8	12.0	10.5	10.5	10.8	10.8	11.3
Tomato	6.3	6.3	5.8	6.0	7.0	6.6	5.9	5.0	4.0	4.8	4.9	4.3
Watermelon	6.9	8.4	11.5	12.0	13.1	10.3	10.8	13.5	15.5	19.1	19.7	21.4

Figures in parentheses are percentages of the total protected vegetable area in the Republic of Korea.
Source: Ministry of Agriculture, Forestry and Fisheries (1994).
Note: Figures in paranthes are total protected area of all vegetables.

Vegetable Prices

The price indices for all vegetables deflated by the Producer Price Index (PPI) remained relatively constant during 1981-93. Real prices of radish and Chinese cabbage, as well as of condiment vegetables, such as chili, garlic and onion, are quite unstable and do not exhibit a significant increasing trend. On the other hand, real prices of carrot and fruit vegetables, such as cucumber, tomato and watermelon, showed a rising trend with a sharp increase in the late 1980s, but have come down since then (Table 7).

Table 7. Annual (deflated) price indices of important vegetables, 1980-93

Year	Radish	Chinese cabbage	Chili	Garlic	Onion	Carrot	Cucumber	Tomato	Water-melon	All vegetables
1980	137.2	111.3	191.0	41.8	90.5	47.3	55.7	59.6	32.0	87.3
1981	147.0	107.6	105.2	120.7	122.1	48.8	55.9	46.4	42.8	95.9
1982	91.2	81.8	107.4	126.1	64.4	34.6	42.8	31.9	29.0	82.6
1983	105.6	104.5	66.3	88.6	33.7	32.1	43.4	48.0	33.1	68.7

Contd. Table 7.

Year	Radish	Chinese cabbage	Chili	Garlic	Onion	Carrot	Cucumber	Tomato	Water-melon	All vegetables
1984	100.3	79.1	150.4	106.9	122.6	44.5	45.4	42.7	44.6	93.9
1985	117.5	117.4	172.6	113.4	59.7	45.3	50.0	48.8	32.5	97.4
1986	118.3	92.1	110.6	58.6	96.0	52.9	62.2	45.9	44.8	76.9
1987	180.6	150.4	132.7	38.2	55.4	71.4	67.2	55.6	46.4	85.9
1988	217.9	188.7	108.2	78.4	61.2	61.5	86.6	77.9	52.6	98.1
1989	157.2	161.8	54.0	81.5	76.8	65.4	74.9	67.6	55.6	87.4
1990	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1991	78.1	90.8	142.9	83.1	103.0	71.9	82.3	89.7	91.5	100.7
1992	83.9	74.4	179.7	78.4	47.3	82.2	91.6	113.6	95.2	108.0
1993	74.1	58.7	165.1	86.1	46.4	67.3	88.9	108.0	102.1	105.3

Source: National Agricultural Cooperative Federation (1993).

Risk in Vegetable Production

An assessment of risk in vegetable production was made by using the coefficients of variation (CV) estimated after detrending the series. The detrended CVs for individual and total vegetable area, production, and yield are reported in Table 8. The CV of rice was also included for comparison.

Table 8. Detrended coefficients of variation (%) in area, production, and yield of selected vegetables, 1970-93

Name of vegetable	Area	Yield	Production
Carrot	27.6	12.3	25.9
Chili	33.7	24.7	23.9
Chinese cabbage	14.2	28.5	30.6
Cucumber	17.0	16.3	19.2
Garlic	19.8	14.7	22.6
Onion	29.2	12.4	28.0
Radish	11.8	20.4	24.5
Tomato	15.7	13.2	16.3
Watermelon	15.3	4.7	15.8
Welsh onion	14.2	20.3	23.3
All vegetables	11.1	17.7	19.4
Rice	8.2	10.9	11.3

With the exception of the CV in the yield of watermelon, the CVs in area, yield, and production of vegetables are all higher than those for rice, indicating that vegetable cultivation is relatively risky. Despite the potential counterbalancing effects of individual vegetables on total vegetables, the CVs for total vegetable area, yield, and production are also higher than the corresponding CVs for rice.

The relatively high CV of total vegetable production suggests that variability in vegetable availability and consumption is considerably higher than in cereals, especially when exports and imports of vegetables are limited.

The highest production CV was observed for Chinese cabbage, closely followed by the CVs for onion, carrot, radish, chili, Welsh onion, and garlic. The production CV for these vegetables ranged from 31 to 23%. CVs were relatively low for the production of watermelon, cucumber, and tomato, ranging from 19 to 16%.

The area allocated to chili, onion, and carrot was quite unstable as evidenced by their CVs. The CVs for the yield of Chinese cabbage, chili, radish, and Welsh onion were relatively the highest among vegetables, while the CV was relatively low in the case of watermelon (Table 8).

Seasonality in Prices

Generally, there is clear seasonal variation in vegetable prices. However, the seasonality in prices is likely to be different for different vegetables, depending on the seasonality of demand, storage costs, share of protected cultivation, and length of the main harvest period. Prices of vegetables cultivated under protection, such as cucumber, are high from December to March because of high production cost. Prices of garlic and onion rise gradually from fall to winter due to increasing storage costs. On the other hand, the price of chili is relatively stable throughout the year because of its good storability. Vegetables as a whole show about 10% seasonality in price (Table 9).

Table 9. Seasonal price indices by crop, 1991-93

Crop	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonality
C. cabbage	100.0	102.9	144.8	136.1	115.1	118.1	134.6	201.5	218.5	118.3	88.9	110.6	145.8
Cabbage	100.0	93.2	98.9	112.0	117.8	104.6	90.4	105.1	145.0	132.9	116.0	110.4	60.4
Carrot	100.0	99.3	100.8	112.1	119.7	120.8	119.6	126.1	146.9	166.4	141.0	118.1	67.6
Chili	100.0	101.8	103.5	104.5	105.4	111.7	116.5	105.0	122.1	118.3	111.2	109.8	22.1
Cucumber	100.0	99.6	96.0	71.7	54.4	49.0	45.6	55.0	59.5	69.6	80.5	102.3	124.3
Garlic	100.0	97.6	103.3	99.3	101.0	97.6	95.9	97.3	102.0	100.5	100.3	105.0	9.5
Lettuce	100.0	66.4	69.0	46.3	32.2	33.8	53.4	40.0	39.6	52.2	90.4	122.6	280.7
Onion	100.0	104.0	114.6	93.3	65.3	60.8	82.2	113.2	127.3	133.7	134.6	141.1	132.1
Radish	100.0	96.2	103.9	143.6	159.2	118.2	118.9	167.4	196.8	146.5	122.8	137.0	104.6
Spinach	100.0	101.7	97.4	85.0	83.6	105.6	141.2	175.6	185.5	120.3	101.9	115.4	121.9
Welsh onion	100.0	100.2	107.0	95.8	79.9	108.9	130.2	139.5	146.9	145.1	137.3	145.8	83.9
Vegetables	100.0	100.2	101.1	102.7	100.0	97.7	97.9	103.7	106.6	104.3	104.1	107.3	9.8
Fruits	100.0	103.8	106.8	109.4	113.6	116.0	109.6	111.3	112.1	112.4	102.5	103.3	16.0
Meat	100.0	99.9	99.1	100.4	100.9	100.9	103.2	104.3	104.0	103.0	102.0	100.5	5.2
Rice	100.0	100.7	101.1	102.5	102.6	102.7	102.1	102.1	102.5	103.0	103.8	104.5	5.5

Source: Agricultural & Fisheries Marketing Corporation (1994).
Official files of National Statistical Office, Seoul.

Economics of Production

Input use

Input quantities for different vegetables are reported in Table 10. A great variation in input use was observed across vegetable species and within vegetable species grown under different management conditions. For example, labor use varied from about 1200 hours/ha for radish and carrots to 7300 hours/ha for protected tomato. A similar variation was observed in machine, fertilizer, manure, and pesticide use. Input use is generally higher under protected conditions compared to when a crop is grown in an open field. Cucumber is the most input-intensive vegetable when grown under forced conditions, followed by tomato (protected), and chili (protected). Radish and carrot are the least input-intensive vegetable crops.

Table 10. Input quantities (per ha) for the production of major vegetables

Crop	Cropping Method/period	Seed (kg)	Labor (hours)	Equipment (hours)	Fertilizer[1] (kg nutrient)	Manure (kg)	Pesticide[2] (US$)[3]
Cabbage	open	8	1614	129	N:359+P:219+K:251=829	14,880	200.4
Carrot	open	193	1223	124	N:258+P:202+K:202=662	8,490	234.1
Chinese	Spring	13 dl[4]	1613	135	N:306+P:145+K:203=654	19,850	178.4
cabbage	Summer	13	1407	86	N:383+P:215+K:320=918	9,300	2440.1
	Autumn	15	1493	131	N:318+P:162+K:216=696	18100	181.6
Cucumber	open	25	3281	218	N:399+P:186+K:322=907	22,530	488.5
	forced	28	7962	257	N:521+P:283+K:502=1306	69,130	1332.2
	semi-forced	28	7137	438	N:590+P:274+K:503=1367	51,990	1003.6
Garlic	open	1470	1800	77	N:273+P:213+K:221=707	10,800	122.1
Lettuce	open	31	1964	126	N:253+P:134+K:140=527	17,440	120.2
	protected	30	4858	286	N:298+P:163+K:212=673	26,480	224.8
Onion	open	76 dl	1629	74	N:324+P:210+K:230=764	14,392	154.8
Pumpkin	open	53	1846	140	N:266+P:150+K:188=604	17,680	135.3
	protected	75	5020	220	N:376+P:206+K:297=879	31,510	308.0
Radish	Spring	57	1225	107	N:260+P:152+K:177=589	16,870	122.5
	Summer	63	1242	101	N:280+P:173+K:217=670	11,010	178.7
	Autumn	79	1211	109	N:270+P:143+K:169=582	14,060	129.7
Red	open	9	2317	534	N:315+P:184+K:283=782	4,955	331.6
chili	protected	15	8737	332	N:427+P:261+K:324=1012	39,900	565.8
Spinach	open	633 dl	1592	94	N:260+P:136+K:141=537	18,960	115.1
Tomato	open	18	2892	188	N:334+P:211+K:288=833	22,400	349.4
	protected	21	7322	375	N:356+P:260+K:353=969	40,680	593.0
Water-	open	26	2122	167	N:230+P:169+K:212=611	18,640	338.5
melon	protected	35	4862	237	N:280+P:184+K:264=728	33,100	395.7
Welsh onion	open	84	2254	164	N:344+P:179+K:212=735	19,610	316.2

Source: Rural Development Administration (1994).
[1]Fertilizer includes lime and silica for chili, onion, and garlic. Fertilizer data are for 1991.
[2]Includes insecticide and herbicide.
[3]US$1 = 808 won.
[4]dl = deciliter.

Factor Share

The relative share of different inputs in vegetable cultivation is reported in Table 11. For comparison, factor shares for rice are also reported. The shares of seed, fertilizer, and family and hired labor in total costs are much higher for vegetables compared to the factor shares of these inputs for rice. On the other hand, the shares of chemicals, implements, and the category "other costs" are higher for rice compared to those for vegetables. Thus, vegetable crops are clearly labor intensive relative to rice. "Other costs", a category which includes irrigation, accounts for a major share of cost in rice cultivation, but a minor share of the total cost of vegetable production.

While the cost of family labor is generally large, the cost share of most other inputs, especially seed, varies significantly across vegetables. For example, seed contributes more than one-fourth to the total production cost of garlic, while it is a minor proportion of the total cost in cabbage (Table 11).

Table 11. Factor share (%) for vegetable and rice production[1]

Crop	Seed & seedlings	Fertilizer	Chemicals	Electricity & fuel	Implements	Farm bldg. & facilities	Hired labor	Family labor	Other costs [2]
Cabbage	2.6	12.4	2.8	0.7	3.3	0.2	16.9	53.6	7.5
C. cabbage	3.7	11.8	2.7	0.9	3.0	0.1	13.9	57.0	7.0
Carrot	10.4	13.6	3.6	0.7	3.4	0.2	16.1	48.0	4.0
Cucumber	4.6	7.0	3.0	0.6	2.8	0.3	10.2	59.0	12.5
Garlic	28.9	10.2	1.3	0.2	0.9	0.2	10.2	40.8	7.3
Lettuce	3.0	9.1	1.2	0.6	3.0	0.3	12.1	65.8	5.0
Onion	8.3	14.8	1.4	0.2	1.2	0.3	19.7	41.7	12.5
Radish	6.5	15.4	2.6	1.0	3.2	0.2	13.9	55.8	1.5
Red pepper	6.0	6.7	3.4	2.0	2.1	0.3	7.6	58.8	13.0
Rice	2.3	5.8	4.6	0.4	5.7	0.4	6.4	34.7	39.6
Spinach	6.5	10.8	1.5	0.6	4.0	1.2	12.4	54.9	8.1
Tomato	3.7	8.3	2.3	0.5	2.2	0.1	9.2	58.9	14.7
Watermelon	6.2	8.4	3.2	0.8	2.0	0.3	11.2	57.2	10.6
Welsh onion	4.7	10.1	3.1	0.8	3.4	0.2	20.0	54.3	3.5

Source: Rural Development Administration (1994).

[1] Calculations are based on cultivation in the open. Own land and own capital are not included in production costs because of lack of published data.

[2] Includes expenditures on irrigation, custom operations, animals, repairs, and maintenance.

Profitability

Gross revenue, production cost, net income per unit area, benefit-cost ratio, and cost per kilogram of vegetable produced are reported in Table 12. Production costs of cucumber and tomato are relatively high. Net incomes from tomato, garlic, Welsh onion, chili, and cucumber are relatively high, and those from radish, Chinese cabbage, cabbage and spinach are relatively low.

Net income per 0.1 ha of rice is lower than net income from chili, onion, garlic, carrot, tomato, watermelon, Welsh onion, and cucumber, but it is higher than that for Chinese cabbage, radish, spinach, and cabbage. The benefit-cost ratio for rice is higher than for all the vegetables reported in Table 12. These results are partly caused by high government protection for rice cultivation. There is a need to study the domestic resource cost of rice and vegetable cultivation without government protection and subsidies in order to learn how resources in agriculture production in the Republic of Korea could be utilized in a more efficient manner. This is essential in the wake of increased competition after the opening of agricultural trade as a result of the GATT negotiations. Not unexpectedly, the absolute levels of net income for several vegetable species significantly exceed that for rice.

Table 12. Economics of vegetable and rice cultivation per ha

Crop	Cropping method/period	Production (kg)	Production cost (US$)*	Gross revenue (US$)	Net income (US$)	Benefit-cost ratio	Cost/kg (US$)
Cabbage	open	5006	7010	8120	1110	1.16	0.14
Carrot	open	2724	5960	10280	4320	1.72	0.22
Chili	open	219	9880	18490	8610	1.87	4.51
Chinese cabbage	Spring	4801	7770	9800	2030	1.26	0.16
	Summer	4693	6380	9810	3430	1.54	0.14
	Fall	8117	7020	7730	710	1.10	0.09
Cucumber	open	3444	15820	24340	8520	1.54	0.46
	semi-forced	8044	43120	68780	26660	1.62	0.54
	forced	10438	61560	120770	59210	1.96	0.59
Garlic	open	1084	9280	19270	9990	2.08	0.86
Lettuce	open	1868	8810	14120	5310	1.60	0.47
	protected	3686	23580	35210	11630	1.49	0.64
Onion	open	5723	7420	14200	6780	1.92	0.13
Radish	Spring	4033	6470	8430	1960	1.30	0.16
	Summer	3815	5800	8210	2410	1.42	0.15
	Fall	4737	5560	7970	2410	1.43	0.12
Rice		418	3470	7440	3970	2.14	0.83
Spinach	open	1599	7860	10550	2670	1.34	0.49
Tomato	open	3165	14950	24990	10040	1.67	0.47
	protected	6829	41830	66340	24510	1.59	0.61
Welsh onion	open	2983	10060	19160	9100	1.90	0.34
Watermelon	open	2396	10470	13490	3020	1.29	0.44
	semi-forced	3425	26200	40690	14490	1.55	0.76

Source: Rural Development Administration (1993).
*Own land and own capital are not included in production costs.

The cost per kilogram of production varies greatly across vegetable species (Table 12). It is highest for chili and relatively low for Chinese cabbage, radish, onion, and cabbage. The cost of rice cultivation is US$0.83/kg, which is relatively high compared to the cost in other rice-producing

countries (Librero and Rola 2000). This also suggests that rice cultivation in Korea is probably not competitive.

Constraints

Bio-physical Constraints

Presently, there is no literature which systematically compares constraints in vegetable production in Korea by individual crop. Table 13 is based on information provided by experts. The table suggests that natural factors and diseases play a more important role in constraining vegetable production than do other factors.

Table 13. Constraints in vegetable production[a]

Vegetable	Losses due to				
	Insects	Disease	Poor seed quality	Post-harvest losses	Drought & flood
Chili	*	***	-	*	***
Chinese cabbage	-	-	-	***	**
Cucumber	*	***	**	-	-
Garlic	-	-	*	**	***
Onion	-	-	-	**	***
Radish	-	-	-	***	**
Tomato	-	***	**	-	-
Watermelon	**	**	-	-	***

[a] The number of stars indicates the degree of importance, and – implies that the constraint is not relevant.

Economic Constraints

Instability in vegetable production in Korea is the major economic constraint. It causes wide fluctuation in prices and profitability. In addition, serious labor shortages in rural areas have resulted in high wages, now a main constraint to vegetable production. Insufficient capital and low-level management skills have also negatively affected the profitability of vegetable production, particularly in recently introduced protected cultivation.

Marketing Systems

Marketing Channels

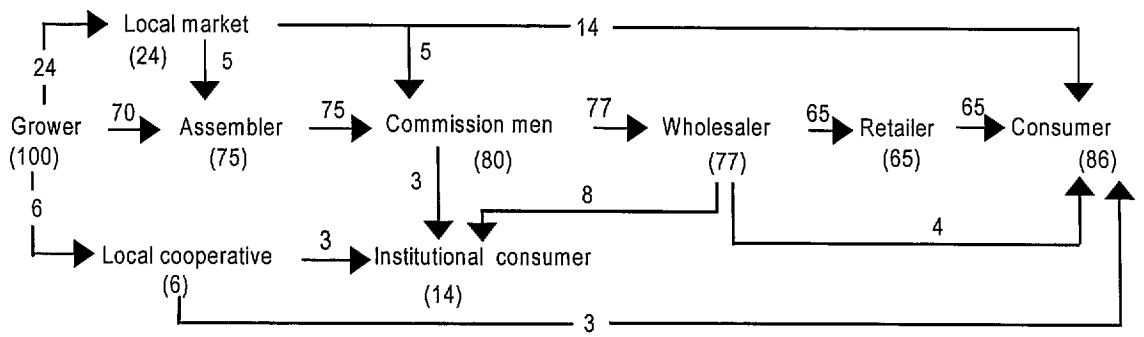
Two different marketing channels are identified for perishable and storable products in Figure 2. The larger part of the marketing volume of vegetables passes through the central wholesale markets.

For garlic, 70% of farmers' produce was found to go to assemblers, 24% to local markets, and 6% to local cooperatives. The local cooperatives sold half of their output to bulk purchasers, and the remaining half to individual consumers. The assemblers and commission agents assemble some

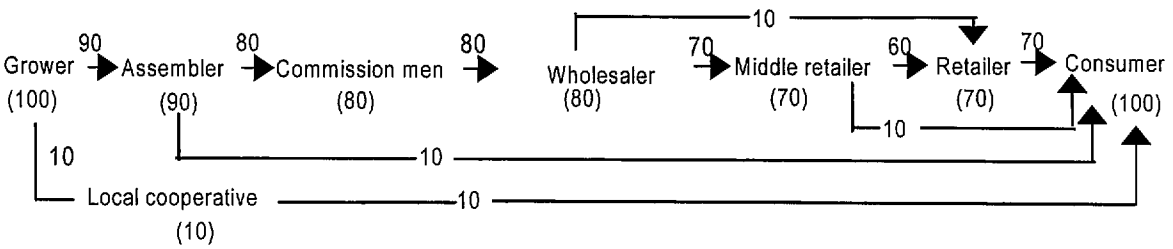
garlic from the local market as well (5% each), and remaining output in the local market goes directly to consumers (14%). From assemblers, the produce flows via commission agents, middlemen wholesalers, and retailers to consumers, with few linkages to consumers (Fig. 2).

In Chinese cabbage, 90% of the farmers' production goes to assemblers and 10% to local cooperatives. The latter then goes directly to consumers. From assemblers, the produce flows through commission agents, middlemen wholesalers, middlemen retailers, and retailers, to consumers, with few transactions between different marketing agents (Fig. 2).

A. Garlic (Seosan - Seoul, July, 1991)



B. Chinese cabbage (Naju - Seoul, December, 1991)



Source: AFMC (1992).

Fig. 2. Marketing channels of major vegetables

Marketing Margin

The percentage of the retail price received by farmers is generally low in vegetables. However, the farmer's share depends highly on the degree of perishability of the crop and on whether or not a contract has been signed with an assembler before harvest. As shown in Table 14, the farmer's share of the retail price for perishable crops, such as radish and Chinese cabbage, is very low, while that for red pepper is considerably higher.

Margins at the retail stage are higher than at the assembling or wholesale stage for most vegetables. This may be because of the relatively small quantities traded at the retail level, and/or the high physical losses. The farmer's share for garlic, onion, Welsh onion, radish, and Chinese cabbage has been decreasing over time, while the farmer's share for chili, cucumber, and carrot is higher than in the past (Table 14). The decrease in the farmer's share of the retail price in some vegetables might be

due to an improvement in the services provided by marketing agents (or increase in the value added), to increases in the profits of marketing agents, and/or to higher transportation costs. The increase in farmer's share of retail prices in some other vegetables might be due to an increase in the share of the shorter marketing channels, such as cooperatives.

Table 14. Marketing margins (percentage) of major vegetables

Crop	Survey date	Farmer's share	Margins by stages			Survey region
			Assembling	Wholesaling	Retailing	
Carrot	October 1981	32.1	7.2	11.3	49.4	Yesan - Seoul
	September 1991	43.3	16.2	23.8	16.7	Pyungchang – Seoul
Chili	October 1981	69.2	9.0	3.4	18.4	Yeongyang - Seoul
	October 1991	76.5	7.1	6.9	9.5	"
Chinese cabbage	May 1981	27.2	13.6	5.4	53.8	Pyungtak - Seoul
	December 1991	11.0	37.2	10.1	41.7	Naju – Seoul
Cucumber	August 1981	45.6	4.8	32.9	16.7	Whasung - Seoul
	June 1991	53.4	6.4	11.6	28.6	"
Garlic	July 1981	60.0	8.5	14.7	15.9	Seosan - Seoul
	July 1991	46.9	16.3	15.5	21.3	"
Onion	July 1981	53.5	16.3	9.7	20.5	Hamptung - Seoul
	July 1991	47.7	16.2	12.7	23.4	Changyeong – Seoul
Radish	August 1981	32.0	8.3	19.2	40.5	Pyungchang - Seoul
	December 1991	15.6	31.6	16.6	36.2	Gochang – Seoul
Welsh onion	October 1981	49.2	21.6	17.7	11.5	Yesan - Seoul
	October 1991	26.8	35.0	9.6	28.6	Jindo - Seoul

Source: Agricultural & Fisheries Marketing Corporation (1992).

No statistics are available to compare the relative efficiency of different marketing channels. The farmers-cooperative-consumer channel, however, is the shortest route to bring vegetables to consumers. Constraints to the expansion of this channel need to be studied with a view to expanding its reach, and thus improve overall vegetable market efficiency.

Marketing Margin by Activity

The shares of different marketing activities, by different actors, in the total marketing margin for radish and Chinese cabbage are reported in Table 15. Profits account for the largest part of the marketing margin, about two-thirds of the total marketing cost. Most profit goes to retailers, followed by wholesalers. Surprisingly, the share of physical losses in total marketing is minimal, contributing only 5-6%. Cleaning, which also involves grading, contributes about 11% to the total marketing cost of both radish and Chinese cabbage. Cleaning and grading are mostly done at the assembling stage. Transportation accounts for 16-19% of total marketing cost. Transportation costs at the retail level are much lower than at the assembler level, indicating that assemblers have to haul vegetables from longer distances than do retailers (Table 15).

Table 15. Shares of marketing activities (%) in total marketing margin by marketing agents for radish and Chinese cabbage

Crop	Activity	Marketing Agent				
		Assembler	Commission agent	Wholesaler	Retailer	Total
Chinese cabbage	transportation	11.3	-	-	7.5	18.8
	profit, overhead cost	4.5	5.4	19.3	34.0	63.2
	loss	-	-	4.2	2.1	6.3
	cleaning, other expenses	9.4	-	2.2	-	11.6
	total	25.2	5.4	25.8	43.6	100.0
Radish	transportation	11.6	-	-	4.1	15.7
	profit, overhead cost	10.9	4.3	19.1	33.3	67.6
	loss	-	-	3.8	1.6	5.4
	cleaning, other expenses	9.7	-	1.6	-	11.3
	total	32.2	4.2	24.5	39.0	100.0

Source: Agricultural & Fisheries Marketing Corporation (1994).
Note: Radish: Kochang-Seoul; Chinese cabbage: Dangin-Seoul.

International Trade

The self-sufficiency ratio in vegetables was 99.5% in 1993, compared to 35.2% for cereals. Therefore, imports and exports of vegetables in the Republic of Korea are limited compared with other agricultural products. Vegetable imports and exports are mostly used to control temporary market situations, and no significant trend can be seen in this trade (Table 16). For example, condiment-type vegetables, such as chili, garlic, and onion, are mainly imported to mitigate annual fluctuations in prices. On average, international trade in vegetables from the Republic of Korea shows a rising trend, seen from a long-term perspective, but it is nevertheless small and unstable in volume. A distinctive feature in the trade of vegetables is that imports from China have increased sharply in recent years.

Table 16. International trade in vegetables (in t), 1980-93

Year	Radish	C. cabbage	Chili	Garlic	Cabbage	Onion	Cucumber	Tomato	Other vegetables	All vegetables
Exports										
1980	0	0	0	52	1316	5000	155	57	229	6809
1981	2798	5200	502	414	2516	7110	79	80	72	18771
1982	1210	2889	1202	407	2700	466	23	123	2422	11442
1983	0	0	1383	842	386	17621	13	72	14958	35275
1984	0	0	0	0	550	0	28	155	6416	7149
1985	0	0	647	1070	4225	246	24	251	3593	10056
1986	0	0	1319	9258	2572	932	25	174	4758	19038
1987	0	0	315	3234	2031	1203	41	173	4037	11034
1988	1143	9122	1914	3091	1783	10966	70	177	7606	35872
1989	778	8389	1269	61	1232	6415	52	2663	19245	40104
1990	0	8838	850	236	309	57	170	137	4705	15302
1991	543	12136	913	18	5923	421	712	291	12917	33874

Contd. Table 16.

Year	Radish	C. cabbage	Chili	Garlic	Cabbage	Onion	Cucumber	Tomato	Other vegetables	All vegetables
1992	477	9589	2658	5226	393	14627	1186	458	23475	58089
1993	1330	13876	776	4035	7144	4332	859	469	13748	46569
Imports										
1980	0	0	0	0	0	0	0	0	0	0
1981	0	0	5661	0	0	0	0	0	415	6076
1982	0	0	2272	4439	14	0	9	31	0	6765
1983	0	0	1198	567	0	0	2	18	0	1218
1984	0	0	18944	9200	567	20000	5	0	3003	51719
1985	0	0	11216	7459	0	9358	10	0	2280	30323
1986	0	0	980	0	0	0	0	0	724	1704
1987	0	0	168	0	0	0	0	0	847	1015
1988	0	3	1013	0	0	86	596	51920	18572	72190
1989	0	15	128	0	0	14	609	65872	32320	98958
1990	0	56	156	95	0	6150	1391	80148	4229	92225
1991	19	0	2721	54	0	4361	1515	18305	39229	66204
1992	0	0	5971	15	0	60	1856	79124	85409	172435
1993	2718	0	554	940	0	3025	3100	79185	8144	97666

The import and export quantities for total vegetables do not include strawberries.
Source: Korea Rural Economic Institute (1993b).

Supply and Demand

Per-Capita Availability

Per capita annual vegetable availability remained at around 200 kg during 1980-1993, except the last year when it jumped to 229 kg (Table 17). Looking at the individual crop availability data, the contribution of Chinese cabbage and radish in total availability is very high at about 36% and 16%, respectively. The availability of radish and cabbage showed some decline during the 1980s and 1990s, although they are still major vegetables in the Korean diet.

Increases in income have resulted in changes in dietary patterns toward more high-quality vegetables. As a result, in the long run, excess supply of vegetables such as chili, radish, and Chinese cabbage can be expected.

Consumption

Traditionally Koreans have relied on grain as the main part of their diet. However, high income growth combined with high income elasticity of demand for vegetables has resulted in partial substitution of cereals by vegetables.

Table 17. Per capita annual vegetable availability, 1980-93

Year	Total production (000 t)	Trade surplus (000 t)	Net availability (000 t)	Population (million)	Per capita availability (kg)
1980	7675.9	6.8	7669.1	38.1	201.2
1981	7985.1	12.7	7972.4	38.6	206.3
1982	8493.9	4.7	8489.2	39.2	216.7
1983	7587.8	34.1	7553.8	39.7	190.2
1984	7851.2	-44.6	7895.7	40.3	196.1
1985	7763.0	-20.3	7783.3	40.8	190.7
1986	8703.0	17.3	8685.7	41.4	209.6
1987	7402.9	10.0	7392.9	42.1	175.7
1988	7651.2	-36.3	7687.6	42.7	180.0
1989	8314.1	-58.9	8373.0	43.4	193.0
1990	8677.4	-76.9	8754.4	43.8	199.9
1991	8608.7	-32.3	8641.0	44.2	195.7
1992	8790.8	-114.3	8905.1	44.5	199.9
1993	10151.8	-51.1	10202.9	44.5	229.1

Source: The source of production data is reported in Table 6. Trade surplus is estimated from data reported in Table 16. Population is taken from IRRI (1995). Per capita availability is estimated as (production – trade surplus)/population.

Seasonality in Consumption

Seasonality in vegetable consumption can be analyzed by studying monthly supplies in major markets. While seasonality (high supplies) in the Seoul Garak-Dong market for watermelon (May-September), tomato (April-July), and garlic (May-June) is very distinctive, it is less strong for cabbage, red pepper, onion, and carrots. Although overall vegetable prices show little seasonality (10%, Table 9), seasonality in the overall supply of vegetables in the Seoul Garak-Dong market is quite high at 200% seasonality (Table 18).

In recent years, seasonality in the consumption of vegetables has decreased somewhat because of changing cultivation methods resulting from the rapid increase in protected cultivation and improvements in storage facilities.

Table 18. Monthly indices of vegetable supply in the Seoul Garak-Dong Market

Crop/Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonality
C. cabbage	100	84	158	235	283	337	324	324	330	293	297	377	349
Cabbage	100	81	109	125	160	133	145	176	135	139	133	130	117
Carrot	100	86	107	95	96	86	86	88	89	76	83	85	41
Cucumber	100	117	192	253	273	343	270	236	192	228	139	107	243

Contd. Table 18.

Crop/Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonality
Garlic	100	71	90	140	719	724	147	88	67	68	67	60	1107
Lettuce	100	137	181	215	240	347	151	172	178	165	112	107	247
Onion	100	86	104	113	178	185	123	154	130	118	112	116	115
Radish	100	99	123	138	149	158	154	171	201	207	295	238	198
Red pepper	100	167	160	155	177	227	166	121	214	114	113	184	127
Spinach	100	88	68	80	73	48	42	24	27	42	72	76	317
Tomato	100	148	696	2447	4391	4127	1900	648	383	297	270	219	4291
Watermelon	100	71	153	412	3612	13865	25141	12506	1447	812	412	288	35310
Welsh onion	100	81	140	156	114	84	86	124	105	123	196	172	142
All vegetables	100	90	126	162	225	270	240	213	184	182	187	180	200

Source: Seoul Agricultural & Marine Products Wholesale Market Management, Wholesale Prices of Agriculture, Fisheries, and Livestock Products, 1992, 1993, 1994.

*The above estimates are based on monthly supplies at the Seoul Garak-Dong market, and, therefore, do not necessarily exactly match monthly consumption patterns.

Price and Income Elasticities

Elasticities differ depending on the estimation method used and the period for which the analysis was undertaken. Income elasticities for Welsh onion (0.63) and onion (0.51) were relatively high, while those for cucumber (0.06), radish (0.06), red pepper (0.12), and Chinese cabbage (0.23) were low. Onion (-0.68) and Welsh onion (-0.51) were also more sensitive to price changes than other vegetables. The price elasticity of demand for cucumber was peculiar, possibly because of estimation problems. While the price elasticity of rice is relatively low, both income and price elasticities of beef are relatively high (Table 19).

Table 19 . Price and income elasticities for vegetables, rice, and beef, 1975-1992

Commodities	Income	Price
Chili	0.12	-0.22
Chinese cabbage	0.23	-0.13
Cucumber	0.06	0.81
Garlic	0.31	-0.30
Onion	0.51	-0.68
Radish	0.06	0.01
Tomato	0.36	-0.61
Watermelon	0.34	0.09
Welsh onion	0.63	-0.51
Beef	0.59	-0.97
Rice	-0.08	-0.29

Source: Korea Rural Economic Institute (1993a, c).

Supply and Demand Projections

The Republic of Korea is self-sufficient in almost all vegetables. International trade in vegetables is small and used only to maintain the seasonal balance between demand and supply and to stabilize extreme price fluctuations. Based on supply and demand elasticities, projections for area, consumption, yield, and imports for major vegetables were made. The harvested areas of most vegetables, especially Chinese cabbage and red pepper, are expected to decrease, while per-hectare yields of most vegetables are expected to increase. Consumption of red pepper, garlic, and onion is expected to increase, as will imports of these commodities.

Consumer Preference

Even though no survey data on consumers' preferences are available, information derived from the Agricultural Product Standards seems to suggest that Koreans like large vegetables (Table 20).

Table 20. Agricultural product standards for vegetables

Vegetable	Type or size	Color	Others
Chili	large, thick outer skin	-	-
Chinese cabbage	large head, white stem and bluish green leaf	-	
Cucumber	large type	light blue	winter
	small type - pickle	light green	summer
Garlic	large	-	pungent
Onion	large and corn type	-	-
Radish	cylindrical and large	-	-
	thick end part	-	
Tomato	large	-	solid, juicy

Source: National Agricultural Cooperatives Federation (1993).

Government Policies

Government policies regarding vegetables are mainly aimed at reducing price fluctuations. For garlic and onion, floor prices are guaranteed contingent on production and marketing agreements between farmers and government. In addition, when the farm-gate price falls below the floor price, price stability is directly pursued through government purchasing at the farm gate and through support for private storage. To meet urgent need, condiment-type vegetables, such as chili, garlic, and onion, are occasionally imported, helping to stabilize their prices.

The ROK government has contributed to the rapid expansion of area under protected production in order to ensure high-quality produce and to help farmers cope with labor shortages. In addition, government programs to improve price and quality competition have been suggested in the context of worldwide trade liberalization of agricultural products. In particular, efforts would focus on reducing production costs, modernizing protected cultivation and marketing facilities, raising quality standards, and instituting quality certification.

Achievements and Research Priorities

Past Research

Research in vegetable economics has concentrated on the following areas:

- Efforts to achieve an improved balance between demand and supply of vegetables with reduced seasonality in supply.
- Assessment of economic feasibility, determining optimal management strategies, and identification of major problems regarding protected cultivation.
- Estimation of price and income elasticities of demand for individual vegetables.
- Forecasting demand and supply of vegetables.
- Analysis of marketing conditions and suggesting possible improvements at wholesale markets.
- Marketing of imported vegetables.
- Trading conditions in rural areas (e.g., standardization, storage, and processing).
- Optimal size and location of marketing facilities.
- Improving marketing information.
- Policies for price stability of condiment vegetables.

Future Research

Important future research areas related to vegetable economics might include the following:

- Suggest ways to improve competitiveness in view of trade liberalization and rising wage rates.
- Identifying ways to reduce price instability.
- Identifying optimal location, size, and cropping pattern of protected agriculture cultivation.
- Analysis of foreign markets of major exportable vegetables.
- Food safety and organic farming for high quality vegetables.
- Consumers' preferences.

Summary and Conclusions

In the Republic of Korea, vegetables are cultivated on about 350 thousand ha, and their annual production is valued at about US$5 billion. Between 1970 and 1992, total cropped area decreased by about 10%, while total vegetable production area increased by 40%. Major vegetable crops include

chili, garlic, Chinese cabbage, radish, and watermelon. Cultivated area of tomato, radish, and Chinese cabbage has decreased in the past 22 years, while the area planted to garlic, onion, carrot, lettuce, spinach, watermelon, and Welsh onion has increased.

Per-hectare yields of most vegetables increased between 1970 and 1993, although at a decreasing rate, especially for radish and Chinese cabbage. Total vegetable production has increased by more than 200% in the past 20 years, even though production of Chinese cabbage and radish is decreasing.

Traditionally, Koreans have relied on rice as their main food. However, high income elasticities for vegetable have resulted an asymmetrical expansion of their demand. Per capita annual vegetable availability at the farm level increased from 83 kg in 1970 to 227 kg in 1979, then remained stagnant at around the 200-kg level during 1980-93. Availability of radish and Chinese cabbage continued decreasing, but other vegetables show an increasing trend, although considerable annual fluctuations exist. Income elasticities of Welsh onion, onion, tomato, and watermelon are relatively high, while those of cucumber, red pepper, and radish are low.

A main area of concern for vegetables is price uncertainty, since annual price fluctuations in vegetables remain high. Another area of concern is the increasingly serious shortage of labor in rural areas, and, as a result, rapidly growing wage levels, which has obvious implications for labor-intensive crops such as vegetables. High seasonality in availability is also a major problem.

Priorities for future research in vegetable economics include: 1) finding ways to mitigate price instability; 2) identifying improved production methods for high quality vegetables attractive to consumers; 3) identifying ways in which the farmer can reduce the cost of production in order to stay competitive in the global market; and 4) reducing the cost of protected cultivation to smooth out seasonality in availability.

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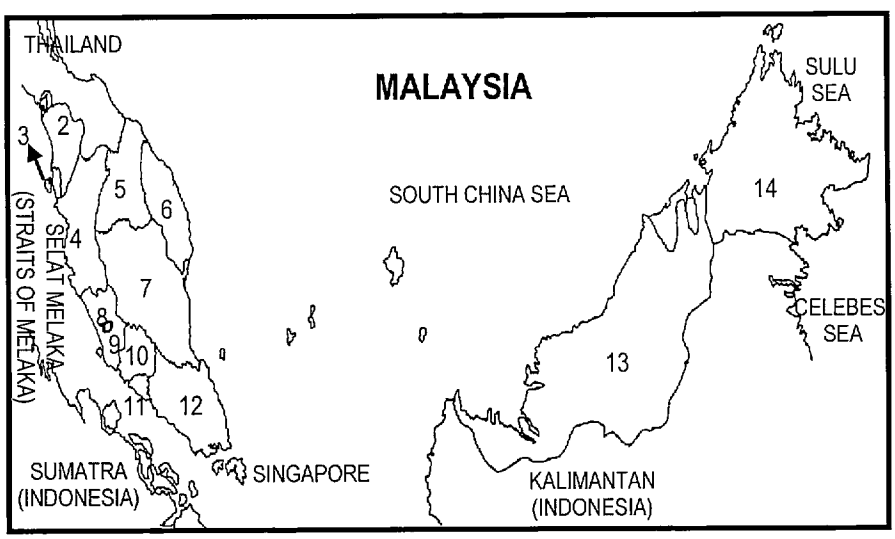
MALAYSIA

Nik Fuad Kamil, Syed Abdillah Alwi, and Mukhtiar Singh

Introduction

Malaysia is a relatively small country (320,000 km^2) with a total population of 20 million in 1995. It is bordered by Thailand in the north, Singapore in the south, and Indonesia in the east and west. The country is surrounded by the South China Sea and the Indian Ocean (Fig. 1). Malaysia consists of three regions: Peninsular Malaysia, Sabah, and Sarawak, each has respectively 6.2, 1.8, and 2.3 million ha of land suitable for agriculture. The topography of Peninsular Malaysia is dominated by a mountain range, called Main Range, which runs through the middle of the peninsula up to an elevation of about 2000 m asl. From this range, many rivers flow towards the flood plains and the coast. The west coast of the peninsula is dominated by alluvial marine deposits while the east coast exposes riverine deposits and sandy beach ridges. In the peninsula, about 8% of land is swampland. Sabah and Sarawak are generally mountainous with almost 70% of Sarawak comprised of very steep areas.



1. Perlis
2. Kedah
3. Pulau Pinang
4. Perak
5. Kelantan
6. Terengganu
7. Pahang
8. Selangor
9. Wilayah Persekutuan Kuala Lumpur
10. Negeri Sembilan
11. Melaka
12. Johor
13. Sarawak
14. Sabah

Fig. 1. Map of Malaysia

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More than half of the country's people live in urban areas. The overall population density in the country in 1995 was 62 people/km^2, which widely varies from 13 in Sarawak to 4713 in Kuala Lumpur (Department of Statistics 1996). Malaysia is a multiracial country comprised of Malays, Chinese, Indians, and indigenous groups. The indigenous people mainly live in the eastern states of Sarawak and Sabah.

Annual per capita income was around US$5000 in 1995, which was growing at the rate of 8-9% per annum (Department of Statistics 1996). Faster growth of the manufacturing sector has lead to a decline in the contribution of agriculture to the country's gross domestic product (GDP), from 23% in 1980 to about 16% in 1993. This is expected to further decline to 13% by the year 2000. However, earnings from agriculture are expected to increase in absolute terms from MYR14.8 billion in 1980 to MYR20.8 billion in 2000 (Abdul Aziz 1993).

In 1995, palm oil was the major contributor to the agricultural GDP which was growing at an annual rate of 5.8%, followed by rubber (growth 2.5%), and cocoa (growth 1.7%). The area under vegetable cultivation during 1994, excluding potato and sweet potato but including chili, was 25,974 ha (about 0.45% of the total cropped area, and 3.74% of the total cereal area). This produced about 0.399 million t of vegetables worth of about MYR574 million or US$220 million (these figures are only for Peninsular Malaysia, believed to contain more than 80% of total vegetable area). Average vegetable yield is about 15.0 t/ha.

A significant portion of total vegetable availability in the country is imported. Net imports after deducting exports amounted to 0.287 million t in 1995. Annual per capita availability of vegetables, after adding net of imports and exports, is 44 kg, about 60% of the recommended vegetable availability of 73 kg (again these figures are for Peninsular Malaysia only). The major vegetable species grown in the country are long beans, chili, cucumber, Chinese mustard, and lady's finger. These account for more than two-thirds of the total vegetable area.

Environment

Topography

In Peninsular Malaysia, a mountainous spine, known as the Main Range or Banjaran Titiwangsa, runs from the Thai border southwards to Negeri Sembilan, effectively separating the eastern and western parts of the peninsula. As a result of the configuration of the country and of the heavy rainfall, many rivers originate in the mountains and fall to the sea on both sides of the peninsular. The longest river on the peninsula is the Sungai Pahang (475 km), followed by the Sungai Perak (400 km).

The most prominent mountain range in Sabah is the Crocker Range. The highest mountain in the range, also highest in Southeast Asia, is Gunung Kinabalu (4101 m). The longest river of Sarawak is the Rajang Sarawak (563 km). The two highest peaks in Sarawak are Gunung Murud (2425 m) and Gunung Mulu (2371 m), the latter of which boasts one of the largest natural caves in the world.

About four-fifths of Malaysia is covered by tropical rain forest. Rice cultivation is practiced throughout the peninsula, but the main and traditional centers are the states of Perlis, Kedah, Selangor, Kelantan, and mainland Pulau Pinang. Most of the larger rubber and oil palm estates are located on the peninsula.

Climate

Malaysia lies entirely in the equatorial zone characterized by tropical climate, governed by the regime of the north-east and south-west monsoons. The north-east monsoon blows from about mid-November until March, and the south-west monsoon between May and September. The periods of change between the two monsoons are marked by heavy rainfall. The south-west monsoon is drier, particularly for the states on the west coast of the peninsula, sheltered by Sumatra.

Being in the tropics, the average temperature throughout the year is high (26°C). The diurnal temperature range is about 7°C. There is some regional variation in temperature. For example, the Cameron Highlands have a mean temperature of 18°, compared to Kuala Lumpur's 27°C. Mornings are generally fine, and rain in the late afternoons is often accompanied by lightning and thunder. Humidity is high (about 80%) due to the high temperature and a high rate of evaporation. Rainfall is generally heavy, about 2500 mm annually.

Major Vegetables and Growing Areas

Vegetables are small-holder crops in Malaysia, with an average farm size of less than one hectare. Vegetable production area is concentrated in the states of Johor, Perak, Kelantan, and Pahang. These four states account for about 75% of the total vegetable production in Peninsular Malaysia. Johor alone contributes about 41% of total vegetable area in the country (Table 1).

Table 1. Vegetable area, number of vegetable farmers, and average farm size in Peninsular Malaysia

State	Area* (ha)	Share in total area (%)	Farmers (number)	Average farm size (ha)
Johor	10618	40.9	1688	1.66
Kedah	1559	6.0	835	0.86
Kelantan	3234	12.5	1610	0.29
Melaka	516	2.0	650	0.72
Negeri Sembilan	539	2.1	179	0.85
P. Pinang	972	3.7	441	0.48
Pahang	2759	10.6	2568	0.65
Peninsular Malaysia	25974	100.0	13037	0.79
Perak	3613	13.9	2433	0.74
Perlis	111	0.4	97	NA
Selangor & F. Territory	894	3.4	1172	1.30
Terengganu	1159	4.5	1364	0.33

* Estimated from data for 12 major vegetables.
Source: Area is from official files of Federal Agricultural Marketing Authority (FAMA), time series data on vegetables from 1985 for 1994, while number of farmers and farm size are from FAMA (1992) for 1991.
NA implies data are not available.

Malaysia produces a wide variety of vegetables, of which about 50 species are grown commercially. The five most popular are long beans, chili, cucumber, Chinese mustard, and lady's finger. Although,

onion, shallot, and garlic are major vegetables consumed, these are not currently economical to produce in Malaysia, thus mainly imported. Johor is the major vegetable growing area for many individual vegetable species (Table 2). The Cameron Highlands in the state of Pahang is the oldest and the largest supplier of temperate vegetables in the country.

Table 2. Major vegetable area and cultivation states, 1994

Vegetable	Area (ha)	Share in total vegetable area (%)	Major growing states (% share in total area of the vegetable)
Cabbage	976	3.8	Pahang (67), Kelantan (29)
Chili	3930	15.1	Perak (24), Johor (24), Kelantan (15), Pahang (12), Kedah (10)
Chinese kale	523	2.0	Johor (76)
Chinese mustard	2739	10.5	Johor (54)
Cucumber	3723	14.3	Johor (37), Kelantan (26), Perak (12)
Eggplant	1375	5.3	Johor (30), Perak (24), Kelantan (19)
French beans	1673	6.4	Johor (59), Pahang (17)
Kangkong	1655	6.4	Johor (54), Kelantan (9), Perak (9)
Lady's finger	2121	8.2	Johor (40), Perak (16), Kedah (10), Kelantan (10)
Long beans	5171	19.9	Johor (42), Perak (19)
Spinach	1552	6.0	Johor (68)
Tomato	536	2.1	Pahang (79)

Source: Official file of FAMA, time series data on vegetables from 1985-94.

Trend Analysis

Production

In Peninsular Malaysia, the area under vegetables increased sharply from 7735 ha in 1983 to about 25,974 ha in 1994, which resulted in a production increase from 145,000 t to 399,000 t in that period. Yield remained fluctuating between 15 and 18 t/ha. Fruit vegetables recorded the biggest increase in both cultivated area and production.

Total vegetable area and production exhibited quite high linear increases in the early years of the period 1983-94, but increase in area stagnated in the later years shown by its negative quadratic term. Per ha yield of all vegetables, however, did not exhibit a statistically significant trend over the study period (Table 3). During 1983-94, the area under eggplant, chili, cucumber, and Chinese kale increased linearly at very high rates (only linear terms are significant), while spinach and kangkong area increased quadratically. The high linear and quadratic rates can be explained by relatively small areas of these crops to start with.

The yield of most crops has either insignificant trend or increased only in the early years, but then stagnated during the later years of 1983-94. With few exceptions, production followed the area trend in most vegetables (Table 3).

Table 3. Trends in area, production, and yield of major vegetables in Malaysia, 1983-94

Vegetable	Area		Production		Yield	
	T	T^2	T	T^2	T	T^2
Cabbage	-0.174	0.015	-0.195	0.015	_	_
Chili	0.205	_	_	_	-0.273	0.015
Chinese kale	0.167	_	0.271	-0.013	0.104	-0.009
Chinese mustard	_	_	_	_	_	_
Cucumber	0.310	_	0.335	_	_	_
Eggplant	0.250	_	_	_	-0.195	0.012
French beans	0.305	-0.013	0.330	-0.015	_	_
Kangkong	_	0.013	_	_	0.065	-0.010
Lady's finger	0.862	-0.049	0.954	-0.060	0.092	-0.011
Long beans	0.488	-0.024	0.518	-0.026	_	_
Spinach	_	0.013	_	_	0.160	-0.016
Tomato	_	_	_	_	_	_
Total vegetables	0.220	-0.006	0.262	_	_	_

Source: Estimated from the official files of Federal Agricultural Marketing Authority (FAMA), time series data on vegetables from 1983 through 1994.

– implies that the coefficient is not significant at least at the 10% level.

Prices

The overall nominal vegetable prices at the retail level are increasing at a rate of 2.8% per annum. Most individual vegetable prices are also increasing in nominal terms at the farm, wholesale, and retail levels, and with few exceptions, the increases are statistically significant (Table 4).

Prices are increasing in real terms too, after deflating the nominal prices with an appropriate consumer price index. This is despite a three-fold increase in production, suggesting that production increase failed to match increasing demand. The extent of price increases varies across vegetable species (Table 4).

The general trend is for the prices of fruit vegetables to increase more than the prices of leafy vegetables over time due to the higher consumer preference for fruit vegetables with their longer shelf-life. Another factor which contributes to such a trend is the longer growing period for fruit vegetables, which makes it relatively harder to adjust their acreage to meet the increasing demand, at least in the short term.

In most cases, increases in the farm and wholesale prices are higher than increases at the retail level, suggesting a decrease in marketing margins. This is an interesting situation, and should be studied more carefully in order to understand the factors contributing to this improvement in market efficiency so that the trend can be reinforced.

Table 4. Growth rate (%) in major vegetable prices, 1985-94

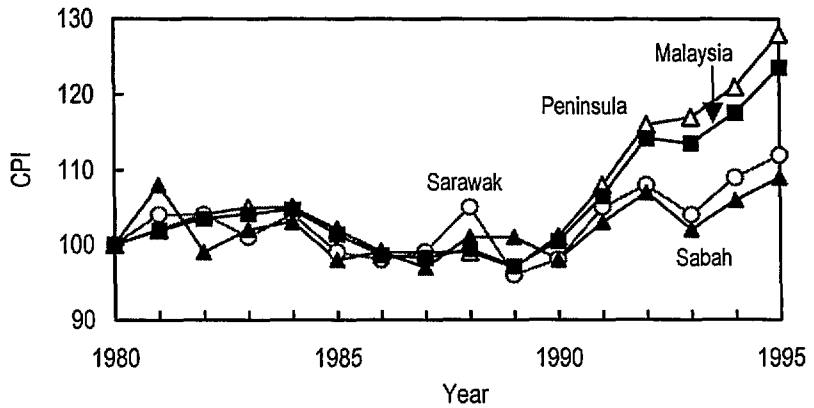
Vegetable	Nominal			Deflated[a]		
	Farm	Wholesale	Retail	Farm	Wholesale	Retail
Cabbage	-	3.4	2.2	-	-	-
Chili	-	2.6	1.8	-	-	-
Chinese mustard	3.3	2.8	2.3	-	-	-
Cucumber	2.8	3.2	2.7	-	-	-
Eggplant	10.3	7.8	6.2	7.5	5.0	3.2
French beans	10.1	9.4	7.8	7.2	6.6	4.9
Lady's finger	7.1	7.1	6.7	4.2	4.3	3.7
Long beans	8.1	7.9	6.1	5.2	5.1	3.2
Spinach	5.7	4.7	4.2	2.9	2.0	1.3
Tomato	5.4	4.7	3.9	2.6	1.9	1.0
Overall vegetables	NA	NA	2.8	NA	NA	1.0

Source: estimated form FAMA, various issues[c] (1980-88, 1995).

[a] To estimate the real prices from the nominal prices, the wholesale prices were deflated with the wholesale consumer price index, retail prices were indexed with the retail consumer price index, and farm prices were deflated with the average of wholesale and retail consumer price indices.

- implies that the coefficient is not significant at least at the 10% level, and NA implies that data are not available.

The overall real vegetable prices at the retail level during 1980-95 drifted upward at a rate of 1.0% per annum. However, the rate of increase during the 1990s was much faster at 3.8%. The rates of increase in retail prices were much higher on the peninsula than in the other two regions of the country (Fig. 2).



Source: Estimated from data reported in FAMA, various issues[c] (1980-88, 1995).

Fig. 2. Trend in real vegetable price at the retail level in different regions of Malaysia.

Despite a higher increase in farm-level prices, however, the profit in vegetable cultivation might not have improved as vegetable farmers faced increasing costs. For instance, since 1990 the cost of insecticide has increased by 20-30%, imported fertilizer by 5-10%, organic fertilizer by 8-10%, and seeds by 20%. Wage rates also increased, by 20%, from MYR14-15 per day in the late 1980s to

MYR17-18 per day in 1993 (Mukhtiar 1994). Farmers have also had to bear an almost 50% increase in transport cost.

Seasonality

Because most vegetable species are very perishable, vegetable prices are highly seasonal. The extent of seasonal price fluctuation ranges from 25 to 157% in different vegetables at different marketing levels (Table 5). In addition, comparison of monthly and weekly seasonal patterns reveals that prices tend to be more seasonal in the short term, at all levels in the marketing chain.

Leafy vegetable prices tend to fluctuate more than prices for fruit vegetables. Prices of highly perishable vegetables, such as cabbage and mustard, fluctuate more compared to the less perishable ones, such as potato. With few exceptions, seasonality is higher at the farm level than at the wholesale and retail levels, suggesting that marketing agents help to smooth out seasonality by adjusting their profits (Table 5).

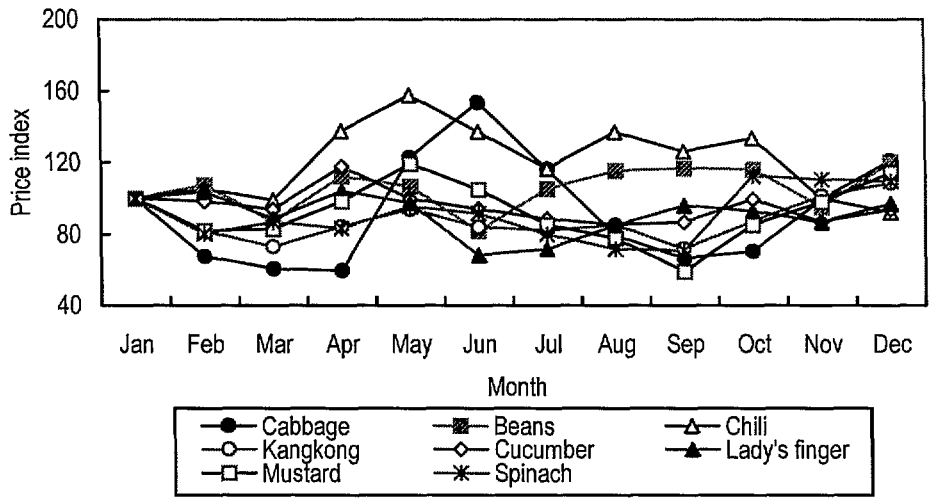
Table 5. Seasonality (%) in vegetable prices in Malaysia (average 1989-93)

			Seasonality		
Crop	Max.	Min.	Farm	Wholesale	Retail
Cabbage	Jun	Mar	156.9	105.1	72.7
Chili	May	Mar	70.7	61.0	34.5
Cucumber	Dec	Jul	37.7	69.8	44.2
Kangkong	Dec	Mar	51.2	57.3	48.0
Lady's finger	Dec	Aug	52.2	39.9	25.3
Long beans	Dec	Jul	47.1	29.3	30.6
Mustard	May	Sep	101.9	106.2	71.0
Onions	Nov	Apr	NA	81.5	35.7
Potatoes	Jun	Feb	NA	45.5	26.9
Spinach	Dec	Jul	58.7	65.3	53.7

Source: Estimated from monthly data reported in FAMA, various issues[a] (1985-1994).
NA implies data are not available.

A bimodal seasonality pattern can be observed in most vegetable prices (Fig. 3a). Most individual vegetable prices at the retail level are high during April-June and November-January. A similar pattern of seasonality was observed in the prices of all vegetables, as a group (Fig. 3b). An average of all vegetable prices has a monthly seasonality of over 32.5% at the retail level.

a. Individual vegetables



b. Overall vegetables

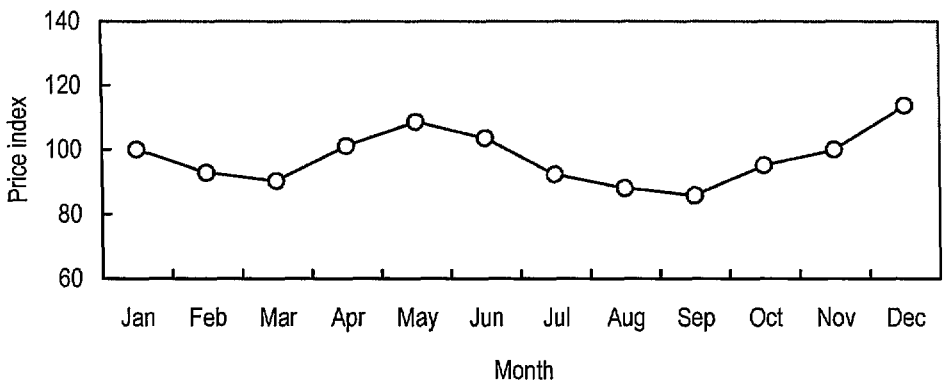


Fig. 3. Seasonality in vegetable prices at the retail level in Malaysia (average of 1989-93).

Risk in Production

Vegetables, as a group, are more risky to produce than field crops such as rice. The detrended coefficient of variation in individual vegetable production is 3-8 times higher than rice. The highest variation is in the production of cabbage, Chinese mustard, and cucumber (Table 6).

Except in chili, variation in vegetable area is higher than in yield, suggesting that government policies that can stabilize area could have far-reaching impact to stabilize vegetable production in Malaysia. However, instability in yield is also quite high, implying that stable vegetable production technologies can also substantially reduce fluctuation in production.

Fluctuation in vegetable production is a cause as well as a consequence of variation in vegetable prices (Table 6). Again, the variation in vegetable prices is many times more than that in field crops at all market levels. In most cases, vegetable prices have higher variation at the farm and wholesale

levels compared to those at the retail level, again suggesting that marketing agents absorb some of the shocks in market prices by adjusting their profits.

Table 6. Detrended CV (%) in area, production, yield, and prices of major vegetables and rice in Malaysia, 1983-94

Crop	Area	Production	Yield	Prices		
				Farm	Wholesale	Retail
Chili	14.7	16.8	29.7	9.3	11.7	11.1
Chinese mustard	22.7	28.7	13.6	9.7	7.8	6.0
Cucumber	19.5	27.4	17.9	8.0	9.8	9.1
Eggplant	22.2	18.8	18.9	16.0	11.5	8.8
Cabbage	24.4	40.0	22.1	14.0	10.4	7.3
Spinach	25.4	18.9	15.5	8.9	11.4	7.2
Tomato	17.2	14.7	12.1	8.8	5.8	4.4
Overall vegetables	14.6	14.8	13.1	NA	NA	NA
Rice	2.5	4.9	3.5	2.1	2.1	1.1

Source: Estimated from official files of Federal Agricultural Marketing Authority (FAMA), time series data on vegetables from 1983-94 for area, production, and yield of vegetables. The area, production, and yield of rice were taken from IRRI (1995). The vegetable price data were taken from FAMA, various issues[c] (1980-88, 1995), and rice price from Ministry of Agriculture (1995).

NA implies data are not available.

Measures to Stabilize Prices

Several options were proposed to reduce and smooth out the fluctuations in the domestic price of vegetables (MARDI 1993). These are listed below:

(1) Correction of market imperfection, especially at the wholesale level. For example, an auction system would lead to improved market transparency and increased capacity for transaction.

(2) Improvement of distribution systems to reduce marketing margins. Reduction in marketing costs would lead to lower consumer prices.

(3) Increased production through reserving suitable land for vegetables supported by appropriate infrastructures (e.g., drainage facilities) and technology. This could result in increased domestic supply, reduced production costs, and lower prices to consumers.

(4) Regulation of supply through post-harvest technological advancement, such as storage and scheduling of production. This would result in less seasonality in vegetable prices and availability.

(5) Further liberalization of imports could improve consumers' welfare and stabilize prices.

(6) Establishment of marketing information systems for major production areas. Timely availability of information would reduce intertemporal and spatial price variations.

Economics and Sustainability of Production

Suitable Physical Requirements

The increasingly sharp competition for resources, especially land, across all sectors, as well as within agriculture, necessitates the use of marginal lands for agriculture, including vegetable production. Hence, an understanding of the requirements for vegetable production on these soil types is important. For vegetable cultivation, level topography and 50 cm or more of well drained loam to clay loam soil with relatively high fertility and having pH in the range 5.5-7.5 are required (Table 7).

Table 7. Optimum topographical and soil conditions for vegetable cultivation in Peninsular Malaysia

Soil characteristics	Requirement	
	Optimal	Intermediate/unsuitable
Topography	Level	Undulating
Depth of soil (cm)	>50	<50
Drainage	Well to moderate	Imperfect
Soil texture	Loam to clay loam	Others
Soil fertility	High to intermediate	Low
Soil acidity (pH)	5.5-7.5	7.5-8.2

Source: MARDI (1982).

Steep mountains and sloping hills are considered unsuitable for vegetable cultivation, even with terraces to reduce slope. Similarly, peat soils need much investment to correct low or high organic matter content and to bring pH into a reasonable range. They are considered only partially suitable even after these improvements. Bris soils, due to their low water retention capacity, are also only partially suitable, even after developing drainage and irrigation facilities (Table 8).

Table 8. Conditions for vegetable production in different areas

Type of area/ soil type	Main limitations	Improvements required	Condition before improvement	Condition after improvement
Steep mountainous	Steep slopes>30°	Terracing	Not suitable	Not suitable
Sloping hills	Slopes between 5-30°	Terracing	Not suitable	Not suitable/ partially suitable
Peat	Low and high organic matter	Drainage and manuring, pH correction. etc.	Not suitable	Not suitable/ partially suitable
Lowland close to river	Low lying	Drainage, irrigation & manuring	·Partially suitable	Suitable
Bris	Low lying, sandy soils, low water retention	Irrigation, drainage & high manuring	Not suitable	Partially suitable/ suitable

Source: MARDI (1991).

Input Use

The Techno-Economic and Social Studies Division of the Malaysian Agricultural Research and Development Institute (MARDI) has published the Production Cost Bulletin since the early 1970s.

The input usage figures reported in these studies were obtained from trials on farmers' fields (Table 9). For the purpose of comparison, input use in rice is also reported here.

Table 9. Quantities of input use (per ha) on selected vegetables and rice in Malaysia

Crop	Labor (Person-day)	Seed (kg)	Fertilizer (t)	Organic Manure (t)	Pesticide (MYR)	Others** (MYR)
Cabbage	184	0.2	2.8	5	935	0
Chinese mustard	222	1.5	1.0	3	300	0
Cucumber	229	3.2	1.6	5	292	3683
Lady's finger	277	6.0	2.7*	2.5	317	0
Long beans	276	8.0	1.4	3	375	5538
Kangkong	155	26.0	0.5	3	174	120
Rice	37	100	0.5	-	207	515

* Including 2.5 t of lime.
** Others include farm machinery, water, etc.
- implies data are not available.
Source: MARDI (1994). The rice data were taken from Seriam and Abidin (1995).

Fertilizer use on vegetables is high, i.e., more than 1 t/ha, except for kangkong. Pesticide cost, especially in cabbage, is also exorbitant and higher than rice. All vegetables need more labor than do field crops such as rice.

Economics of Vegetable Cultivation

Vegetable cultivation is a highly profitable venture. The benefit-cost ratio varies from 179% in chili (kulai type) to 13% in lowland cabbage. With few exceptions, the ratios for most vegetables are comparable or higher than rice (Table 10). Asparagus and chili are considered to be high-value crops, as cost per kg of these vegetables is quite high, and by the same token, cabbage and mustard are considered low-value crops (Table 10).

Table 10. Per ha economics of vegetable cultivation in Malaysia

Crop	Region/(soil type)	Yield (kg)	Gross return (MYR)	Total cost (MYR)	Net benefit (MYR)	Benefit-cost ratio	Cost/kg (MYR)	Source
Asparagus	Cameron Highlands, Pahang	13664	68320	32308	36012	1.11	2.36	Yam (1988)
Asparagus	Perak, Melaka	10132	40528	26435	14093	0.53	2.61	Yam (1988)
Cabbage	Tangkak, Johor	22565	5120	3090	2030	0.66	0.14	Foo (1978)
Chili (Kulai)	Jalan Kebun, Selangor, (Peat)	10300	34500	12350	22150	1.79	1.20	Melor (1995)
Chili (MC4)	Jalan Kebun, Selangor, (Peat)	9300	27900	12350	15550	1.26	1.33	Melor (1995)

Contd. Table 10.

Crop	Region/(soil type)	Yield (kg)	Gross return (MYR)	Total cost (MYR)	Net benefit (MYR)	Benefit-cost ratio	Cost/kg (MYR)	Source
Long beans	Ipoh, Perak, (Tin tailing)	12812	14990	8245	6745	0.82	0.64	Mahmud (1995)
Long beans	Muar, Johor, (Peat)	8067	8874	6512	2362	0.36	0.81	Mahmud (1995)
Long beans	Batu Pahat, Johor, (Mineral)	7506	9458	7433	2025	0.27	0.99	Mahmud (1995)
Long beans	Rompin, Pahang, (Bris)	8215	8215	5227	2988	0.57	0.64	Mahmud (1995)
Mustard	Tangkak, Johor	48118	2223	865	1358	1.57	0.02	Foo (1978)
Rice	North West Selangor (Wet seeding)	4700	2331	1458	873	0.60	0.31	Seriam and Abidin (1995)
Tomato (FMTT138, MT1, BL699)	Jalan Kebun, Selangor, (Peat)	36000	19440	9865	9575	0.97	0.27	Melor (1995)

Factor Share

Estimates of factor share from data reported in different studies conducted under farmers' conditions also suggest that labor share in the total cost is quite substantial, except in mustard. However, pesticide share ranges from 0.9% in asparagus to 12.0% in cabbage (Table 11).

Income by Cropping Pattern

MARDI has been conducting vegetable farming system research on farmers' plots since 1980 (MARDI 1994). The research estimated returns obtained from seven possible rotations on three different soil types.

On alluvial soils, estimated farm income and returns to labor were highest in a system where two leafy vegetables (cabbage, cauliflower) were rotated with fruit vegetables (long beans, bitter gourd) followed by intercropping of three vegetables (two fruit vegetables with a leafy vegetable). The vegetable farming system of cabbage-cauliflower-bitter gourd was found to increase income by more than 100% compared to a traditional system of cucumber-long beans-bitter gourd. However, introduction of a leafy vegetable in a basically fruit vegetable system was not found to increase monthly income significantly.

A comparison of farm income for several vegetable production systems on peat soils suggested that highest incomes are generated when a tomato-cabbage rotation is followed by a chili-cabbage rotation.

Table 11. Review of factor share (%) in selected vegetables in Malaysia

Crop	Region/(soil type)	Year	Labor	Fertilizer	Farm manure	Pesticide	Others	Reference
Asparagus	Cameron Highlands, Pahang	1987	54.6	5.8	15.0	1.2	23.4	Yam (1988)
Asparagus	Perak, Melaka	1987	53.5	6.0	18.5	0.9	21.1	Yam (1988)
Cabbage	Tangkak, Johor	1978	219.0	6.6	10.0	2.0	42.4	Foo (1978)
Chili (MC4, Kulai)	Jalan Kebun, Selangor, (Peat)	1995	143.7	7.8	3.2	5.7	29.6	Melor (1995)
Long beans	Ipoh, Perak, (Tin tailing)	1995	151.9	7.6	10.0	1.0	19.5	Mahmud (1995)
Long beans	Muar, Johor, (Peat)	1995	122.5	4.2	10.0	0.0	53.3	Mahmud (1995)
Long beans	Batu Pahat, Johor, (Mineral)	1995	146.2	4.7	0.0	9.7	29.4	Mahmud (1995)
Long beans	Rompin, Pahang, (Bris)	1995	342.8	5.9	0.0	9.0	12.3	Mahmud (1995)
Mustard	Tangkak, Johor	1978	27.6	5.0	0.0	6.3	61.1	Foo (1978)
Tomato (FMTT138, MT1, BL699)	Jalan Kebun, Selangor, (Peat)	1995	36.0	7.1	4.1	3.5	49.3	Melor (1995)

Vegetable farming systems on bris soil, especially in Kelantan, involve tobacco and watermelon. These crops are traditionally grown in that order after the north-east monsoon. Highest incomes are obtained when these crops are followed by chili, cabbage, and cucumber, or chili and Chinese mustard in an annual cycle. Both cucumber and Chinese mustard appear to be better than long beans as a fourth crop after tobacco-watermelon-chili.

The Federal Agricultural Marketing Authority (FAMA) also used to publish market potential reports for individual vegetable species in the 1970s under the Green Book program, but these reports were discontinued. More recent studies on farm profitability for vegetable cultivation include the following:

Midmore et al. (1996) found that 25% of farmers in the Cameron Highlands lose money. Per hectare farm income and scale of production are unrelated; nor is farm income related to annual volumes of manure, lime or fertilizer, types of ownership, slope of land (natural or man-made), or to soil physical composition.

Other farm profitability studies include those based on farming system practices. The potential of vegetables to enhance incomes from mono paddy cropping on 0.9 ha was studied by Normiyah and Munir (1994). Among the several enterprise combinations considered for paddy land, the one comprising watermelon planted in the first three months on all the land, followed by 0.75 ha of vegetables in the next three months, was shown to generate the highest return.

Mustaffa (1990) computed farm family incomes from cropping system trials on marginal soils, which include acid sulphate, alluvial, and bris soil. Incomes from vegetables under alluvial and bris soils were also estimated. A tomato–long beans rotation was found to generate the highest income, followed by chili–cabbage intercropping on acid sulphate soil.

Sustainable Vegetable Production

In the context of vegetable production in Malaysia, the sustainability issue becomes extremely important since a substantial portion of the vegetables consumed are produced on the highlands (Fuad 1993). Starting in 1979, the World Bank funded a program to test various soil conservation practices for highland crops, including vegetables. The impact of the program was assessed by the Asian Vegetable Research and Development Center (AVRDC) in collaboration with MARDI in 1991. The major objective of the evaluation was to determine the extent of adoption of erosion control practices and factors influencing adoption, in particular, cropping system, soil type, slope, size of holding, land ownership, and history of cultivation. The short term costs of erosion control practices were assessed and compared with the long term benefits to farmers and water and energy users (Midmore et al. 1996).

In opening up new areas for vegetable cultivation, farmers use tractors to level the steep terrain. Top-soil is removed and used to fill other areas. In areas where the terrain is steep, terraces are constructed with varying width according to the gradient of the slope. Except for the use of sandbags for soil conservation on some farms, farmers show less concern to slow errosion.

Fuad (1993) examined the prospects for diversification and commercialization of upland agriculture by floriculture, vegetables, and fruits. For a sustainable development of upland agriculture, the following suggestions were made:

(l) allow agricultural activities only in areas having the "least" adverse impact on the environment;

(2) discourage vegetable cultivation on open terrace benches on steep slopes; but encourage use of rain shelters which intensify crop cycles and increase yields;

(3) extend appropriate cropping systems and efficient use of fertilizers and chemicals with integrated management practices; and

(4) review the existing land tenancy policy to provide security of land tenure, which in turn would encourage investment in conservation practices.

Marketing System

During 1986-90, several studies on vegetable markets were carried out. The project entitled "Marketing Systems of Vegetable in Johor" identified marketing agents and their behavior, market structures and regulations, and commodity flows in the vegetable marketing system in the southern state of Johor (Neguib 1988). Ahmad et al. (1992) identified and evaluated major changes in the Singapore market that were expected to affect vegetable cultivation in Malaysia. The study found that consumers in Singapore emphasize quality over price; suggesting a need for improved packaging, presentation, and quality of Malaysian vegetables. The study provides vital information to marketers and R&D institutions.

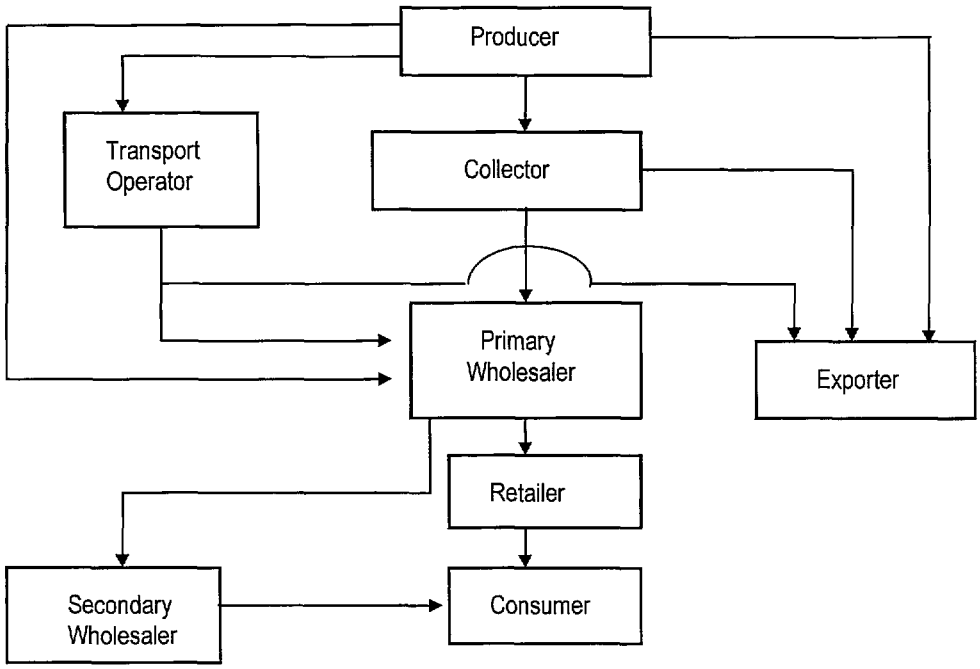
The National Vegetable Workshop, held in 1985, delved into the economics of the vegetable industry in Malaysia. Wong (1985) evaluated the marketing system for vegetables within the context of its constraints and strategies.

Groome and Lee (1990) described the consumption pattern and marketing of vegetables in Miri, Sarawak. An interesting feature in the marketing of vegetables in Miri is the virtual absence of middlemen – the primary producer acts as wholesaler and retailer.

The Federal Agricultural Marketing Authority is also in the forefront in developing an integrated market information systems (MIS) for horticulture. The development of a MIS for perishable products like vegetables would enhance market efficiency. Fauzi and Hasmiah (1992) developed a conceptual framework for computerization of MIS for the horticulture industry in Malaysia, and identified the scope and limitations of such a system.

Marketing Channels

Vegetables produced in Malaysia for the domestic market pass through traditional market channels involving different marketing agents, such as farm-level collectors, lorry operators, and wholesalers based in the major urban centers. Very few farmers have direct links with wholesalers in the major urban centers, or with consumers, except through farmers' markets. Such markets have been established in almost all consumption centers in the country since 1985. The continued dominance of the traditional marketing channels (Fig. 4) is attributed to a number of factors, including matured business relationships, credit ties, and presence of various guilds and chambers of commerce.



Source: Mukhtiar (1994).

Fig. 4. Vegetable marketing channels in Malaysia

The private sector is pervasive in vegetable marketing in Malaysia. This free enterprise system does not mean, however, that adequate competition exists. Despite many wholesalers being present in every market (Table 12), market power is believed to concentrate in the hands of a few in the major

urban centers. This concentration of power is reinforced and perpetuated by a number of factors, including barriers to entry, such as high capital requirement, strong traditional linkages, inadequate market facilities, and, to a certain extent, lack of timely market information.

Table 12. Number of vegetable marketing agents by state in Peninsular Malaysia, 1991

State	Farmers	Wholesalers	Retailers*
Johor	1688	178	2036
Kedah	835	49	218
Kelantan	1610	184	1753
Melaka	650	72	444
Negeri Sembilan	179	14	510
Pahang	2568	157	3897
Perak	2433	144	3175
Perlis	97	12	233
Pinang	441	30	398
Selangor & Federal Territory	1172	277	3671
Terengganu	1364	71	2149

* Includes farmers' markets, night markets and retail markets.
Source: FAMA (1992).

Vegetables are marketed largely on a consignment basis whereby the price received by farmers is known only after the produce is sold, a day or two after delivery. The risk therefore lies with producers. While the consignment system has been recognized as a fairly effective system for handling vegetables, it has forced farmers to be price takers after delivery. This contributes to lack of market transparency in term of prices, seasonal preferences, quality standards, timing, and quantities required by consumers.

This is not to deny some positive benefits of the consignment system. Perishability, quality variability, lack of standardization, and incidence of oversupply sometimes necessitate consignment arrangements between farmers and wholesalers. Under the system, wholesalers are, therefore, more prepared to accept vegetables of varying qualities and quantities as their risk is reduced.

With only three well-equipped wholesale markets, handling an estimated 900 t of vegetables daily, Malaysia has limited facilities for bulk disposal of vegetables. Although wholesaling is also carried out at other strategic locations, infrastructure is lacking.

Marketing Costs and Margins

Marketing margins for leafy vegetables are generally higher than for fruit vegetable. Margins are in the range of 64-81% of the retail price in the case of leafy vegetables and 49-61% for fruit vegetables (Table 13). The higher margins for leafy vegetables are partly due to higher marketing costs, such as transport, and post-harvest losses, incurred by intermediaries, especially retailers. The weight loss for leafy vegetables can be as high as 30-40% compared to 20 % for fruit vegetables.

Table 13. Percentage distribution of consumer price, and marketing margin for important vegetables in Johor, 1990

Vegetable	Farm			Wholesale			Retail			Marketing
	Profit	Costs	Total margin	Profit	Costs	Total margin	Profit	Costs	Total margin	margin[1]
Cabbage	32.7	3.4	36.1	25.4	2.4	27.8	27.0	9.1	36.1	63.9
Chili	48.0	3.2	51.2	33.3	3.9	37.2	7.5	4.1	11.6	48.8
Chinese mustard	16.2	2.6	18.8	33.5	9.9	43.4	26.6	11.2	37.8	81.2
Cucumber	42.1	1.8	43.9	17.8	11.2	29.0	17.8	9.3	27.1	56.1
Eggplant	48.7	1.6	50.3	22.8	4.7	27.5	14.6	7.6	22.2	49.7
French beans	44.6	3.2	47.8	15.4	9.0	24.4	16.7	11.1	27.8	52.2
Kangkong	24.1	7.0	31.1	33.3	6.1	39.4	23.4	6.1	29.5	68.9
Lady's finger	40.3	1.4	41.7	26.8	3.7	30.5	22.1	5.7	27.8	58.3
Long beans	34.8	4.7	39.5	14.6	8.1	22.7	26.1	11.7	37.8	60.5
Spinach	18.4	4.1	22.5	30.2	6.5	36.7	27.1	13.7	40.8	77.5
Tomato	38.8	2.5	41.3	22.2	3.1	25.3	29.7	3.7	33.4	58.7

[1]The marketing margin is the sum of profit and marketing costs of only wholesalers and retailers.
Note: Costs refer to marketing costs.
Source: FAMA (1990).

The retailers' margin is larger than the wholesalers' in spinach, cabbage, long beans, tomato, and French beans. However, the opposite is true for Chinese mustard, kangkong, lady's finger, cucumber, eggplant, and chili (Table 13).

A study on cost and marketing margins (FAMA 1990) showed that marketing cost is a small proportion of the retail price compared to profits earned by wholesalers and retailers. In this study, the retailers' profit varied from 7.5% of the retail price in chili to 30% in tomato, while wholesalers' profit varied from 15% of the retail price in long beans to about one third in Chinese mustard, spinach, kangkong, and chili (Table 13).

Profit of the retailers and wholesalers is perceived as a fixed proportion of the prices they pay, and is normally considered to be exorbitant. However, when the marketing margin (including marketing cost and profit) at a particular market level was regressed on the prices the marketing agents pay, negative relationships were found in all vegetables at both the wholesale and retail levels (Table 14). This suggests that as the prices that marketing agents pay increase, they have to reduce the margin. Because marketing costs are generally fixed, this implies that as prices rise, marketing agents are forced to reduce their profits.

The negative relationships between marketing margin and prices are generally stronger and statistically more significant at the retail level than at the wholesale level (Table 14), suggesting that marketing margins, though high, are more competitive at the retail level. The relationships at the retail level are generally higher than 0.7, implying that a 1% increase in the prices retailers have to pay would force them to reduce marketing margin (mainly their profit) by 0.7%.

Table 14. Relationship between marketing margin and prices, 1989-93[1]

Vegetable	Market level	
	Wholesale	Retail
Cabbage	-0.39	-0.71***
Chili	-0.51***	-0.80***
Cucumber	-0.45	-0.70***
Kangkong	-0.53	-0.56***
Lady's finger	-0.25	-0.85***
Long beans	-0.05	-1.04***
Mustard	-0.52	-0.79***
Spinach	-0.13	-0.75***

[1]Dependent variable=natural log of monthly margin; Independent variable=natural log of monthly prices marketing agents pay.
Source: Estimated from monthly data reported in FAMA, various issues[a] (1985-1994).
*** implies the coefficients are significant at the 1% level.

Total marketing margins in eggplant, French beans, long beans, spinach, and tomato dropped significantly during 1985-94. The reduction in the total margins for spinach was due to greater reduction in margin at the wholesale level, while reduction in the total margins for eggplant, French beans, long beans, and tomato, were due to greater reduction in margins at the retail level. The increase in the wholesale margin in chili was offset by a decrease in the retail margin, while the opposite was true for kangkong. There was no change in any margin for Chinese mustard, cucumber, and lady's finger (Table 15).

Table 15. Growth in marketing margins (%/annum) for selected vegetables, 1985-94

Vegetables	Wholesale	Retail	Total
Cabbage	5.20**	-2.68**	0.62
Chili	3.41***	-2.39	0.32
Chinese Mustard	-0.17	-0.91	-0.63
Cucumber	0.86	-0.80	-0.16
Eggplant	-2.93	-3.53***	-3.23**
French beans	0.09	-3.97***	-2.09*
Kangkong[a]	2.34**	-2.58**	-0.64
Lady's finger	0.40	-0.34	-0.32
Long beans	1.35	-3.85***	-1.50**
Spinach	-1.01	-0.73	-0.89*
Tomato	-1.19	-1.74	-1 53*

[a] Kangkong is estimated for the period 1987-94.
Source: Estimated from data reported in FAMA, various issues[c] (1980-88, 1994).
***, **, * imply the coefficients are significant at the 1%, 5%, and 10% level, respectively.

International Trade

Malaysia is a net importer of vegetables, and the trade deficit is growing due to rapid increase in the value of imported vegetables and slow increase in the value of exported vegetables (Table 16). Importation of vegetables increased from 381,100 t valued at 108.2 million MYR in 1980 to 551,600 t valued at 560.4 million MYR in 1995. Potatoes, onions, shallot, and garlic accounted for 70% of the import value. While a major portion of these imports are for vegetables which cannot be produced competitively in Malaysia, the high and increasing import figure is of grave concern to the country. An alarming development is the increase in importation of cabbage and tomato, which had traditionally been produced locally. This trend might indicate deterioration in Malaysia's comparative advantage in producing these vegetables.

In terms of exports, the vegetable industry contributed 100.9 million MYR to foreign exchange earnings in 1995, compared to 30.3 million MYR in 1980 (Table 16). More than 20 vegetable species were exported, but cucumber, Chinese mustard, long beans, chili, and spinach were the major exports during 1995.

Table 16. Export, import, and trade deficit in vegetables (quantity in 000 t and value in million MYR), 1980-95

Year	Export		Import		Deficit	
	Quantity	Value	Quantity	Value	Quantity	Value
1980	98.7	30.3	381.1	108.2	282.4	77.9
1981	123.9	41.4	437.0	142.0	313.1	100.6
1982	11.1	33.8	411.2	190.1	400.1	156.3
1983	101.8	34.6	238.5	201.3	136.7	166.7
1984	2.2	1.7	126.3	206.5	124.1	204.8
1985	109.1	30.6	285.1	211.0	176.0	180.4
1986	118.6	34.6	284.8	226.5	166.2	191.9
1987	143.2	41.3	279.7	216.4	136.5	175.1
1988	202.0	59.9	354.6	273.8	152.6	213.9
1989	170.8	78.8	607.7	297.9	436.9	219.1
1990	179.2	76.2	612.0	305.8	432.8	229.6
1991	78.8	43.0	513.4	346.3	434.6	303.3
1992	93.8	59.7	433.4	352.1	339.6	292.4
1993	203.1	108.8	520.4	412.2	317.3	303.4
1994	189.7	94.8	547.9	443.0	358.2	348.2
1995	265.0	100.9	551.6	560.4	286.6	459.5

Source: For 1980-92, Ministry of Agriculture, various issues (1980-1992). For 1993-95, Department of Statistics, various issues (1993-1995).
Note: The imports and exports include potatoes and other tubers.

Malaysian vegetable exports are narrowly focused on the Singapore market, with little success at penetration into other markets, such as Hong Kong and Japan (Table 17). Any undesirable change in Singapore's bilateral trade in vegetables could seriously undermine the Malaysian vegetable industry.

Table 17. Contribution of trading countries (%) in total vegetable import and export

Country	Export				Import			
	1990		1994		1990		1994	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	-	-	-	-	21.0	47.0	67.7	79.8
Brunei	1.1	4.3	2.8	21.5	-	-	-	-
China	-	-	-	-	7.0	8.1	13.6	7.8
Indonesia	-	-	-	-	38.8	13.6	7.3	5.4
Singapore	98.5	90.3	97.1	78.2	-	-	-	-
Taiwan	-	-	-	-	7.2	8.0	0.9	0.4
Thailand	-	-	-	-	19.5	14.3	7.5	2.3
Others	0.4	5.4	0.1	0.3	6.5	9.0	3.0	4.3

Source: Official files of FAMA, time series data on vegetables from 1985 through 1994.

Imports are more diversified than exports, although they are also coming more and more from Australia (Table 17). Australia's share of Malaysia's imports increased steadily, from 47% in 1991 to 80% in 1994, while the shares of Taiwan, Thailand, and Indonesia decreased steadily during this period. More than 20 vegetable species were imported, but major imports were cabbage, carrot, cauliflower, chili, and tomato in 1993.

Supply and Demand

Availability

The annual per capita availability of vegetables doubled from 23.6 kg in 1983 to 44.4 kg in 1995. The major jump came during 1988-90 when availability increased from 23 kg to 52 kg. However, since then it has stagnated. The contribution of domestic production to the net availability ranged from 49% in 1985 to 74% in 1988 (Table 18). The contribution of imports in availability is relatively high as compared to other South Asian and Southeast Asian countries.

Vegetables have been assessed as having high potential for the domestic market (Mukhtiar 1992). This is reflected in the increase in vegetable availability over time. The domestic potential could be exploited further considering the relatively low annual per capita availability in Malaysia (about 44 kg in 1995) compared to Taiwan (154 kg) and South Korea (229 kg) (this book).

Table 18. Per capita availability of vegetables in Peninsular Malaysia, 1983-95[a]

Year	Production[b] (000 t)	Import[b] (000 t)	Export[b] (000 t)	Net availability[c] (000 t)	Population (million)	Per capita availability (kg/annum)	Share of production (%) in availability
1983	175.0	186.2	80.3	280.9	11.9	23.6	62.3
1984	169.1	242.2	84.6	326.7	12.2	26.8	51.8
1985	133.2	224.0	86.7	270.5	12.5	21.6	49.3
1986	172.2	228.2	94.7	305.7	12.8	23.9	56.3

Contd. Table 18.

Year	Production [b] (000 t)	Import [b] (000 t)	Export [b] (000 t)	Net availability[c] (000 t)	Population (million)	Per capita availability (kg/annum)	Share of production (%) in availability
1987	174.4	229.1	126.5	277.0	13.1	21.1	63.0
1988	227.5	268.3	189.1	306.7	13.5	22.7	74.2
1989	356.5	347.6	157.6	546.5	13.8	39.6	65.2
1990	385.9	515.8	167.9	733.8	14.2	51.7	52.6
1991	386.3	431.7	74.2	743.8	14.6	50.9	51.9
1992	370.3	342.0	88.8	623.5	14.9	41.8	59.4
1993	382.7	415.6	203.0	595.3	15.3	38.9	64.3
1994	399.2	531.9	183.0	748.1	15.7	47.6	53.4
1995	430.0	541.6	255.0	716.6	16.1	44.5	60.0

[a] The production figures are for 15 major vegetables in Peninsular Malaysia. Population is also for Peninsular Malaysia. However, this production accounts for up to 80% of the total vegetable production in the country.
[b] The production, imports, and exports exclude potato and sweet potato.
[c] Estimated as production - export + import.

Consumption

Increase in population and incomes, accompanied by greater health awareness, have contributed to a modest rise in the consumption of vegetables from 38.4 kg in 1982 to 49.4 kg in 1991 (Table 19). Thus, increase in per capita availability might not be as great as shown by the production statistics earlier. It might be due to an improvement in the data collection procedures, instead.

Table 19. Per capita annual consumption (kg) of vegetables in Malaysia during 1982-1991

Vegetable	1982	1985	1988	1991
Angled loofah	0.95	0.78	0.91	1.03
Bitter gourd	0.90	0.89	0.85	0.54
Cabbage	2.70	3.78	4.47	4.65
Carrot	0.41	0.48	0.64	0.73
Cauliflower	0.31	0.29	0.34	0.35
Chili	2.50	2.10	2.48	1.82
Chinese cabbage	0.60	0.59	0.76	0.51
Chinese mustard	4.06	3.79	4.88	5.97
Cucumber	3.14	3.25	3.94	3.28
Dry chili	-	0.46	0.51	0.45
Eggplant	1.93	1.36	1.46	1.58
French beans	0.93	0.96	1.07	1.24
Garlic	0.71	0.96	1.61	1.03
Ginger	0.32	0.35	0.36	0.32

Contd. Table 19.

Vegetable	1982	1985	1988	1991
Kale	0.30	0.34	0.86	0.77
Kangkong	1.68	2.43	2.64	2.90
Lady's finger	1.07	1.39	1.29	1.35
Lettuce	0.23	0.15	0.22	0.20
Long beans	3.20	3.58	3.64	4.16
Onion	4.20	5.32	5.77	4.55
Potato	2.73	2.21	2.90	2.43
Pumpkin	0.25	2.56	0.64	0.51
Radish	0.26	0.24	0.30	0.30
Spinach	1.75	2.37	2.67	2.45
Tomato	1.06	0.95	0.85	0.49
White mustard	0.49	0.63	0.85	0.61
Yam bean	0.44	0.42	0.48	0.41
Others	1.29	4.57	4.89	4.73
Total	38.41	47.20	52.28	49.36

Source: FAMA, various issues[b] (1982, 1985, 1988, and 1991).
- implies data are not available.

Consumption by Income Group

The household consumption survey conducted by FAMA has exposed the vegetable consumption pattern by income groups (Table 20). Short of a deeper analysis, data shown in the table suggest that higher income groups consume more vegetables compared to the lower income groups, although the difference is not significant among the middle income groups in the range of 1001-3000 MYR and very high income groups of more than 3000 MYR. Moreover, the percentage of expenditure on vegetables as a proportion of food expenditure is a declining function of income.

Table 20. Per capita annual consumption (kg) by income group in Malaysia, 1991

Vegetable	Income						
	< MYR501	MYR501 - MYR1000	MYR1001 - MYR1500	MYR1501 - MYR2000	MYR2001 - MYR3000	MYR3001 - MYR5000	> MYR5000
Angled loofah	0.97	1.12	1.10	0.42	0.69	0.53	0.64
Bitter gourd	0.21	0.67	0.52	0.76	0.45	0.15	0.16
Cabbage	2.63	2.65	2.70	2.79	3.21	3.41	2.95
Carrots	0.23	0.69	1.03	1.54	1.10	2.20	1.15
Cauliflower	0.14	0.34	0.58	0.78	1.08	0.59	0.13
Chili	2.13	2.27	2.66	2.54	2.05	1.83	2.49
Chinese cabbage	0.26	0.55	0.86	0.81	0.82	1.37	1.55
Cucumber	2.75	2.46	2.13	2.08	2.02	1.79	1.26

Contd. Table 20.

Vegetable	Income						
	< MYR501	MYR501 - MYR1000	MYR1001 - MYR1500	MYR1501 - MYR2000	MYR2001 - MYR3000	MYR3001 - MYR5000	> MYR5000
Eggplant	1.64	1.58	1.50	1.60	1.66	1.20	1.42
French beans	0.58	1.14	1.64	2.03	2.74	3.13	1.42
Garlic	1.05	1.08	1.24	1.22	1.14	1.56	1.73
Ginger	0.34	0.28	0.31	0.34	0.24	0.25	0.43
Kale	0.15	0.77	1.45	1.34	2.18	1.21	3.61
Kangkong	2.21	1.98	1.73	1.46	1.58	1.97	2.27
Lady's finger	0.98	1.33	1.70	1.65	1.10	2.42	1.09
Lettuce	0.05	0.15	0.25	0.22	0.29	0.26	0.19
Long beans	4.72	4.93	5.13	5.33	3.69	5.23	2.23
Pakchoi	3.35	3.95	4.31	4.18	4.48	4.76	5.00
Pumpkin	0.38	0.54	0.64	0.66	0.63	0.60	1.05
Radish	0.11	0.30	0.35	0.31	0.21	0.17	0.00
Shallot	4.44	4.27	4.30	4.47	4.78	5.19	4.97
Spinach	1.98	3.01	3.27	3.18	3.19	3.33	1.93
Tomato	0.35	0.81	1.50	2.28	1.80	1.43	3.10
Yam bean	0.13	0.59	0.49	0.32	0.21	0.34	0.00
Others	0.58	0.96	1.32	1.13	1.16	3.00	5.81
Total	32.36	38.42	42.71	43.44	42.50	47.92	46.58

Source: FAMA (1991).

Consumption by Region

Baring a few exceptions, more vegetables are consumed in urban areas than in rural areas (Table 21). Thus, additional vegetable demand is expected in Malaysia as urbanization proceeds at a faster rate through the 21st century.

Almost all vegetables are consumed more in the urban areas, except angled loofah, cucumber, eggplant, ginger, pumpkin, and kangkong, which are more preferred by rural people. Stronger urban preference for cabbage and pakchoi is evident from the table.

Table 21. Per capita annual consumption (kg) of vegetables by rural and urban groups in Malaysia, 1991

Commodity	Urban	Rural
Angled loofah	0.89	1.07
Bitter gourd	0.55	0.46
Cabbage	5.91	2.69
Carrots	0.99	0.42
Cauliflower	0.59	0.19
Chili	2.77	2.23
Chinese cabbage	0.72	0.40
Cucumber	2.40	3.54
Eggplant	1.38	1.73
French beans	1.48	0.91
Garlic	1.30	0.92
Ginger	0.28	0.32
Kale	1.16	0.45
Kangkong	1.88	2.27
Lady's finger	1.53	1.11
Lettuce	0.25	0.13
Long beans	5.21	4.03
Pakchoi	9.11	3.51
Pumpkin	0.41	0.61
Radish	0.32	0.21
Shallot	4.83	4.17
Spinach	3.36	2.34
Tomato	1.27	0.64
Yam bean	0.45	0.37
Others	1.09	0.83
Total	50.13	35.55

Source: FAMA (1991).

More glaring differences in vegetable consumption are seen across regions in Malaysia. For example, annual per capita consumption of pakchoi is 14.5 kg in Persekutuan, compared to only 3.6 kg in Kelantan (Table 22).

Price and Income Elasticities

Only one estimate on demand elasticities is available (Saharan and Ahmad 1994). The demand elasticity for potato reported in the study is fairly inelastic (-0.2). However, data collected in periodic FAMA consumption surveys can be used to estimate a complete set of demand elasticities for vegetables.

Table 22. Per capita annual consumption (kg) of individual vegetables in selected states of Malaysia, 1991

Vegetable	Johor	Kedah	Sarawak	Persekutuan	Sabah	Kelantan
Angled loofah	0.92	1.11	2.24	0.16	1.35	1.31
Bitter gourd	0.56	0.35	1.61	0.23	1.13	0.04
Cabbage	4.61	4.18	3.01	5.52	6.33	3.74
Carrots	0.59	0.58	0.38	1.36	1.10	0.04
Cauliflower	0.20	0.24	0.18	0.90	0.25	0.29
Chinese cabbage	0.34	0.28	0.54	0.94	0.92	0.01
Cucumber	2.72	4.06	3.08	2.04	5.14	3.04
Eggplant	1.65	1.10	2.87	1.25	3.36	2.43
French beans	0.91	1.07	1.58	2.70	2.22	0.07
Kale	0.39	0.39	2.00	1.03	1.60	0.01
Kangkong	3.30	2.64	2.84	2.80	3.55	1.65
Lady's finger	1.33	1.78	1.50	1.91	0.32	0.27
Lettuce	0.21	0.02	0.04	0.34	0.13	0.02
Long beans	4.82	2.59	6.38	5.82	6.08	2.50
Pakchoi	6.23	5.74	6.04	14.52	4.60	3.62
Pumpkin	1.08	0.65	2.00	0.15	0.50	0.04
Radish	0.13	0.65	0.33	0.04	0.01	0.11
Spinach	2.78	1.80	2.91	4.66	1.26	0.36
Tomato	0.90	1.24	0.20	1.81	1.17	0.24
Yam bean	0.58	0.29	0.74	0.08	-	-
Others	0.69	1.40	1.08	0.69	1.33	0.08
Total	34.94	32.16	41.55	48.95	42.35	19.87

Source: FAMA, various issues[b] (for 1991).
- implies data are not available.

Policy Issues and Constraints

The National Agricultural Policy (1992-2010) outlines a strategic plan for the vegetable industry to attain a targeted self-sufficiency level of 125% by 2010. Production is expected to increase at 9.3% and 7.1% per annum in the periods 1991-2000 and 2001-2010, respectively, to reach 2.7 million t by the year 2010. The projection predicts that there will be substantial expansion of area under vegetables in the highlands and lowlands. Production will be diversified to include indigenous varieties whose cultivation will be encouraged on a commercial basis.

Demand for quality vegetables is expected to rise as a result of consumers' greater awareness about health and nutrition. Demand for so-called chemical-free vegetables, produced through organic agriculture and minimal use of chemicals, is also expected to increase.

Despite these projections, competition for resources between the agriculture and non-agriculture sectors, as well as within agriculture, might pose a serious challenge to the vegetable industry. The aging of the farm population, and labor shortages, will further aggravate the situation. Rising

production costs might erode any comparative advantage in vegetable production. Competition from neighboring countries has already hurt tomato production and increasing costs have reduced cabbage production. Under such circumstances, a serious government push would be required to keep domestic supply of vegetables increasing. Without such a push, the demand-supply gap will increase, pushing prices higher and/or driving up imports.

Other socioeconomic and institutional constraints include lack of adequate access to land and secure tenure, large fluctuations and uncertainty in prices, inadequate institutional credit facilities for farmers, and ineffective research and extension efforts.

High humidity, prevalent in Malaysia during most of the year, results in greater incidence of pests and diseases. This creates instability in production, and results in excessive use of agrochemicals. Thus, chemical residues on vegetables have become a serious concern of consumers.

Conventional handling techniques and poor infrastructure cause much spoilage of produce. Thus, collection of produce is costly, especially from scattered production areas. Lack of reliable supplies of good quality produce and lack of credit are other major constraints facing the vegetable marketing sector (World Bank 1985).

The vegetable processing industry is extremely small, covering only processing of chili, mushroom, ginger, cabbage, and peas. The major constraints are lack of a consistent supply of quality raw material, and low prices of the finished product (TESD 1989).

Status and Achievements of Agriculture Research

The Malaysian Agricultural Research and Development Institute is the main organization involved in vegetable research in the country. Universities, the Department of Agriculture, and other institutions conduct research into vegetables. The general strategy for vegetable research involves identification of appropriate technologies capable of increasing yield, and development of efficient management systems in both production and post-harvest handling in order to lower cost.

The Techno-Economic and Social Studies Division (TESD) of MARDI has been involved in the gathering and analysis of data, research planning, industry monitoring, policy analysis, marketing research, and study into resource economics and technology impact. The major thrust of the work is to increase the efficiency of agricultural research by ensuring that the research system continues to be relevant and responsive to the needs of the target clientele groups as well as to national objectives.

Establishment of the Agricultural Statistics and Information System has allowed for the storage, retrieval, and validation of important domestic and international data pertaining to agricultural commodities (including vegetables). The situation and outlook studies (S&O), published annually, cover all commodities and enterprises under MARDI's purview. The S&O for individual commodities are consolidated into a report entitled "Situation and Outlook of the Malaysian Agriculture Sector and Implications on MARDI's Research Priorities." This report forms the basis for the review and planning of MARDI's research programs, formulation of research strategies and programs, and determination of research priorities for each commodity, including vegetables.

Another organization, FAMA, conducts economics research into vegetables, especially on marketing. The daily prices, trading volumes, and other market information, including consumption, recorded by FAMA has increased the scope of vegetable research.

Other institutes conduct research on a wide range of economic issues relating to vegetables. They include agricultural marketing organizations, regional development authorities, central planning agencies, and international development and research organizations. In addition, conferences, seminars, and workshops are held which relate either specifically to vegetables or to the agriculture sector in general. Both macro- and micro-economic perspectives of the vegetable industry are emphasized in these seminars and workshops.

Achievements of Past Technological Research

The major achievements of technological research and the impact on vegetable production are as follows:

Development of Superior Cultivars

About 2300 accessions of several vegetable types have been collected. High yielding cultivars for lowland and highland cultivation with resistance to common diseases, and having desired quality, have been identified. It is suggested that R&D should concentrate more on high valued and imported vegetables and place less emphasis on leafy species, because leafy vegetables, being perishable, do not face competition from foreign producers.

Efficient Production Systems

A package of technologies for crop husbandry has been developed, including aspects of nutrient requirements and disease and pest control (making use of microbial agents as natural insecticide). The use of reflective mulch in chili cultivation can reduce crop loss due to virus, and increase yield from 6 t/ha to 15-26 t/ha. High-priced vegetable species normally grown in the highlands have been successfully cultivated in the lowlands under rain shelters. The identification of heat tolerant cabbage varieties has promoted production in the lowlands on peat and bris soils, with yield potential exceeding 30 t/ha. There is a need to study adoption constraints in order to help expand the adoption of these yield-enhancing technologies.

Pest Management

Technologies to control diamondback moth, the most serious insect pest affecting the brassicas, have been developed using a combination of biological and chemical methods. This approach has potential to significantly increase marketable yield and profits in cabbage. The number of pesticide applications can be reduced from 9 to 3. The technique is practiced by 70% of farmers in the Cameron Highlands (Syed 1996).

Mechanization and Water Management

Farm implements developed include a seeder, herbicide sprayer, fertilizer injector, and nursery planting machine. Water requirements have been determined and irrigation systems for efficient vegetable production have been designed.

Optimum Nutrient Application

Nutrient uptake by various vegetable species has been determined, and, together with results from fertilizer trials, the information will be used to formulate optimum fertilizer applications for vegetables grown on peat and mineral soils. Diagnostic guides to identify deficiency symptoms for major nutrients and micronutrients in popular vegetable species have also been developed.

Post-harvest Technology

The key to successful marketing of perishable vegetables is good handling and storage. Technologies for primary processing, in-house packing, and storage of cabbage, Chinese mustard, tomato, eggplant, cucumber, long beans, and French beans have been developed.

Data Availability

Area, Production, and Yield

The statistics on area, production, and yield by individual vegetable variety and region in Peninsular Malaysia are regularly published by the Ministry of Agriculture. However, data for Sabah and Sarawak are not available.

Monthly farm, wholesale, and retail prices of major vegetables, by region, are published regularly by FAMA. However, figures on monthly traded quantities are not available. Therefore, data on prices help to quantify the seasonality in prices, but not in availability.

Trade

Data on import and export of individual vegetables by destination are published by the Ministry of International Trade and Industry, and compiled by FAMA.

Consumption

The data on the consumption of individual vegetable species by income group and region are gathered by FAMA every three years through a household consumption survey. However, not all vegetables are included in these surveys. Each survey should quantify all vegetables consumed at different times of the year, along with the prices paid by consumers for each.

Achievements of Socioeconomic Research

Economics of Vegetables

The input use and economics of vegetables for various soils have been estimated by MARDI. However, these estimates are for the experimental station. Individual studies are available on the economics estimated for farmers' fields, but these studies are not comparable because of differences in time period, place, and methodologies. The economics of vegetables under on-farm conditions need to be estimated by a central organization.

Vegetables in the Farming System

Relative profitability of vegetables under alternative cropping systems, and optimum vegetable-based cropping systems for alternative environments have been identified by MARDI. Information generated has provided a new dimension to efforts in crop diversification. Various vegetable cropping systems have been developed which reduce risk and physical losses, and give high incomes.

Marketing Margins

Marketing margins for important vegetable varieties can be estimated from farm, wholesale, and retail price data. These margins were divided into profits and marketing costs in a FAMA study. However, details of marketing cost, physical losses, and profit are not available. Moreover, to compare efficiency of alternative marketing systems, knowledge of marketing margins for these systems would be required. To know the relative importance of the different market systems, commodity flow in each system would have to be quantified.

Demand Forecasts

Vegetable demand forecasts are mainly based on the expected income and population increases. There is a need to estimate the supply, demand, and income elasticities of individual and total vegetables. This will help to produce more accurate demand projections, and result in better allocation of research resources.

Summary and Conclusions

This paper provides vital information on the Malaysian vegetable sector, including assessment of trends in production, trade, marketing, consumption, farm management, and policy, and it evaluates the status and achievements of past vegetable research.

The substantial production increase in the late 1980s was mainly due to area expansion, while yield remained unchanged. This caused annual per capita vegetable availability to increase from 23 kg in 1988 to 52 kg in 1990. Since then, total production and per capita availability have remained stagnant or have even declined. The stagnated production in the wake of increasing incomes during the 1990s caused a strong upward pressure on vegetable prices and increased the trade deficit to about 450 million MYR. Despite rising farm prices, domestic supply did not rise, because farm costs, such as labor, fertilizer, insecticide, etc., rose as well.

Higher income groups generally consume more vegetables, suggesting that additional demand will be generated with the fast economic development in the country. More glaring differences exist across regions and between rural and urban populations. Thus, migration to big urban centers, and possible narrowing of regional consumption differences will also create substantial additional demand.

Marketing margins in the vegetable trade are high, mainly accounted for in the high profits of retailers, wholesalers, or both. Our analysis indicates that profits of the marketing agents are not fixed, rather they are negatively correlated with the prices each agent pays. This suggests that these agents do not have as much monopoly power as is perceived. The high profits of marketing agents are probably due to poor infrastructure causing heavy post-harvest losses.

There is bimodal seasonality in vegetable prices, implying a bimodal seasonality in availability. Generally, prices are high during April-June and November-January. Higher seasonality is observed in the prices of more perishable leafy vegetables than in fruit vegetables.

Vegetables are input intensive and require more labor than cereal crops, such as rice. Thus, expansion in vegetable cultivation will generate additional jobs. The benefit-cost ratio is also higher in most vegetables than in field crops. However, high instability in area and yield of most vegetables indicate risk in vegetable cultivation. Thus, stability measures aimed at reducing variation in the area put to vegetables and to reducing variability in yield through stable technologies will go a long way toward expanding vegetable production.

Vegetable cultivation requires many times more cash in hand than does cultivation of other field crops. The major cost items are labor and chemicals. Thus labor- and chemical-saving technologies could help reduce the cost of production.

Other production constraints are high insect pest attack, labor shortage, lack of appropriate mechanical technologies, large fluctuations in prices, inadequate credit, and ineffective research and extension. The marketing constraints include use of conventional post-harvest handling techniques, unreliable supplies, poor infrastructure, and lack of credit.

The government can play a vital role in improving the efficiency of the industry via the following measures: (a) establishment of production and marketing systems; (b) provision of more (and secure) land titles to experienced growers; (c) improvement in growers' access to credit; (d) focusing of R&D on resolving problems of chili production; and (e) training of extension workers to provide specialized services, emphasizing pest and disease control, and correct use of agrochemicals (World Bank 1985).

The Techno-Economic and Social Studies Division of MARDI suggests the following strategies to improve the competitiveness of the vegetable industry:

1) With acute labor shortage and rising labor costs, vegetable production should be capital intensive and operated on a large-scale commercial basis.

2) Exploitation of growth potentials from local and export demand will involve the development of improved post-harvest handling techniques, increasing shelf life, and enhancing product presentation. With improved production and post-harvest practices, Malaysia could compete with producers in Australia, Holland, and other countries.

3) Greater awareness regarding production of chemical-free or minimal-chemical vegetables should be fostered in order to take advantage of expanding demand generated by health-conscious consumers.

4) A standardized system for grading physical attributes and quality should be established, especially for export markets.

Information Gaps and Future Research Priorities

In Malaysia, future research should focus on:

1) Quantitative assessment of existing and potential constraints to yield and production, and constraints to the adoption of modern technologies.

2) Modeling the operations of the vegetable industry, and assessing the impact of government policies.

3) Estimation of supply, demand, and income elasticities. This will lead to more accurate forecasts of national supply and demand.

4) Economic evaluation of producing "chemical-free" vegetables under various production systems.

5) Assessing the economic potential of indigenous vegetable species.

6) Strengthening the methodologies for the estimation of post-harvest losses with emphasis on developing a complete profile of post-harvest losses for major vegetable species, including identification of causes of these losses.

7) Assessing the private and public cost of alternative vegetable production systems in terms of their capacity to ameliorate environmental problems.

8) Quantitative evaluation of the impact and distribution of the benefits of vegetable research.

9) Monitoring of vegetable consumption by income group and region should be continued. The consumption survey should include all vegetables and the prices consumers pay for each vegetable variety.

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NEPAL

Ganesh B. Thapa and Dibakar Paudyal

Introduction

Nepal is predominantly an agricultural country with over half of its gross domestic product originating in agriculture, and more than 80% of its labor force engaged in the sector. It is obvious that agriculture must play a dominant role in the country's development, mainly through the creation of employment for the expanding labor force and by increasing labor's productivity. The sector's most urgent tasks are to provide food for a growing population, employ surplus labor gainfully, enhance farmers' incomes, and raise the nutritional status of the population from its present low level. As recognized by the Eighth Five Year Plan of Nepal, vegetable cultivation can contribute towards meeting most of these objectives (NPC 1992).

Nepal, with an area of 147,181 km^2, extends for about 800 km along the Himalayas between latitudes 26 and 30 degrees north and longitudes 80 and 88 degrees east. Nepal is wedged between the People's Republic of China in the north and the Republic of India in the south, west, and east. The country is land-locked, with the nearest accessible seaport more than 600 km from its south-eastern border.

The country can be divided into three physiographic regions: the Tarai, Hills, and Mountains. The population, total area, cultivated area, and cropping intensity in these zones are shown in Table 1. In the Mountains, less than 3% of the total land area is cultivated, compared with 16.5 and 65.5%, respectively, in the Hills and Tarai.

Table 1. Population, total area, cultivated area, and cropping intensity in Nepal by ecological zone, 1991–92

	Mountains	Hills	Tarai	Total
Population ('000)	1,349.9	8,505.9	8,635.3	19,841.1
Total area ('000 ha)	6,308.5	6,329.4	2,110.4	14,748.3
Cultivated area ('000 ha)	176.9	1,047.3	1,374.8	2,599.0
Cropping intensity (%)	161	177	175	176

Sources: Population: CBS (1993a); Total area: LRMP (1986); Cultivated area: CBS (1993a); Cropping intensity: CBS (1993b).

The country's population was about 19.8 million in 1991 (CBS 1993a). The Tarai is the most densely populated region, with about 44% of the total population living on only about 14% of the total land area (density 409 people/ km^2). In contrast, the Mountain region, with nearly 43% of the total area, has only about 7% of the total population (density 21 people/km^2). The density in the Hills region is 134 people/km^2.

In 1991–92, average per capita food consumption in Nepal was about 1.03 kg/day of which cereals constituted 50%, non-cereal plant food 15%, fruits and vegetables 21%, and livestock products 14% [Department of Agricultural Development (DoAD 1992c)]. The diet of the people is heavily dominated by rice.

Rice is the major crop, occupying about 37% of the total cropped area, followed by wheat with 16% of the cropped area. Other crops grown in the country are maize, millet, barley, potato, cash crops, and a variety of fruits and vegetables. Total area under vegetables in 1995 was estimated to be about 144,000 ha, only about 4% of the total cropped area. In the Tarai, the important vegetables grown are tomato, eggplant, chili, cucurbits, okra, onion, cauliflower, cabbage, and potato. The most important subtropical and temperate vegetables grown in the Hills include cauliflower, tomato, potato, radish, cabbage, carrot, peas, cucurbits, beans, and celery. Temperate vegetables, such as radish, turnip, broad-leaf mustard, etc., which require a short growing season during the warm season, are produced in the Himalayan region. Production of vegetable seed is most suited to the trans-Himalayan region, which has arid conditions and good irrigation facilities.

In 1995, total vegetable production, excluding potato, was estimated to be 1.33 million t, at an average yield of roughly 9.2 t/ha. With an estimated population of 22 million in 1995, annual per capita vegetable availability at the farm level is estimated to be about 60 kg.

Physiographic Regions

As mentioned earlier, Nepal can be divided into three physiographic regions (Hills, Mountains, and Tarai). The Mountain region of Nepal is divided into high Mountain and high Himal; and valleys between mid Mountains and Tarai are classified as Siwaliks. Together with the Hills and Tarai, there are therefore five physiographic regions in the country (Fig. 1). The following is a brief description of each region.

Tarai

The Tarai region covers an area of about 2.1 million ha; elevation ranges from 60 to 330 m above mean sea level (amsl) (PACMAR and EC 1991); soils are deep and well-suited to crop production. This region has a high potential for increasing crop production through irrigation development, construction of roads, and improvement in the supply of agricultural inputs. The potential for increased production of winter vegetables is very high.

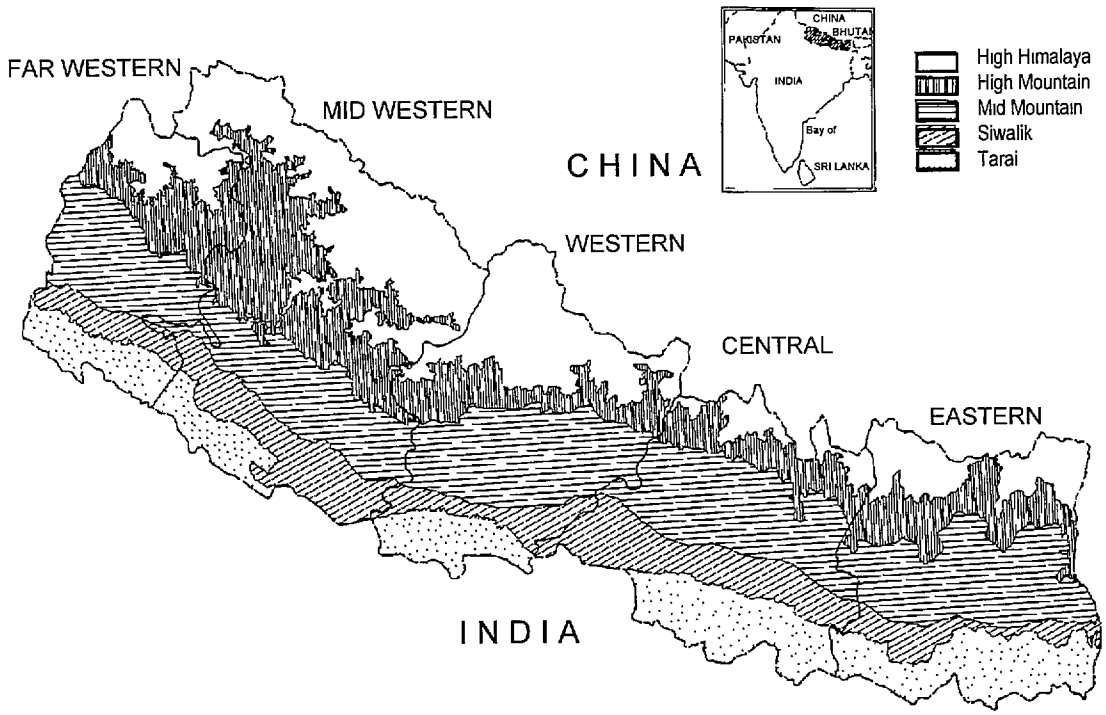


Fig. 1. Physiographic regions of Nepal

Siwaliks

The Siwalik region covers 1.9 million ha. Although the hills in this region are extremely rugged, the distance from valley bottom to ridge top is usually less than 700 m. Most of the cultivable land in this region is in the Dun Valleys, which have some potential for vegetable production.

Mid Mountains or Hills

With an area of 4.4 million ha, this region consists of low to moderately high mountains and deeply incised river valleys. Elevation in this region ranges from 500 to 3000 m. Most farming is done on terraces built on slopes of less than 30°. In order to overcome land degradation problems, the government has emphasized horticulture development in this region.

High Mountains

This region has an area of about 2.9 million ha and elevation ranges from 3000 to 5000 m. More than 90% of the total cultivated land in this region is on terraced sloping land. A wide range of warm temperate and cool temperate vegetable crops can be grown, but lack of roads is a bottleneck to the marketing of surpluses.

High Himal

This region covers 3.4 million ha and elevation ranges from 2500 to 8848 m. Total cultivated area is less than 0.2% of the whole region. Expansion of cultivated area is limited by lack of arable land and irrigation. Although access to this region is extremely difficult, trekkers in some areas of this region are generating a small but steadily growing demand for vegetables.

Agroecological Zones

Based on physiography, delineation of presently cultivated area, and altitude, four distinct agroecological zones can be identified with different potentials for vegetable production (PACMAR and EC 1991).

Tropical Zone

The tropical zone runs east–west along the southern part of Nepal, with elevation ranging from 60 to 1000 m. The temperature fluctuates between 7° and 24°C in December–January and between 24° and 41°C in June–July, with the mean temperatures around 20–24°C. Annual rainfall varies from 1300 mm in the east to 600 mm in the west. This climate is found in some parts of the mid Hills and Siwaliks and all parts of the Tarai. This zone has good road access and accounts for about 60% of the total cultivated land in the country. Seasonal variation in temperature and rainfall in this zone permits the cultivation of vegetables in different seasons of the year. Potato and other temperate crops are grown in the cool dry season, but other crops grow best in the monsoon season.

Subtropical Zone

The subtropical zone also runs east–west almost along the middle part of the country with elevation between 1000 and 1500 m. Summers are long, humid, and warm, with temperatures of 13–27°C in June–July and 2–17°C in December–January. Annual rainfall varies between 2800 mm in the east and 1000 mm in the west. This climate is found in some parts of the high Hills and most parts of the middle Hills and Siwaliks, and covers about 20% of the cultivated land. As in the tropical zone, most vegetables, including potato, can be grown here. Road access is limited to some interior valleys of the Mid Mountain Region or Hills.

Warm Temperate Zone

The warm temperate zone is restricted to hill slopes in the mid and high Mountain physiographic regions and has elevation ranging from 1500 to 2000 m. The zone is neither very cold during winter nor very hot during summer, but there is occasionally snow in the higher areas. The average winter daily temperatures fluctuate between 9° and 10°C in December–January and between 12° and 21°C in June–July. Annual mean temperatures range from 15° to 17°C, while annual rainfall varies from 900 mm in the east to 140 mm in the west. This type of climate can be found in many parts of the high Hills and covers about 12% of the cultivated land. The most commonly grown vegetables in this zone include cauliflower, cabbage, radish, broad-leaf mustard, and potato. Road access is even more limited in this zone than in the tropical and subtropical zones, which means there are fewer accessible commercial production pockets.

Cool Temperate Zone

In the cool temperate zone, elevation ranges from 2000 to 3000 m. Temperatures are usually low and there is snowfall every year. Mean annual temperatures range from 10° to 15°C. The eastern part receives more rain than the western part. This zone is restricted to areas of the major Himalayan mountain chain and has about 1.5% of the total arable land. Fresh vegetables and virus-free, good quality vegetable seed can be produced commercially in the cool temperate zone. Good quality seed for crops such as cabbage and carrot are produced in some pockets of this agroecological region. Commercial production is constrained by lack of roads in this zone.

Communications

By and large, transportation and communication systems in Nepal are poor. Although great progress has been achieved by the construction of the East-West Highway and the north-south link roads, in 1990 only 48% of the country was within a one-day walk of a road head (PACMAR and EC 1991). Only about a quarter of the 10 million inhabitants of the Hill and Mountain regions have effective access to roads capable of delivering inputs and carrying produce to markets. The total road length in Nepal is reported to be 10,724 km (DoR 1995). Road distribution is 53% in the Tarai, 42% in the Hills and only 5% in the Mountains.

Social Taboos

A number of socioeconomic and cultural taboos influence vegetable production and consumption in the country. The following are typical examples:

- A very common notion among consumers in Nepal is that vegetables add "taste" and "variety" to food, but that they are not a rich source of nutrients.
- In rural areas, vegetables are not normally sold, as this is considered to negatively affect one's dignity. This belief has hindered development of commercial vegetable production.
- It is widely believed, particularly in rural areas, that lactating mothers should not eat green vegetables because they are harmful to both mother and baby. This belief adversely affects the nutritional level of these vulnerable groups.
- It is believed that people with a fever, cold, or other sickness should not consume vegetables.

These beliefs result from ignorance about the nutritional value of vegetables. Most of them are now disappearing for various reasons, including general improvement in people's educational status; exposure of rural people to the food habits of educated urban dwellers; media campaigns about food, health, agriculture, and child care; awareness about the need to raise production and income; and availability of markets for vegetables, particularly near urban centers and highways.

Major Vegetable Species and Production Areas

As stated above, diverse topographic features and climatic conditions in Nepal permit the successful production of a large number of vegetables. About 250 vegetable crops are grown in Nepal, of which more than 50 are common (Pun 1987).

In terms of area, production, and value of production, cauliflower is the most important vegetable in the country, followed by cabbage. Other important vegetables in terms of area include tomato, eggplant, and chili. Onion is the fourth most important vegetable based on volume and value of production.

Major vegetable production pockets are shown in Fig. 2. They are mainly along the major highways and close to urban centers. Major areas of vegetable production and periods of supply to urban centers are presented in Table 2.

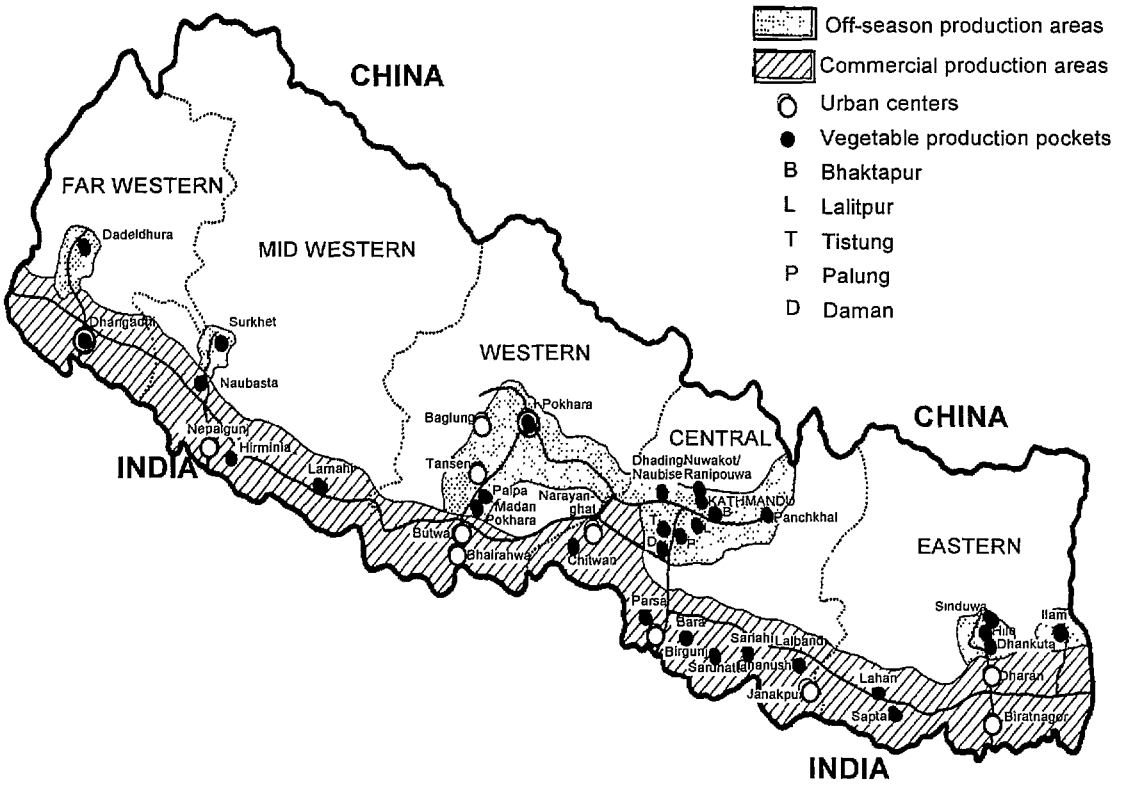


Fig. 2. Important vegetable production pockets and major urban centers in Nepal.

Vegetable Development Programs

Between 1980–81 and 1989–90, the government implemented vegetable production programs by categorizing the total vegetable area into three types of programs based on production and marketing potential. The *Special Program* was launched in irrigated areas with motorable roads and easy access to markets. In such areas, technology, inputs, credit, and other support were intensively provided to commercial vegetable growers by the government. In 1990, 31 districts of the country, out of a total 75, were covered by this program. The *General Program* was implemented in other accessible areas. Government support was limited to input supply and farmer training. The main objective of this program was to increase vegetable production for local consumption. A sizable vegetable area came

under the *Least Priority Program*, in which the government provided limited extension support. This area benefited indirectly from technology dissemination in adjoining special and general program areas.

Table 2. Major vegetable production areas and periods of supply to urban centers

Crop	% of total veg. area	Period of supply	Production districts	Varieties grown*
Broad leaf mustard	5.3	Nov-Feb	Kathmandu Valley	Khumal Broad Leaf,
		May-Jul	Mustang, Dhankuta, Terhathum	Marpha Broad Leaf
		Nov-Jan	Chitwan, Dang	
Cabbage	11.0	Jun-Jul	Makwanpur, Dhankuta, Ilam Terhathum, Palpa	Golden Acre, Pride of India
		Dec-Mar	Bara, Parsa, Chitwan	Late Large
		Apr-Jun	Kathmandu Valley	Drumhead, Copenhagen
Cauliflower	13.7	Nov-Dec, Feb-Mar	Kathmandu Valley, Palpa	Kathmandu Local
		Sep-Jan	Bara, Rautahat, Sarlahi Banke	Snowball 16 Dipali, Kibo Giant
		Oct-Dec		Nuwakot
		May-Oct	Makwanpur, Dhankuta, Terhathum	
Chili	6.8	Aug-Sep	Kathmandu Valley, Kavre, Dhading	Jwala, Yatsufusa, Nepali Local
		Jun-Jul	Bara, Sarlahi, Dhanusha	
Eggplant	6.6	Sep-Dec	Sarlahi, Dhanusa, Bara, Saptari	Kranti, Noorki, Birgunj White,
		Jan-Feb	Siraha	Sarlahi Green,
		Mar-May	Dhading	Purple Long
		Jun-Aug	Kath. Valley, Nuwakot	
Fresh beans	4.3	Apr-Jul	Kathmandu Valley	Kentucky Wonder,
		Oct-Dec, Mar-May	Dhading	Contender Giant, Stringless
Market tomato	7.5	Oct-Feb	Sarlahi, Dhanusha, Bara Siraha, Banke	Pusa Ruby, Pusa Early Dwarf
		Mar-May	Dhading, Nuwakot	Roma, CL 1131
		Jun-Sep	Kavre, Kathmandu Valley, Dhading	
Okra	5.1	May-Jul	Bara	Pusa Sawani, Local
		Aug-Sep	Kath. Valley	Parwani Kranti
Onion	5.7	Apr-Jun	Bara, Saptari Kathmandu Valley	Red Creole, Kath. Local, Nasik Red
Peas	4.8	Aug-Oct	Makwanpur	New Line Perfection,
		Oct-Dec	Bara	Bonne Ville
		Jan-Feb	Dhankuta	
		Mar-Apr	Kath. Valley	
Radish	5.2	May-Oct	Makwanpur, Nuwakot Palpa	White Neck, Minoo Early, Pyuthane Red,
		Nov-Feb	Kath. Valley, Rautahat	Chalis Dine
Others**	24.0			

* Most varieties are widely adapted and so can be grown in different production areas during different seasons.

** Others include several vegetables, such as carrot, sweet pepper, cucumber, sponge gourd, bitter gourd, bottle gourd, pointed gourd, snake gourd, spinach, celery, squash, turnip, broccoli, green garlic and Swiss chard.

Source: Rekhi et al. (1990) and VDD (1991).

Trend Analysis

National Trends

Time series statistics were available for total vegetables and potato, but not for individual vegetables. Therefore, this analysis is confined to total vegetables and potato. Estimated growth rates in total vegetable and potato area, yield, and production for 1974–1995, as well as disaggregated data for 1974–83 and 1984–95, are presented in Table 3.

Table 3. Growth rates (%/year) in area, production, and yield of vegetables by period

	Total vegetables			Potato		
Period	Area	Yield	Production	Area	Yield	Production
1974–1995	2.95	2.91	5.86	3.64	2.67	6.31
1974–1983	5.68	0.59*	6.19	0.79*	1.46*	2.25*
1984–1995	0.13*	5.03	5.16	4.24	5.04	9.28

*Not significant at the 5% level.
Source: Trends in total vegetables were computed from Vegetable Development Division (VDD), 1995 data and trends in potato were estimated from Ministry of Agriculture 1995 data.

The total vegetable area in Nepal increased steadily from 82,000 ha in 1974 to about 140,000 ha in 1988, but has stayed more or less constant since. Over the 21-year period, vegetable area and yield both grew at an annual rate of about 3.0%, so total vegetable production in Nepal increased by 5.9% per year.

However, the improvements did not follow a consistent pattern. In the first decade, vegetable area expanded rapidly, but yields increased only marginally. During the following decade, there was little increase in vegetable area, but yields increased significantly, due mainly to the spread of improved varieties and increase in the use of other complementary inputs in irrigated areas.

The potato area more than doubled from 48,000 ha in 1974 to 106,000 ha in 1995 (3.6% annual growth), while its production increased more than three times from 285,000 to 898,350 t (6.3% per annum). The yield increase in the period was also impressive, from about 6 t to 8.5 t (2.7% per annum) (Table 3). However, most of this increase took place in the last decade.

Trends by Program

The areas covered by Special, General, and Least Priority programs in 1980 were 1.3%, 6.9%, and 91.8%, respectively, of the total vegetable area. By 1989, these shares changed to 3.6%, 16.9%, and 79.5%. Total vegetable area in Nepal also increased dramatically during this period, so although the area under the Special Program was still only a very small percentage of the total in 1989, its annual growth rate in the 1980s was more than 16% (Table 4). Yields also increased during this period; in one decade, yield per ha under this program increased from 6 t/ha to 15 t/ha, which is quite remarkable.

Table 4.Growth rates (%/year) in area, production, and yield of vegetables by program areas, 1980–1989

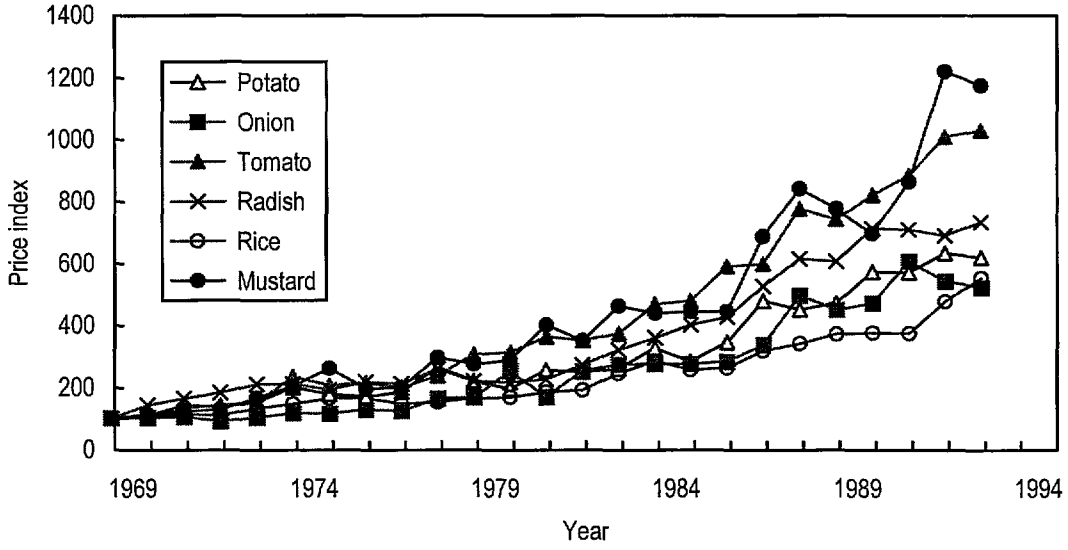
Program	Area	Production	Yield
Special Program	16.13	26.38	8.82
General Program	10.57	16.60	5.45
Least Priority Program	1.72	3.65	1.90

Source: Computed from VDD (1991) data.

Under the General Program, area more than tripled during this period, from 7200 to 23,700 ha, and yield per ha increased from 5 to 9.4 t/ha. The annual production growth rate was 16.6%.

Price Trend

Nominal price indices of national average retail prices of major vegetables, cereals, and cash crops between 1969 and 1993 are presented in Fig. 3. In general, increases in vegetable prices were higher than for cereal. Among vegetables, the increase in the price index of tomato was the highest at 1025 over a period of 24 years, followed by the price indices of radish and potato. However, onion suffered a setback in prices in relative terms, as the price index of this commodity rose less than that of rice, the main staple food.



Source: DoAD various issues.

Fig. 3. Trend in major vegetable and cereal price indices, 1969-93

Variability in Production

Unexpectedly, the coefficients of variation (CV) in vegetable production and yield (estimated after detrending these variables) were generally lower than those values in rice production. This might be due to the aggregation of so many vegetables in the total vegetables category, such that the lower value of any of the parameters of one vegetable in a given year might be compensated for by the

corresponding higher value of the same parameter for other vegetables. It might also be due to unreliable statistics, evident from the same values for area, production, and yield of vegetables being repeated for many years. The detrended CV of potato and rice area increased by 61% and 112%, respectively from 1974–83 to 1984–95 (Table 5). The CV of potato yield increased more dramatically (208%) during this period, whereas that of rice declined by 8%.

Table 5. Coefficients of variation (%) in vegetable and rice production, area, and yield by period during 1974-95

	Total vegetables			Potato			Rice		
Period	Area	Yield	Production	Area	Yield	Production	Area	Yield	Production
1974–83	5.79	3.71	2.72	4.02	3.97	3.49	2.12	9.91	9.87
1984–95	3.90	4.11	2.89	6.47	12.27	12.18	4.49	9.15	13.17
1974–95	5.11	3.99	2.80	5.57	8.93	8.73	3.58	9.62	11.74
% Change (1974–95)	-33	11	6	61	208	249	112	-8	33

Source: Computed from VDD (1991) and MoA (1995) data.

International Trade

Total imports of vegetables in Nepal have far exceeded total exports. Nepal exported vegetables worth NPR 6.3 million but imported NPR 104.3 million worth of vegetables in 1991. The trade deficit has been widening over time as vegetable exports are declining while imports are increasing at a high rate (Table 6). Nepal's vegetable exports and imports are mainly limited to trade with India.

Table 6. Annual growth rates and variability in exports and imports of vegetables, 1982–83 to 1990–91

	Potato		Tomato		Onion and garlic		Others	Total
	Quantity	Value	Quantity	Value	Quantity	Value	Value	Value
Import growth (%)	12.0	15.4	7.5	1.8	7.0	13.5	6.0	13.7
Export growth (%)	-17.5	-9.3	-0.5	17.3	-12.8	1.5	5.3	-2.8
CV (%) import	39.1	46.4	77.9	78.5	27.1	42.3	32.9	40.7
CV (%) export	58.8	42.8	62.8	94.3	74.4	90.1	59.8	36.4

Source: Computed from Department of Customs (various issues 1990-1992) data.

Note: Because import and export tariffs on agricultural products are minimal, customs authorities do not maintain accurate trade statistics. In addition, the long and open border with India leads to movement of agricultural products all along the border, which cannot be covered by a limited number of customs checkpoints. As a result, import and export data might be biased downward.

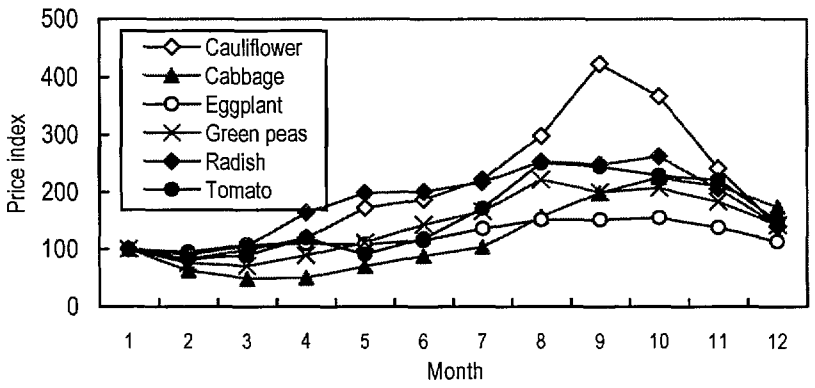
The main vegetables imported are potato, onion, garlic, and tomato. The trade in potato constituted more than half of the total trade value; imports were worth NPR 64.5 million, and exports NPR 2.8 million. In 1991, Nepal exported about 800 t of potato, but imported about 41,000 t. The trend in potato imports has not been consistent; imports increased from 16,000 t in 1981 to a high of about 54,000 t in 1988, but then declined to the 1991 level. In contrast, potato exports have in general showed a trend of gradual decline during this period. Onion and garlic imports increased from 4,800 t in 1983 to a high of 11,400 t in 1988. Exports of onion and garlic were only a fraction of imports.

Export and import data for tomato, onion, and garlic show wide year-to-year fluctuations and no clear trends as suggested by high coefficients of variation (CV) in these statistics (Table 6). The high degree of variability in the import and export of vegetables is indicative of the unstable nature of vegetable production, the drastic changes in vegetable trade policies in the wake of vegetable shortages and surpluses, and perhaps also the inconsistency and unreliability of the recording system of the customs offices.

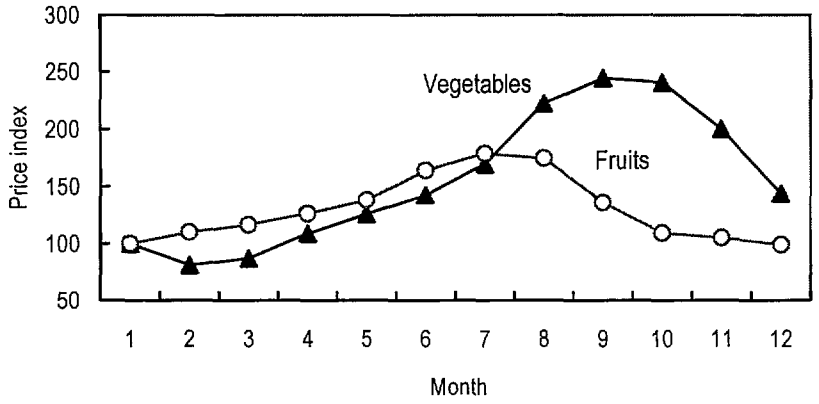
Seasonality

The seasonal monthly price indices start increasing in April, from their lowest level during January–March, and peak during August–October (Fig. 4). The extent of seasonality in individual vegetables varies from more than 400% in cauliflower to 63% in eggplant. The average seasonality in the price of all vegetables as a group is about 200%, which is much higher than the average seasonality in fruit prices (Fig. 4).

A. Individual vegetables



B. Overall fruits and vegetables



Source: DoAD (various issues 1991-1994).

Fig. 4. Seasonality in vegetable and fruit prices (average of 1989-93)

It is usually believed that high vegetable prices are compensated by low fruit prices, and that therefore overall micronutrient availability from these sources does not change. However, this is only partially true.

Farm Management Practices

Based on available literature, a brief review of the farm management practices of vegetable growers in different regions of Nepal is presented below.

Kathmandu Valley (Representing Nepal's Hills)

Pandey (1993) documented the management practices of a specialized group of vegetable farmers (called the *Jyapoo*) of the Kathmandu valley. The management practices described in that study are summarized below.

Cropping Patterns

The cropping systems in Kathmandu valley, representing Nepal's Hills, are reported in Table 7. Three distinct cropping systems are prevalent in the valley: rice-based, maize-based, and vegetable-based. Rice-based cropping systems are predominant, although vegetable-based cropping systems in this area are more common than in other regions. Vegetable-based cropping systems are being adopted by farmers in other hill areas of Nepal, such as Pokhara. In the peri-urban area of Kathmandu valley, mixed cultivation is also practiced for some groups of vegetable crops. In such cases, planting, intercultural, and harvesting activities are intensive, and cropping intensities can be as high as 500–600%.

Table 7. Vegetable cropping systems in Kathmandu valley (representing Nepal's Hills)

First crop	Months	Second crop	Months	Third crop	Months
A. Rice-based cropping systems					
Rice	June-Oct.	Cole crops-cole crops	Nov.-Feb.	Beans/cowpeas/chili/tomato/ cucurbits	Feb.-May
Rice	June-Oct.	Turnip/carrot-turnip/ root crops-cabbage	Nov.-Feb.	Eggplant/sweet pepper/tomato	Feb.-May
Rice	June-Oct.	Fava bean/peas	Nov.-Feb.	Mustard/squash/cucumber	Feb.-May
Rice	June-Oct.	Onion/garlic	Nov.-Feb.	Amaranthus/mustard	Feb.-May
Rice	June-Oct.	Broad leaf mustard	Nov.-Feb.	Potato (radish/bean)	Feb.-May
Rice	June-Oct.	Cress/spinach/lettuce	Nov.-Feb.	Tomato/sweet pepper/ eggplant/cucumber/squash	Feb.-May
Rice	June-Oct.	Cabbage/cauliflower	Nov.-Feb.	Squash/cucumber	Feb.-May
Rice	June-Oct.	Fallow/cauliflower	Nov.-Feb.	Potato	Feb.-May
Rice	June-Oct.	Radish-radish	Nov.-Feb.	Sweet pepper (mustard)	Feb.-May
Rice	June-Oct.	Radish	Nov.-Feb.	Onion-mustard	Feb.-May
Rice	June-Oct.	Carrot/knolkhol	Nov.-Feb.	Cucumber	Feb.-May

Contd. Table 7.

First crop	Months	Second crop	Months	Third crop	Months
B. Maize-based cropping patterns					
Maize	May-Aug.	Cole crops	Aug.- Dec.	Onion/cress/spinach	Dec.- Apr.
Maize	May-Aug.	Root crops	Aug.- Dec.	Garlic/potato/cole crops	Dec.- Apr.
Maize	May-Aug.	Broad leaf mustard	Aug.- Dec.	Cabbage/potato/onion/cauliflower	Dec.- Apr.
Maize	May-Aug.	Cole crops	Aug.- Dec.	Late cole crop/leafy vegetable Green onion/carrot/leafy green	Dec.- Apr. Dec.- Apr.
Maize	May-Aug.	Potato	Aug.- Dec.	Onion/carrot/leafy greens	Dec.- Apr.
C. Vegetable-based cropping patterns					
Beans/cowpeas	May-Aug./Sep.	Radish/turnip	Aug. - Dec.	Onion/garlic	Dec.-Apr.
Carrot	May-Aug./Sep.	Beans/cowpeas	Aug. - Dec.	Radish/knolkhol/turnip	Dec.-Apr.
Chili	May-Aug./Sep.	Broad leaf mustard	Aug. - Dec.	Potato/radish	Dec.-Apr.
Chili/ginger	May-Aug./Sep.	Winter vegetables	Aug. - Dec.	Winter vegetables	Dec.-Apr.
Colocasia	May-Aug./Sep.	Broad bean	Aug. - Dec.	Mustard	Dec.-Apr.
Gourd	May-Aug./Sep.	Spinach/cress/ coriander/fenugreek	Aug. - Dec.	Peas/turnip/carrot/ spinach/cress/coriander	Dec -Apr
Okra/pumpkin/ cucumber	May-Aug./Sep.	Cole crops	Aug. - Dec.	Squash/cucumber/potato/beans	Dec.-Apr.
Soybean	May-Aug./Sep.	Onion green	Aug. - Dec.	Coriander/lettuce	Dec.-Apr.
Sweet pepper	May-Aug./Sep.	Potato	Aug. - Dec.	Late cauliflower/cabbage	Dec.-Apr.
Tomato/eggplant	May-Aug./Sep.	Radish/mustard	Aug. - Dec.	Onion/potato	Dec.-Apr.

/ dividing crops means one or the other.

Adoption of Vegetable Material

Vegetable material (or varieties of different vegetables) adopted by farmers are reported in Table 8. Most of these varieties have been adapted, acclimatized, and naturalized by Jyapoo farmers, and these varieties have acquired indigenous traits due to the processes of natural selection and genetic shift. This indigenous germplasm has also been used as a source of breeding material by national vegetable scientists. Although most Jyapoo farmers lack formal training in plant breeding, they use individual/mass selection procedures for crop maintenance and seed production. For example, medium- and early-maturing plants are allowed to flower and set seeds. Seeds from these plants are then combined and used as planting material in the next season.

Soil Preparation

Human labor is used for soil preparation in the valley as the use of animal labor is prohibited for religious reasons. Land is prepared by pulverizing soils to allow easier root penetration, to facilitate mixing manure and fertilizer, and to help destroy harmful insects and pests. Crops such as cress, spinach, fennel, fenugreek, garlic, onion, and coriander are sown on sunken beds, and crops such as cauliflower, cabbage, broad leaf mustard, potato, radish, tomato, chili, and eggplant are planted on raised beds.

Table 8. Vegetable types adopted and maintained by Jyapoo farmers in Kathmandu Valley

Vegetable	Variety
Asparagus bean	Red Seeded White Pod
Bitter gourd	White long
Broad leaf mustard	Khumal Broad Leaf
Capsicum	Mild Pungent (adapted from California Wonder)
Cauliflower	Kathmandu Local
Chili	Kathmandu Local
Colocasia	Local
Coriander	Local
Cress	Nepali
Cucumber	Kusle, Nepali
Eggplant	Purple Long
Fennel	Local
Fenugreek	Local
Garlic	Local
Ginger	Local
Lettuce	Adapted from Imported Variety
Okra	Local
Onion	(Nepali) Light Red
Pumpkin	Local
Radish	Pyuthane
Spinach	Gobre, and Patane
Sponge gourd	Light Green Long (Kathmandu Local)
Squash	Gray
Tomato	Local
Turnip	Kathmandu Red

Source : Pandey (1993).

Planting and Nursery Management

The choice of planting technique is influenced by factors such as the type of vegetable, the schedule for marketing, the desired yield, and the shape, size or weight of the product. For example, carrot, radish, turnip, spinach, cress, coriander, celery, beans, and okra are sown directly. Eggplant, cauliflower, broad leaf mustard, chili, cucumber, and tomato are transplanted. Cauliflower, eggplant, and chili are also replanted for delayed production.

Nursery seedbeds are generally preferred near the residence or in a safe corner of the main field. The nursery soil is given a fine tilth and weeds, plant debris, pebbles, chaff, etc., are removed. After preparing raised or sunken beds, 2–5 kg/m^2 of well decomposed compost is mixed with the nursery soil. Seeds are usually broadcast and covered with a mixture of soil, ash, and compost.

Irrigation

The timing and quantity of irrigation water to be applied are influenced by conditions such as the type of crop produced, type of soil, temperature, stage of plant growth, etc. In Kathmandu valley, the soils are heavy clay and so drainage is more important than irrigation for successful vegetable production, especially during the monsoon and autumn seasons. Good drainage is essential in rice-based vegetable cropping patterns and for rainy season vegetable production. Crops such as cauliflower and cabbage, which are highly susceptible to high soil moisture, are planted on raised beds.

Weeding and Other Cultural Practices

Weeding is mostly done manually, and no herbicide is used. Weeds are fed to animals or are composted, depending upon the distance of the farm from the household, the type of animal raised, and the quantity and type of weeds gathered.

Vegetable growers of the Kathmandu valley have traditionally practiced biological methods to control insects and diseases in vegetables. For example, when garlic, onion, carrot, ginger, basil, dundu, chive, and coriander are interplanted with brassicas and other vegetable crops, the incidence of feeding and sucking insects on vegetable crops is low. Mixed or companion crop planting also promotes the population of predators of most harmful insects. The following traditional intercultural practices are reported to control insects:

- Tobacco leaf extracts and washing soap solution for aphids and smaller sucking insects.
- Garlic, clove extract, and kerosene oil to prevent caterpillars, cutworms, and aphids.
- Leaf and leaf extracts of chinaberry (*Melia azedarach* L.) as an insect repellent.

However, such practices are being rapidly replaced by indiscriminate use of pesticides, causing concerns for public health and the environment.

Harvesting

Harvesting vegetables usually requires more labor than harvesting other food or cash crops. Most vegetables are harvested in more than one batch. Rainy periods and early morning hours are avoided for harvesting. Usually baskets called *kharpan* are used for transporting vegetables.

Western Hills

Important practices followed by vegetable farmers in this region are, as found by Budathoki et al. (1993), are discussed below.

Cropping Pattern

In the Hills, the three types of cropping systems, similar to those prevalent in the Kathmandu valley (see Table 7), are maize-based, rice-based, and vegetable-based. However, the vegetable-based cropping patterns are not as important here as in the Kathmandu valley.

Soil Fertility Management

Hill farmers depend primarily on organic manure, either compost prepared from locally available organic materials or farmyard manure. Large amounts of both types are applied to kitchen gardens at the time of land preparation. In addition, farmers also use wood ash, cattle urine, leguminous crops, mulch, recycled weeds, etc., as part of soil fertility maintenance.

Plant Protection

Traditional practices used by farmers to minimize crop losses include:

- use of local varieties
- mixed cropping
- use of wood ash, cow dung slurry, diluted cattle urine, and plant extracts
- adjustment of planting time.

Moisture Conservation and Management

Farmers also practice moisture conservation methods, such as the use of residual soil moisture, shallow plowing, mulching, household waste water, etc. During the monsoon months, when precipitation is very heavy, farmers use raised beds (about 30–45 cm) separated by trenches for drainage.

Eastern High Hills

In the high Hills of eastern Nepal (above 1800 m) potato farming is mostly fallow-based and farmers follow a low input system. This practice, called the *Buk method*, has the following features:

- The vegetation which grows during the fallow period provides necessary soil nutrients, and additional manure or fertilizer is not used.
- Inter-cultural operations are not done.
- Cultivation is done on natural slopes on a four- to six-year fallow cycle. First, the vegetated soil is sliced and piled. Then these piles of grass roots and surface vegetation are burned. Finally, individual potato seeds are sown into the piles.
- Plots are planted on a communal basis, so fencing is not required because everyone is mindful about keeping their animals out of their fields, and the chance of theft is low.

Tarai

In the Tarai, farming is mainly rice-based, and only small areas are given over to year-round vegetable-based cropping systems. The rice-based cropping systems in which vegetables are grown are described in Table 9. No substantial research effort has been undertaken to identify the farm management practices adopted for different vegetables grown in this area.

Table 9. Vegetable cropping patterns in the Tarai

First crop (July-Oct)	Second crop (Nov-Feb)	Third crop (Mar-Jun)
Rice	Tomato/onion/ eggplant/peas/garlic	Pumpkin/cucumber/ gourd/cowpea/okra/chili
Rice	Cauliflower/cabbage	Garlic/potato/cole crops
Rice	Potato/cauliflower/ eggplant	Bottle gourd/bitter gourd/ okra/cucumber/maize
Vegetables	Vegetables	Vegetables

Sources: Jansen et al. (1994).

Economics of Production

Input Use

Inputs for seven types of vegetable crops in four districts representing Hill and Tarai regions are presented in Table 10.

Table 10. Comparison of input use in vegetables and cereal crops, 1992–93

Input	Crop	Tarai		Hills		Average
		Sarlahi	Bara	Dhading	Makwanpur	
Labor (days/ha)	Cauliflower	371	377	374	278	350
	Potato	-	311	-	320	316
	Okra	516	493	407	-	472
	Onion	-	270	-	-	270
	Peas	-	-	353	314	334
	Radish	-	-	-	320	320
	Tomato	401	437	343	-	394
	Average for vegetables	429	378	369	308	371
	Maize	135	135	165	158	148
	Paddy	159	162	250	205	194
	Wheat	102	109	130	130	118
	Average for cereals	132	135	182	164	153
Fertilizer (kg NPK/ha)	Cauliflower	239	149	183	412	246
	Okra	206	101	193	-	167
	Onion	-	252	-	-	252
	Peas	-	-	52	77	65
	Potato	-	302	-	240	271
	Radish	-	-	-	5	5
	Tomato	21	56	179	-	85
	Average for vegetables	155	172	152	184	166
	Maize	6	6	10	60	21
	Paddy	54	106	94	86	85
	Wheat	58	58	60	60	59
	Average for cereals	39	57	55	69	55

Contd. Table 10.

Input	Crop	Tarai		Hills		Average
		Sarlahi	Bara	Dhading	Makwanpur	
Pesticides (NPR/ha)	Cauliflower	-	-	644	27	336
	Okra	1203	990	240	-	811
	Onion	-	-	-	-	-
	Potato	-	1200	-	11	606
	Peas	-	-	104	660	382
	Radish	-	-	-	10	10
	Tomato	-	-	145	-	145
	Average for vegetables	1203	1095	283	177	690

Source: DoAD (1992a, b).
Note: Pesticide use in cereal crops was not reported.
- not included in the survey.

Labor

The most labor-intensive crops were okra and tomato. Labor use on vegetables was generally higher in the Tarai than in the Hills. Labor inputs to vegetable cultivation were higher than to cereal cultivation, mainly because of the higher labor requirement for harvesting of vegetables.

Fertilizer

Subsistence vegetable farmers choose to apply large quantities of farmyard manure because they grow vegetables on small pieces of land. On the other hand, commercial vegetable farmers in general do not have enough organic manure and have to rely on chemical fertilizer (Pandey 1993). Fertilizer use was much higher on vegetables than on cereals.

Pesticide

Tarai farmers used higher doses of pesticides than Hill farmers because the environment of the Tarai is more conducive for bacterial and fungal growth.

Other Inputs

Subsistence vegetable farmers, especially the Jyapoo farmers in the Kathmandu valley, produce their own seed. Commercial farmers buy vegetable seeds from other sources who provide information about cultivars and their specific requirements; the main criteria considered include quality, type, grade, appropriateness by season, etc. (MoA 1986). In the Special production area, 87% of commercial farmers used chemical fertilizer, 88% used improved seeds, and 82% used pesticides; in the General production program area, these figures were found to be 69%, 46%, and 54%, respectively (MoA 1986). Another study (MoA 1987) showed that all surveyed farmers used farmyard manure, about 90% used poultry manure, and 96% used pesticides.

Cost Structure

The cost structure of some vegetables is shown in Table 11. For simplicity, all variable costs (except

those for labor, fertilizer, and pesticides) and all associated fixed costs were added together in "other cost." The share of fertilizer and pesticide costs is small, mainly because of the low use of these inputs, but also because of subsidization of fertilizer.

Table 11. Cost of production and input share in selected vegetables in Nepal (average of Tarai and Hills), 1991–92.

Vegetable	Cost (NPR/ha)					Percentage share (%)			
	Labor	Fertilizer	Pesticide	Other cost	Total	Labor	Fertilizer	Pesticide	Other cost
Cauliflower	10662	3133	168	5539	19502	54.7	16.0	0.9	28.4
Okra	14489	1960	811	4489	21749	66.6	9.0	3.7	20.6
Peas	10790	746	382	6145	18063	59.7	4.1	2.2	34.0
Potato	10265	1957	606	10887	23715	43.3	8.2	2.6	45.9
Radish	11120	63	10	5575	16768	66.3	0.4	0.1	33.2
Tomato	11810	1045	48	6271	19174	61.6	5.4	0.3	32.7

Source: DoAD (1992b).

Farm Level Profitability

Seed Production

There have been a number of studies on the economics of vegetable seed production in Nepal (No-Frills 1989; Munankami 1990; Munankami and Dhakal 1990; Munankami and Gautam 1990; Munankami and Jha 1990; Munankami and Mahat 1990; Munankami and Neupane 1990; Munankami et al. 1990; Napit and Thapa 1990; Pandey et al. 1990; Munankami and Neupane 1991). These studies have covered vegetable crops such as radish, carrot, broad leaf mustard, pole bean, tomato, and onion. The production areas surveyed have included various locations in the Tarai, mid Hills, and high Mountains. Most of these studies have shown that vegetable seed production is more profitable than the production of food-grain crops (Table 12).

Table 12. Economics of vegetable seed production per ha in Nepal

Crop	Region	Year	Input use			Total cost[1] (NPR)	Gross income[2] (NPR)	Net return[3] (NPR)	Reference
			Fertilizer (NPR)	Pesticide (NPR)	Human labor (days)				
Broad leaf mustard	Terhathum	1990	1246	267	325	8900	13540	4640	Munankami & Neupane (1991)
Carrot	Mustang	1989	5134	5134	986	85570	101900	16330	Munankami & Dhakal (1990)
Onion	Rukum	1990	893	1225	637	46300	97310	51010	Munankami & Gautam (1990)
Radish	Bhaktapur	1989	1720	560	580	21800	32960	11160	Pandey et al. (1990)
Radish	Dhankuta	1990	1566	209	389	10440	20660	10220	Munankami et al. (1990)
Radish	Rukum	1990	922	922	755	30740	40460	9720	Munankami & Neupane (1990)

[1]Total costs include costs for human and bullock labor, seeds, fertilizer, plant protection chemicals, equipment and sprayers, interest, land and water tax, repair and maintenance of farm equipment, and depreciation of farm equipment; [2]Gross income=value of main and byproducts; [3]Net returns=gross income – total costs.

Vegetable Production

Comparative net profitability scenarios between vegetables and competing crops in two Hill and two Tarai districts are presented in Table 13. Although vegetables are more expensive to produce than cereals, they are also more profitable. The average net return from vegetables was five times more than that from cereals in Sarlahi, and seven times more in Bara (Table 13). Cauliflower gave the highest net return, especially in the Tarai (Bara district).

Table 13. Cost of production and returns (NPR/ha) to vegetables in selected Tarai and Hill districts, 1991–92

Item	Crop	Tarai		Hills		Overall average
		Sarlahi	Bara	Dhading	Makwanpur	
A. Total costs	Cauliflower	19,883	17,679	19,796	20,645	19,501
	Okra	23,981	21,944	19,323	-	21,749
	Onion	-	28,824	-	-	28,824
	Peas	-	-	16,806	19,320	18,063
	Potato	-	27,254	-	20,173	23,714
	Radish	-	-	-	16,848	16,848
	Tomato	15,348	20,965	21,211	-	19,175
	Average for vegetables	19,737	23,333	19,284	19,247	21,125
	Rice	7,492	7,974	11,099	8,603	8,792
	Wheat	-	6,477	7,395	7,239	7,037
	Average for cereals	7,492	7,226	9,247	7,921	7,915
B. Gross returns	Cauliflower	63,000	76,550	67,504	60,500	66,889
	Okra	54,546	57,749	59,312	-	57,202
	Onion	-	57,532	-	-	57,532
	Peas	-	-	50,882	48,000	49,441
	Potato	-	66,155	-	54,000	60,078
	Radish	-	-	-	37,500	37,500
	Tomato	40,348	42,112	44,819	-	42,426
	Average for vegetables	52,631	60,020	55,629	50,000	53,010
	Rice	14,080	16,511	18,645	17,079	16,587
	Wheat	-	8,305	8,999	10,120	9,141
	Average for cereals	14,080	12,425	13,822	13,600	12,864
C. Net returns	Cauliflower	43,117	58,871	47,708	39,855	47,388
	Okra	30,565	35,805	39,989	-	35,453
	Onion	-	28,708	-	-	28,708
	Peas	-	-	34,076	28,680	31,378
	Potato	-	38,901	-	33,827	36,364
	Radish	-	-	-	20,652	20,652
	Tomato	25,000	21,147	23,608	-	23,252
	Average for vegetables	32,894	36,686	36,345	30,754	31,885
	Rice	6,588	8,570	7,546	8,476	7,795
	Wheat	-	1,828	1,604	2,881	2,104
	Average for cereals	6,588	5,199	4,729	5,679	5,001

Source: DoAD (1992b).

An earlier study also reported higher returns (gross margin) for vegetable crops than cereal crops in Hill and Tarai districts (Rekhi et al. 1990). However, this study did not give detailed information on total costs and net returns of these crops.

These studies have shown high profitability in vegetable production compared to other crops. However, a substantial volume of vegetables comes from India, suggesting that vegetable production in India might be more cost-effective than production in Nepal. A study undertaken by the Ministry of Agriculture and Winrock International has analyzed the comparative advantage of Indian and Nepali agricultural produce (including fresh vegetables) in Nepali markets. The results of the study were not available to the author at the time this report was written.

Production Constraints

Vegetable production in Nepal is influenced by a number of biophysical and socioeconomic constraints (Pun 1987; Rana 1990; Rekhi et al. 1990; Baker and Gyawali 1994; Jansen et al. 1994). Table 14 gives a brief review of the economic constraints to vegetable production which have adversely affected the growth of this subsector.

Table 14. Constraints in vegetable production in Nepal

Vegetable studied	Region/ district	Year	Vegetable production constraints									Reference
			1	2	3	4	5	6	8	9	10	
General	Peri-urban	1994	+	+		+			+	+	+	Jansen et al. 1994
Potato	Kathmandu	1987	*	**	***	*	**	*				Pandey 1993
	Bara	1987	**	*	***	*	***	***				
Potato	Kathmandu	1989	***	**	**	*	*	**				Lalika 1989
Tomato	Dhading	1991	+	+		+						Pretty 1992
Tomato	Sarlahi	1992	+	+		+			+			Bhattarai 1992

Constraints: 1 = Insect loss; 2 = Disease loss; 3 = Weeds; 4 = Non-availability of good quality seed; 5 = Post-harvest loss; 6 = Flooding or high rains; 7 = Lack of credit; 8 = Non-availability of fertilizer; 9 = Poor irrigation facilities; 10 = Lack of marketing facilities. The number of stars indicates the extent of severity of the constraint. If neither objective nor subjective quantification was available, a (+)mark shows that the constraint was studied, but that severity is not known.

Almost all studies undertaken so far have tended to list constraints faced by farmers in the production of vegetables, but have not prioritized these constraints.

Marketing System

One of the important government policies in the Eighth Five-Year Plan is to improve the agricultural marketing system through government and private sector participation (NPC 1992). The Plan recognizes that unless appropriate marketing infrastructure is developed and other related support is provided, it will not be possible to increase vegetable production and consumption.

Markets and Marketing Channels

Basically, there are two types of vegetable markets:

- producers' supply markets or collection centers located in the vicinity of production pockets; producers or middlemen bring vegetables to such markets for sale to wholesalers
- consumer markets located near major urban centers

Such major urban market centers in the country get supplies from producers' markets and from India. Wholesalers and commission agents supply vegetables from collection centers to urban centers.

The marketing channels for vegetables differ by the origin of the product. The products might come from local areas or other areas within the country, or they might be imported. Also, there are different systems for potatoes and other vegetables.

At the local scale, farmers take their produce to the local market centers and sell either to retailers or direct to consumers. These simple marketing channels are found both in the Tarai and in the Kathmandu valley. The market channels in this case are:

i) Farmer→ Retailer→ Consumer

ii) Farmer →Consumer

When vegetables come from distant market centers, the marketing channels are rather more complex, with another middleman (a wholesaler or an assembler or perhaps even both) dealing between the producer and the retailer. The marketing channels are as follows:

iii) Farmer→ Wholesaler→Retailer→ Consumer

iv) Farmer→Assembler→ Wholesaler→ Retailer→ Consumer

v) Farmer→Assembler→ Retailer→ Consumer

In the case of Kathmandu vegetable markets, channel (iii) is the most common for the vegetables produced in adjoining districts. Bhattarai (1992) described the marketing channels for tomato produced in Sarlahi district in the central Tarai, which is almost identical to the channels followed for commercial vegetables produced domestically (Fig. 5).

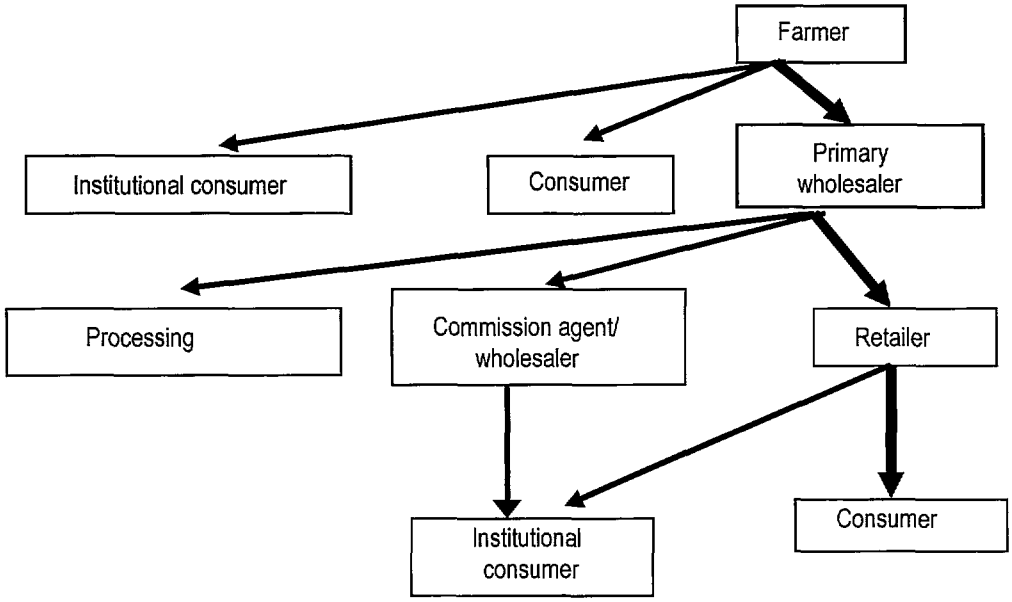
In a few production pockets, the Agricultural Marketing Development Division of the Department of Agricultural Development has organized some marketing groups in recent years. The following two channels are used for vegetables supplied from such areas:

vi) Farmer→ Marketing group→Wholesaler→ Retailer → Consumer

vii) Farmer→ Marketing group→ Retailer→Consumer

Vegetables imported from India are handled by commission agents who sell them to wholesalers in the Kathmandu market. Wholesalers then sell to retailers. For this the following market channel holds:

viii) Commission Agent→ Wholesaler→ Retailer→Consumer



Note: Width of the arrow is indicative of the magnitude of flow.
Institutional consumers include hotels, restaurants, and processing units.
Source: Bhattarai (1992).

Fig. 5. Marketing channels for tomato in Sarlahi, Nepal

Marketing Costs and Margins

Marketing margins for four vegetables at 11 locations were estimated by the Agricultural Projects Services Center (APROSC 1989) and are summarized in Table 15.

Table 15. Marketing agents' share of the consumers' price for selected vegetables, 1988–89

		Absolute share (NPR/kg)				Percentage share (%)			
Vegetable	Location	MC	Farmer**	Wholesalers	Retailer*	MC	Farmer**	Wholesalers	Retailer*
Cabbage	Dhalkewar, Dhanusha	0.9	1.5	1.1	1.5	18.0	30.0	22.0	30.0
	Birgunj, Parsa	0.8	2.0	1.3	1.5	14.3	35.7	23.2	26.8
	Lahan, Siraha	1.4	1.8	0.9	1.5	25.0	32.1	16.1	26.8
	Ralaiya, Bara	0.8	1.8	1.1	1.5	15.4	34.6	21.2	28.8
Cauli-	Dhalkewar, Dhanusha	1.1	2.8	1.4	1.8	15.5	39.4	19.7	25.4
flower	Birgunj, Parsa	0.9	2.5	1.6	2.0	12.8	35.7	22.9	28.6
	Ralaiya, Bara	0.9	2.3	1.9	2.0	12.6	32.4	26.8	28.2
Onion	Rajbiraj, Saptari	1.5	2.0	1.1	1.4	25.1	33.3	18.3	23.3
	Lahan, Siraha	1.3	1.2	1.3	1.6	24.1	22.2	24.1	29.6
Potato	Palung, Makwanpur	0.6	1.3	0.1	0.1	28.8	59.8	5.7	5.7
Tomato	Sarlahi	3.8	2.7	1.2	2.5	37.1	26.5	11.8	24.5

Sources: APROSC (1989) for cauliflower, cabbage, tomato, and onion, Satyal (1979) and Munankami (1985) for potato.
* Local transport cost at retail level also included.
** Farmer's share includes farm-level marketing costs.
MC = Marketing costs.

Of all the locations considered, tomato traded in the Sarlahi market had the highest marketing costs because this crop is highly perishable compared to the other crops considered (Table 15).

The farmer's share was highest in potato and lowest in tomato. It should be noted that the farmer's share for tomato is, in fact, composed of production cost plus on-farm marketing cost, and thus their real share is far below that reported in the table. The retailer's share of the consumer's rupee is higher than that of the wholesaler except in potato. This may be because of the high physical losses at the retail level in the former group of vegetables, in addition to the high local transport costs borne by the retailer.

A breakdown of marketing costs for selected vegetables is shown in Table 16. Transportation always accounts for the largest share of the marketing cost; management and taxes absorb only a small share.

Table 16. Shares of marketing operations in total marketing costs (%) for selected vegetables, 1988–89

Vegetable	Location	Packaging	Transport	Losses	Handling	Management	Taxes
Cabbage	Dhalkewar, Dhanusha	11.0	60.9	8.8	11.0	2.8	5.5
	Birgunj, Parsa	13.2	53.1	15.9	13.2	3.3	1.3
	Lahan, Siraha	7.4	74.0	7.8	7.4	1.9	1.5
	Kalaiya, Bara	10.4	59.0	14.2	13.1	3.3	0.0
Cauliflower	Dhalkewar, Dhanusha	9.1	50.0	25.0	9.1	2.3	4.5
	Birgunj, Parsa	11.3	45.3	28.2	11.3	2.8	1.1
	Kalaiya, Bara	11.1	50.0	25.0	11.1	2.8	0.0
Eggplant	Lalbandi, Sarlahi	11.2	55.8	13.4	11.2	2.8	5.6
	Dhalkewar, Dhanusha	10.5	57.9	13.2	10.5	2.6	5.3
	Birgunj, Parsa	12.6	50.3	20.1	12.6	3.1	1.3
	Kalaiya, Bara	7.2	71.6	10.8	7.2	1.8	1.4
	Lahan, Siraha	10.1	56.6	17.6	12.6	3.1	0.0
Onion	Rajbiraj, Saptari	12.0	61.4	9.2	7.0	8.7	1.7
	Lahan, Siraha	13.1	57.6	10.1	7.7	9.6	1.9

Source: APROSC (1989).

Marketing Constraints

Vegetables are transported from production or collection centers to markets mainly on trucks or night busses. No specialized vehicles are used to transport perishable vegetables. Transportation facilities from farms to collection centers or road heads are poor (Bhattarai 1992).

Nepal lacks infrastructure facilities, such as integrated market centers, wholesale markets, collection centers, warehouses, and processing units. A marketing information system to provide information to farmers about the prices prevailing at different market levels for various commodities, does not exist. Linkages and coordination among farmers, transporters, middlemen or agents, wholesalers, and retailers are not institutionalized (Winrock International 1993). All these problems disconnect markets from each other. Thus seasonal prices across markets do not move in the same direction. For example, during August–November, radish prices are highest in Dhanusha but lowest in Kathmandu (Fig. 6).

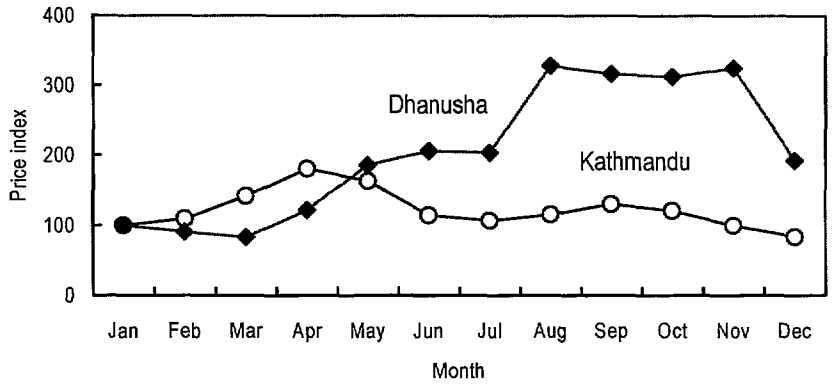


Fig. 6. Differential movements in seasonal prices of radish in Kathmandu and Dhanusha

Farmers lack knowledge on post-harvest technologies. Bruising and injury during harvesting, lack of precooling and cleaning of vegetables, absence of grading and standardization, and improper packaging, all contribute to biophysical deterioration of the product and economic loss to farmers. A study in selected markets of Nepal in 1991 showed that total physical losses from the origin market to the retail outlets were 23% for tomato, 16% for cabbage, and 12% for cauliflower (Werner and Subedi 1991).

Supply and Demand

Per Capita Availability

Per capita availability of vegetables and potato was computed for the period 1984 to 1995 using available secondary data on production, imports, and exports (Table 17). Annual per capita availability of vegetables and potato increased by 2.0% and 5.7% per year, respectively, over this period, and the combined per capita availability of vegetables and potato increased at an annual growth rate of 3.5%. While the reliability of these estimates is open to question, it is true that consumption has increased, particularly in urban and accessible rural areas, despite the sharp increase in vegetable prices.

Consumption by Income Group and Location

The multipurpose household budget survey conducted by the Nepal Rastra Bank estimated annual per capita vegetable consumption in Nepal to be about 38 kg in 1985. This is close to the figure estimated from vegetable availability if 20% post-harvest losses are assumed (Table 17). Leafy green vegetables constituted the most important vegetable type in all locations, followed by fruit vegetables, and roots and bulbs (Table 18).

Table 17. Annual per capita vegetable availability(kg) in Nepal, 1984 to 1995

Year	Vegetables	Potato	Total
1984	48	34	82
1985	50	27	77
1986	51	28	79
1987	52	37	89
1988	53	39	92
1989	54	40	94
1990	58	44	102
1991	60	46	106
1992	58	47	105
1993	60	49	109
1994	56	51	107
1995	60	53	113
Growth rate (%)	2.0	5.7	3.5

Assumptions: (1) Total availability = production + imports – export; (2) Per capita availability = total availability / population.

Table 18. Annual per capita vegetable consumption (kg) by region, physiographic zone, and vegetable type, 1985

Vegetable type	Urban Tarai	Urban Hills	Kath Valley	Rural Tarai	Rural Hills	Rural Mtns	Nepal
Fruit vegetables							
Cucurbits	7.9	9.1	7.0	9.0	8.5	2.7	8.4
Legumes	1.3	2.8	2.2	1.2	0.9	0.3	2.0
Miscellaneous	4.7	5.1	4.6	2.5	1.0	0.1	4.9
Other vegetables	2.8	7.3	5.6	2.3	2.1	1.8	4.7
Total	16.7	24.3	19.4	14.9	12.5	4.8	19.9
Leafy greens	7.5	18.0	13.9	9.0	8.3	9.6	12.0
Roots and bulbs	4.7	8.6	6.6	3.1	3.3	3.8	6.3
Grand total	28.9	50.9	39.9	27.0	24.2	18.3	38.3

Source: NRB (1989).

Among various locations, vegetable consumption was the highest in the urban Hills and lowest in the Mountains. In the Hills, the consumption of vegetables was significantly higher in urban areas than in rural areas. However, such a difference was not observed in the Tarai between urban and rural areas (Table 18).

Other important sources of data for vegetable consumption are the food consumption surveys of selected districts conducted by the Department of Food and Agricultural Marketing Services (DFAMS) in 1984 (Table 19).

Table 19. Annual per capita consumption (kg) of vegetables and potato in selected Hill, Mountain, and Tarai districts of Nepal, 1984

District	Area	Vegetables	Potato
Jhapa	Tarai	43.4	27.3
Rupandehi	Tarai	31.6	3.3
Dhankuta	Hills	25.6	20.6
Gorkha	Hills	24.1	15.5
Solukhumbu	Mtns	11.4	86.0
Mustang	Mtns	28.1	61.8

Source: DFAMS (1984, 1985).

The consumption of vegetables (and potato) by income decile in different geographic areas is shown in Table 20. In all areas, consumption levels increase with income. The consumption level of the highest income decile tends to be about 2-3 times the level of the lowest decile.

Table 20. Annual per capita vegetable and potato consumption (kg) in Nepal by ecological zone and income decile, 1985

Region	Income decile[1]									
	1	2	3	4	5	6	7	8	9	10
Rural Tarai	25	31	31	33	34	37	41	44	45	56
Rural Hills	21	23	22	26	29	34	35	35	39	44
Rural Mountains	17	18	24	25	27	31	36	34	42	47
Urban Tarai	33	36	40	43	44	48	52	60	67	72
Urban Hills	38	44	47	56	66	62	71	89	91	114
Hills	23	25	24	29	33	37	38	41	44	51
Tarai	25	32	31	34	35	38	42	46	47	57
Mountains	17	18	24	25	27	31	36	34	42	47
Nepal	23	28	28	31	33	37	40	42	45	54

Source: NRB (1989).
[1]The income deciles are defined as: 1= lowest 10%; 10 = highest 10%.

Price and Income Elasticities

Price and income elasticities for vegetables and other foods in Nepal are presented in Table 21. These elasticities were computed by Thapa and Koirala (1992) using published data from the multipurpose household budget survey conducted by the Nepal Rastra Bank in 1985. A food characteristics demand system (FCDS) model was used in computing these elasticities. An important attribute of this model is that it is relatively easy to use with sparse data from published sources (Bouis 1991).

Table 21. Price and income elasticities for vegetables and other foods in Nepal, 1985

Location/Income	Vegetables	Rice	Wheat	Maize	Meat	Fruits
Income elasticities						
Tarai						
Low income	0.28	0.45	-0.08	-0.28	1.51	1.37
High income	0.18	0.28	-0.13	-0.27	1.29	1.16
Hills						
Low income	0.18	0.71	0.47	0.05	1.30	0.14
High income	0.32	0.45	0.21	-0.14	1.21	0.30
Mountains						
Low income	0.33	0.82	0.63	0.35	1.20	0.23
High income	0.32	0.61	0.41	0.15	1.13	0.22
Own-price elasticities						
Tarai						
Low income	-1.03	-0.69	-0.94	-1.12	-1.06	-1.16
High income	-0.95	-0.53	-0.75	-0.87	-1.05	-1.14
Hills						
Low income	-1.08	-1.00	-1.13	-0.91	-1.09	-1.87
High income	-1.01	-0.77	-0.87	-0.61	-1.06	-1.48
Mountains						
Low income	-1.11	-1.12	-1.20	-1.02	-1.11	-1.57
High income	-1.02	-0.94	-0.98	-0.76	-1.08	-1.51

Sources: (i) Thapa and Koirala (1992); (ii) Unpublished results from FCDS model estimations by Thapa and Koirala.

These results show that income elasticities for vegetables, the least expensive source of micronutrients, are positive but inelastic in both low and high income groups in all three locations.

Own-price elasticities for vegetables are negative and slightly lower for low-income groups than for high-income groups in all three ecological belts.

Vegetable Policies

Demand and Supply Projections

Until 1990, only one study on vegetable demand and supply had been undertaken in Nepal; it was limited to the Kathmandu valley. However, a major effort was made recently to project the demand and supply of vegetables and potato for the country to the year 2010. The Master Plan for Horticulture Development was prepared in 1991 by Pacific Management Resources Inc., USA, and the East Consult (P) Ltd, Nepal, for the Government of Nepal and the Asian Development Bank. This study estimated current per capita consumption levels for subsistence and commercial consumers for 28 individual vegetable species. Assumptions were made about changes in consumption patterns associated with a shift toward urban living and cash economy and about population growth. Using these data, production targets were computed and various strategies and programs were identified to achieve the production targets.

Input Subsidy Policy

The government provides price and transportation subsidies on fertilizer with the objective of increasing food production and lowering farmers' costs. However, the inability of the government to allocate sufficient budget for this purpose limits the capacity of the Agricultural Input Corporation to import enough fertilizer to meet farmers' demand. In addition, continuation of the subsidy encourages unauthorized cross-border movement of fertilizer (Wallace 1986; Crown Agents 1991). Although fertilizer prices have tended to be slightly higher in Nepal than in India in recent years, some smuggling still takes place because fertilizer from Nepal (which is all imported) is considered by Indian farmers to be superior to Indian brands. The government has removed price subsidies on phosphate and potassium fertilizer, but urea prices are only 55% of the actual cost. In addition, the government provides a transportation subsidy for remote Hill districts. The continuation of a subsidy on urea is related to the adoption of a similar policy in India. The subsidy makes urea cheaper to all farmers, including vegetable farmers, but for the reason stated above, it adversely affects the supply situation in Nepal. Various studies have shown that the availability of fertilizer is a greater constraint than is price.

Underdeveloped Markets for Inputs

Distribution systems and markets for fertilizers, pesticides, seeds, and other inputs are not well developed in Nepal. In the absence of a good network of dealers and cooperatives, farmers have to travel long distances to purchase these inputs. Moreover, inputs are not available at the right time and in the quantities required. Although some acts have been passed to protect farmers from the sale of low quality inputs, such laws are not strictly enforced. The government should enforce existing acts and regulations (e.g., Seed Act, Pesticides Act) and should enact new laws (e.g., Marketing Act) to protect the interests of farmers. The growth of producers' associations in recent years is expected to exert pressure on the government to play a facilitating role in creating appropriate markets for inputs.

Lack of Credit

Studies show that only 24% of the farm families who take loans obtain them from institutional sources. The rest have to use the non-formal sector (NRB 1980). Among those who borrow from institutional sources, large farmers have better access to such credit than small and marginal farmers. The cumbersome banking procedures also discourage small vegetable growers. Loan approval takes a long time, and collateral is required. This situation requires a simplification of application procedures and a small-farmer orientation of the rural credit supply system.

Poor Irrigation Facilities

The gravity-based irrigation network so far developed in Nepal is primarily to provide supplementary irrigation to rice crops. In most of these systems, the flow of water drops drastically during winter. Farmers have used groundwater schemes, particularly shallow tubewells, for vegetable production in areas of the Tarai. Although the government subsidizes the purchase and installation of tubewells, the operation and maintenance costs of such systems are very high. More importantly, only large farmers have benefited from these systems (World Bank 1989). The Agricultural Development Bank of Nepal and some non-governmental organizations have promoted treadle and rower pumps for the benefit of small and marginal vegetable farmers.

Shortage of Good Quality Seeds

Climatically adapted and disease-free seeds or seedlings are not usually available in Nepal (PACMAR and EC 1991). The annual requirement of vegetable seed is estimated to be more than 500 t (Rekhi et al. 1990), but the current level of quality seed production is estimated to be only about 200 t. The rest of the demand is met through farmer-to-farmer exchange of seeds of unknown quality. Many studies have shown that seed production in Nepal is profitable. However, seed production has been limited due to several constraints, including an unfavorable policy environment. There is a need for comprehensive study of this situation after which action should be initiated to alleviate these constraints.

Support for the Cold Storage Industry

It is reported that Nepali farmers transport their perishable produce (most notably seed potato) across the border for cold storage in India because the charges for storage in Nepal are 2.5–4.5 times higher than in India (Gill and Bajracharya 1994). As a result, Nepali cold stores are underutilized. Poor performance is the result not only of technical factors, such as design and construction defects and the small size of operations, but also of government policies. For example:

- cold stores in Nepal are listed as industries and do not qualify for the special provisions given to agro-based industries, such as tax holidays, low interest rates, and lower electricity tariffs
- electricity charges for cold storage do not take into account off-peak-hour facilities, as spelled out in the government policy
- import duties are charged on refrigeration units required for cold storage and on specialized refrigerated vehicles at rates equivalent to imports for personal use.

Trade Restrictions

BISCONS (1994) reported that unauthorized cross-border trade in vegetables is promoted because of ad hoc valuation by customs offices and advance income tax collection. Although the Municipality Act of 1992 clearly specifies that agricultural produce brought into municipal areas for commercial purposes is to be charged octroi at 1% of the value of the goods, some municipalities are charging different rates. In addition, some municipalities make multiple octroi collections, beyond the provisions of the Act. All of these lead to unnecessary cost and delay. Vegetable exports from Nepal are subjected to ad hoc valuation and exporters face harassment by municipal authorities because such supplies do not possess official valuation papers, unlike supplies coming from India which carry official receipts given by customs offices.

Pesticide Regulations

Studies show that there is indiscriminate and heavy use of broad-spectrum pesticides on vegetable crops in Nepal (Baker and Gyawali 1994). Farmers continue to use dangerous chemicals, such as organochlorines and organophosphates. According to a survey of farmers who had been using pesticides for over five years, more than 60% waited less than two weeks between spraying and harvesting the crop. This has led to increased health hazards, particularly in urban areas. On the production front, regular misuse of broad-spectrum pesticides has resulted in resistance of pests to pesticides, resurgence of pests, and secondary pest outbreaks.

However, the government enacted the Pesticides Act in 1992, and the Act has been promulgated. The Act calls for a Registrar, together with a Pesticide Board, to develop regulations and guidelines for registration of imported chemicals, and licensing of pesticide wholesalers, retailers, and commercial applicators. The government will enforce the law by designating each district's Plant Protection Officer as an inspector. However, not all districts have plant protection officers, and it would be very difficult for these officers to effectively perform their duties as they have other responsibilities. Moreover, the disincentives to break the law are not strong enough to deter offenders. A further complication is that the long and open border with India makes it difficult to effectively enforce the regulations.

Exchange Rate Policy

Nepal has a floating exchange rate with other currencies, but a fixed exchange rate with the Indian currency. Higher inflation and lower growth in factor productivity in Nepal compared to India is making Nepal's exports to India uncompetitive (Sharma 1994). On the other hand, Indian agricultural products, including fresh vegetables, are competing with Nepali produce in Nepali markets. The uncontrolled flow of vegetables from India results in unremunerative farm-gate prices of vegetables in Nepal, particularly during peak production. On the other hand, off-season supplies mostly come from India, and fetch good prices in Nepal.

Inadequate Marketing Support System

Although Nepal has an extension system for the dissemination of new production technology to farmers, post-production aspects, such as post-harvest handling, information on markets, volume of arrivals or prices offered, and development of a support system, etc., are mostly neglected (Pun 1987). As noted above, this has resulted in an inefficient market system, where marketing margins are excessive and losses in the system are enormous. The government should work as a facilitator in creating infrastructure and in providing market information to mitigate these problems.

Research Achievements and Information Gaps

Achievements

Biophysical research in Nepal has emphasized varietal development. Agronomic, soil fertility, and plant protection issues have also been investigated. Improved vegetable varieties were first introduced in Nepal in the early 1950s. With the establishment of the Vegetable Development Division in 1972, technical activities such as collection of indigenous and exotic germplasm, variety testing, and seed production were initiated. Beginning in the 1980s, more serious attention was given to identifying farmers' problems, and using trials and experiments in an attempt to solve them. These included yield performance trials and agronomic, fertilizer, and plant protection experiments for important summer and winter vegetables.

By 1988 the research system had recommended 47 varieties of 30 different vegetables for different ecological regions (NARC 1989). Several recommendations, such as the optimum date for sowing and planting, the optimum age of seedlings, correct spacing, etc., have been developed and passed to farmers. Some work has also been done toward the identification and recommendation of herbicides.

Inorganic fertilizers for vegetables have been tested for different ecological regions, on the basis of which appropriate dosages have been recommended for individual crops. Similarly, several chemicals have been identified for the control of vegetable insects and diseases.

The socioeconomic research into vegetables was mainly financed by donor agencies and implemented by various national and international consultants. These projects have led to the preparation of a number of seminar papers and technical reports, mainly on vegetable seeds, post-harvest technology, and marketing. The major breakthrough in vegetable research in recent years has been the completion of the Master Plan for Horticulture Development, which delineates strategies to achieve targets. A brief review of some important areas of agricultural economics research on which some noteworthy work has been done in Nepal is presented below.

Under a USAID-sponsored project, 'Marketing research for hill cash crops in Nepal', implemented by No-Frills Consultants and Agricultural Marketing Improvement Strategies, analytical and detailed studies of the economics of vegetable seed production in different production environments were undertaken. These studies covered radish, onion, broad leaf mustard, and pole bean seed production in the mid Hills, carrot seed production in the high Hills, and tomato seed production in the Tarai. An FAO-supported project, 'Fresh vegetable and vegetable seed production', implemented since 1981 in collaboration with the Vegetable Development Division, DoAD, sponsored surveys of the cost of vegetable seed production and vegetable seed marketing. These surveys covered a number of vegetables from all the three physiographic regions. Several studies have been completed which provide valuable information on post-harvest issues, such as physical losses among different methods of transportation, constraints in post-harvest technology, suitability of alternative methods of packaging, and transportation methods (Werner and Subedi 1991, 1992; Shrestha and Werner 1992). Some of these studies have actually led to the introduction of improved methods of packaging and transportation. In addition, this project organized several workshops on vegetable seeds.

Several studies have been done to determine marketing costs and margins of vegetables, including tomato, potato, cauliflower, cabbage, eggplant, and onion (Satyal 1979; Munankami 1985; APROSC 1989; Bhattarai 1992). Most of these studies have computed costs and margins for vegetables transported from the Tarai to Kathmandu valley markets. They provide useful information about the efficiency of marketing, and the shares of various actors in marketing channels.

In recent years, studies have documented the indigenous practices of vegetable farmers in the Kathmandu valley (Pandey et al. 1990; Pandey 1993) and in the western Hills (Budhathoki et al. 1993). A unique method of potato cultivation in the high Hills of Nepal was the subject of another study (Dhakal 1993).

Information Gaps

Research on vegetables in general, and agricultural economics research in particular, has not received due attention. This situation is the result of the public sector's overwhelming emphasis on selected food-grain crops for research and development efforts. Rice, maize, and wheat have received a disproportionately large share of government resources, whereas other subsectors of agriculture, such as horticulture and livestock, have suffered (Table 22).

Table 22. Public sector research expenditure by commodity group, 1980–81 and 1988–89

Commodity group	Percentage of research budget	
	1980/81 (actual)	1988/89 (allocated)
Field crops	42	43
Fisheries	8	22
Horticultural crops	22	17
Livestock	28	18

Source: Thapa (1994).

As can be seen from the economics of vegetable production section, economic studies on vegetables have been carried out so far by different agencies and programs on an ad hoc basis without any continuity. More importantly, most of these are based on primary data collected in connection with program or project activities. Very few researchers have conducted studies based on secondary or time-series data, primarily because of the inaccessibility and unreliability of such data. Some examples of the government's neglect of the vegetable subsector are as follows:

(a) The Agricultural Statistics Division of the Ministry of Agriculture does not collect area, production and yield data on vegetable crops. The collection of such data is limited to major food-grain crops, cash crops, potato, livestock and livestock products, and fisheries. The exclusion of horticultural crops is basically due to lack of financial and human resources. The Vegetable Development Division (VDD) of DoAD is the only source of vegetable-related data. However, many researchers question the reliability of data reported by VDD because they are not based on any scientific data collection procedures. The area, production and yield data are based on progress reports of annual targets of VDD for various districts. Thus, VDD data are heavily influenced by the annual targets.

(b) The Economic Analysis Division (EAD), DoAD, publishes annual data on costs of production for several food and cash crops. These data are a good source of information on input and output quantities, costs and returns. However, EAD does not collect similar information for vegetable crops (except in 1991–92 when EAD conducted a separate study on the economics of fruit and vegetable crops).

(c) Farm management surveys conducted by the Ministry of Agriculture (MOA) present detailed economic analyses for food-grain crops, potato, cash crops, and livestock, but not for vegetable crops.

(d) The Socio-economic Research and Extension Division (SERED) and the Farming Systems Research and Development Division (FSRDD) in the Nepal Agricultural Research Center (NARC) also focused their research on food-grain crops, with some study of the livestock subsector. These divisions did not include the horticulture subsector in their research program.

Future Research Priorities

Biophysical Research

Several studies have identified important biophysical research priorities for Nepal (Rekhi et al. 1990; Shah 1990). Some of these priorities are:

- Breeding of varieties suitable for the different farming systems in Nepal
- Improvement of traditional vegetables so far neglected by the national and international research systems
- Development of appropriate post-harvest and processing technologies
- Production of high-quality seeds both for domestic and export markets
- Collection, conservation, and utilization of local genetic resources
- Development of varieties suitable for off-season vegetable production
- Development of crop production technologies with emphasis on the time and method of planting, plant production, weed control, fertilizer management, and pest control
- Varietal purification and maintenance.

Socioeconomic Research

The following are the priority areas for socioeconomic research on vegetables in Nepal:

Data Collection

Data on area, production, and yield of individual vegetable species is crucial in order to do analyses for many policy issues. Such analyses assist in the planning of vegetable improvement programs or in identifying areas for intervention. Aggregate data obscure the differential potential of individual vegetable species and are not useful for realistic planning and evaluation work. Regional data on individual vegetables can also help to identify suitable areas for different vegetables. Therefore, it is strongly recommended to start collecting individual vegetable data by district.

Rigorous Analysis of Farm-level Profitability

As cost and return data have the potential to serve many planning and research needs, e.g., generating technical coefficients and determining farm-level profitability, there is a need to collect these data from representative production environments for major vegetables on a regular basis. Careful analysis of costs of production and returns from vegetable crops vis-a-vis other competing crops is essential to establish farm-level profitability under varying production environments. Such analyses should be done for individual crops as well as for different cropping patterns. Analyses done so far have been inadequate in terms of rigor (e.g., no analysis is available on the labor use pattern), crop coverage, regional representation, regularity, etc.

Analysis of Economic Constraints

An in-depth study of economic constraints affecting vegetable production is urgently needed. Given the importance of vegetables and vegetable seed production in raising income levels and employment opportunities, particularly in the Hills, it is essential to undertake a study to identify economic constraints faced by this subsector.

Comparative Advantage of Nepali Produce

In most urban centers of Nepal, Indian vegetables are competing with domestically produced vegetables. While an overvalued exchange rate (vis-a-vis the Indian rupee) is an important reason for this situation, there are other possible factors, such as higher productivity in India, economies of scale enjoyed by Indian farmers, and a more advanced transportation network in India. There is a need for an in-depth study to identify factors responsible for this situation.

Constraints in Vegetable Marketing

As commercial vegetable production expands, farmers start facing marketing related problems. Although in recent years the government in Nepal has taken steps to liberalize the economy, many inconsistencies remain in marketing-related policies and legislation and their implementation on the ground. It is necessary to identify these constraints so that measures can be taken to overcome them.

Constraints in Cold Storage Industry

Although there are 10 cold stores presently operating in Nepal, farmers in the Tarai store their potato seed in Indian cold stores. The difference in storage charges outweighs the transportation and other transaction costs. The Nepali cold storage industry suffers from a number of problems, such as high electricity charges, irregularity in electricity supply, lack of economies of scale, and design defects. There is a need to conduct a study to analyze these issues and to collect information from across the border to be able to compare relative costs and returns.

Policy Issues

Very few studies have attempted to analyze the actual or potential impact of government policies and regulations on vegetable production, trade, and consumption. The government policies that can have such an impact include policies on fertilizer price, transportation subsidies, subsidies on irrigation, subsidies on vegetable seeds, etc. Government regulations, such as advance income tax on vegetable imports, pesticide regulations, etc., can also affect the vegetable subsector. Therefore, studies should be carried out to understand such policy issues.

Summary and Conclusions

Nepal's diverse topographic features and climatic conditions permit successful production of about 250 vegetables, of which about 50 are common. Vegetables are grown almost everywhere, but the more concentrated areas are located along the major highways and in the vicinity of urban centers.

Vegetable area grew by 2.95% per annum between 1974 and 1995. The increase in vegetable yield (2.91%) was equally impressive. As a result of area and yield increases, total vegetable production in Nepal increased by 5.86% annually in the period. The high rate of increase in vegetable production and more imports resulted in an increase in per capita annual availability, from 48 kg in 1984 to 60 kg by 1995.

Available reports show that vegetable consumption was the highest in the urban Hills and lowest in the Mountains. The consumption of vegetables in the Hills was significantly higher in urban areas than in rural areas. Such a difference, however, was not observed in the Tarai between urban and rural areas.

The consumption of vegetables and potato increased with income. The consumption levels of highest income deciles tended to be about two times the levels of the lowest decile. The income elasticities for vegetables were positive but inelastic in both low and high income groups.

Total imports of vegetables far exceeded total exports between 1982 and 1990, in terms of both quantity and value. Nepal's vegetable exports and imports are mainly limited to India. The main vegetables imported are potato, onion, garlic, and tomato. The trade in potato constituted more than half of the total trade value.

Vegetable marketing studies show that the retailer's share of the consumer's rupee is higher than the wholesaler's. This might be due to the high physical losses at the retail level and because of high local transport costs borne by the retailers. Packaging, transportation, handling, and management costs did not differ much by crop and were in the neighborhood of 12 to 14% of total marketing costs.

Various production and marketing related constraints have adversely affected the production of vegetables in Nepal. Major production constraints include shortage of good quality seed, poor irrigation facilities, and shortage of production inputs, such as chemical fertilizers. Underdeveloped markets for inputs, inadequate market information and support systems, and lack of cold storage and other physical facilities are some of the important marketing related problems. Indiscriminate and inappropriate use of pesticides and other chemicals pose major health hazards to urban consumers as the well as to farmers.

Other policy issues that affect vegetable production and marketing include an overvalued currency, the inability of the government to withdraw subsidies or to sufficiently allocate budget for fertilizer subsidization, lack of legal provisions for efficient input and output marketing (e.g., Marketing Act, Nursery Act), and prevalence of trade restrictions, such as octroi charges, ad hoc valuation by customs officials, and advance income tax collection at customs check points.

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PAKISTAN

Muhammad G. Chaudhry and Bashir Ahmad

Introduction

Pakistan is the western-most country of South Asian. With a population of 128 million in 1996 and a total area of 796.1 thousand km^2, population density exceeds 160 people/km^2. During 1970-93, the population doubled from an annual growth rate of more than 3%. Data for 1996 indicate per capita cultivable land availability of about 0.17 ha, and per capita income of about US$495. Agriculture's share in gross domestic product (GDP) decreased from 36% in 1971 to 26% in 1988, and then stayed at that level thereafter. In 1993, 47.5% of the labor force was engaged in farming, down from 58% in 1976. About 70% of the population resides in rural areas (Government of Pakistan 1995). The country is divided into four provinces (Punjab, Sind, Northwest Frontier Province (NWFP), and Baluchistan), and 82 administrative units called districts (Fig. 1).

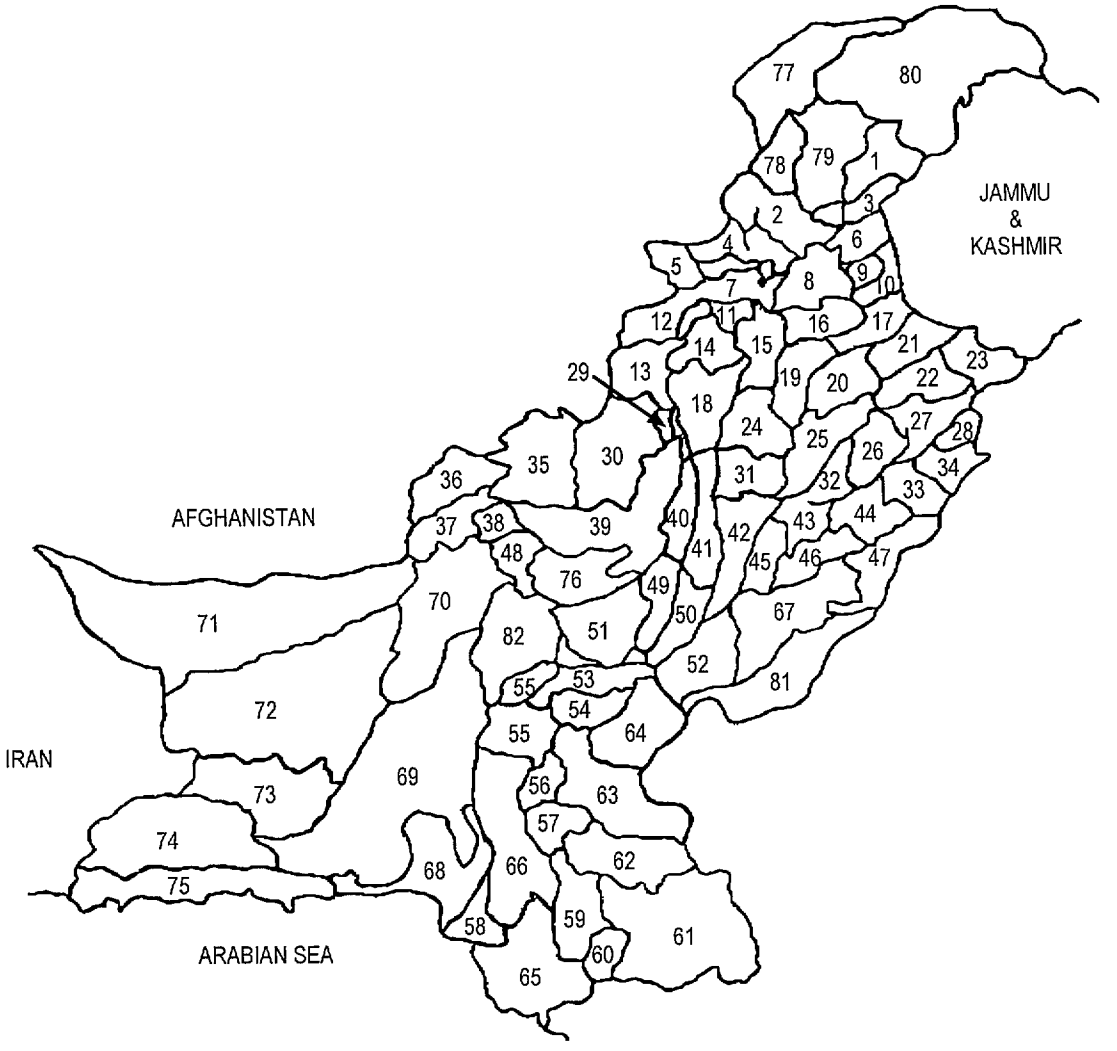
Major crops grown in Pakistan include wheat, cotton, rice, sugarcane, fodder, maize, tobacco, vegetables, and annual fruit. The area under vegetable cultivation during 1994, excluding potato and sweet potato but including onion, garlic, and chili, was 0.381 million ha (about 1.67% of the total cropped area), producing about 4.06 million t of vegetables. The production value of all vegetables is about PKR 22 billion or 21% of the value of all cereal production. In contrast to the modest yields of 2-3 t for most field crops, average vegetable yields are in the neighborhood of 10 t/ha. Per capita availability of vegetables at the farm gate, after excluding exports and potato, is about 89 g/day, less than half the recommended daily vegetable consumption.

In 1991, average per capita food consumption was about 1 kg/day, of which cereals constituted 42%, non-cereal plant food 9%, fruits and vegetables 32%, and livestock products 17% (Government of Pakistan 1993b). Wheat is the staple food, accounting for more than one-third of total consumption.

General Information

Topography

Major coastal areas of the south lie at sea level. Elevations begin to rise gradually through the major plains of the Indus Valley and then meet steeply rising mountains in the north and north-west. The Indus Valley plains contain the country's most fertile land, and most crop production is concentrated there.



BALUCHISTAN
30. ZOHB
35 QILA SAIFULLAH
36. PISHIN
37. QUETTA
38 ZIARAT
39. LORALAI
48. SIBI
51. DERA BUGTI
68. LASBELA
69. KHUZDAR
70 KALAT
71. CHAGI
72. KHARAN
73. PANJGUR
74. TURBAT
75. GWADAR
76 KOHLU
82 KACHHI

NWFP
1 KOHISTAN
2 MOHMAND
3. MANSEHRA
4. KHYBER
5. KURRAM
6. ABBOTT-ABAD
7. KOHAT
11. KARK
12. N. WAZIRISTAN
13 S. WAZIRISTAN
14. BANNU
18. D.I. KHAN
29. FR. DI. KHAN
77. CHITRAL
78. DIR
79 SWAT
80. GIL GIT AGENCY

PUNJAB
8. ATTOCK
9. ISLAM-ABAD
10. R. PINDI
15. MIAN WALI
16. CHAKWAL
17. JEHLUM
19. KHUSHAB
20. SARGODHA
21. GUJRAT
22. GUJRANWALA
23. SIALKOT
24. BHAKAR
25. JHANG
26. FAISALABAD
27. SHEIKHUPURA
28. LAHORE
31. LAYYAH
32. T.T. SINGH
33. OKARA
34. KASUR
40. DE-EX D.G. KHAN
41. D.G. KHAN
42. MUZAFFARGARH
43. KHANEWAL
44. SAHIWAL
45. MULTAN
46. VEHARI
47. B. NAGAR
49. DE-EX RAJAN PUR
50. RAJAN PUR
52. RAHIMYAR KHAN
67. BAHAWALPUR
81. CHOLISTAN

SIND
53. JACCOBABAD
54. SHIKARPUR
55. LARKANA
56. N. FEROZE
57. NAWAB SHAH
58. KARACHI
59. HYDERABAD
60. BADIN
61. THARPARKAR
62. SANGHAR
63. KHAIRPUR
64. SUKKUR
65. THATTA
66. DADU

Fig. 1. District-level map of Pakistan.

Climatic Factors and Vegetable Cultivation

Much of Pakistan is classified as arid to semi-arid with a tropical or subtropical climate. Pakistan experiences four somewhat distinct seasons: winter (December-February), spring (March-April), summer (May-September), and autumn (October-November). During the spring and autumn seasons, daily temperatures do not exceed 10-25°C, while winters are even colder, and temperatures fall to single digit figures with occasional frost. Summers are considerably warmer with day temperatures between 40 and 50°C. In the mountainous areas, subzero temperatures are common during the winter, while summer temperatures are mild, hardly exceeding 25°C. The coastal areas are characterized by a lack of extreme temperature variation. On the basis of climatic conditions, soil types, and physiography, Pakistan can be divided into 10 distinct agroecological zones (PARC 1980).

Pakistan receives virtually year-round supplies of irrigation water from the snow-covered mountain ranges of the north, which permit vegetable and other crop cultivation throughout much of the country. Diversity of climate in the country also ensures vegetable availability throughout the year.

Table 1 shows cultivation times of different vegetables along with their major cultivation areas. Most vegetables are usually grown either in autumn or spring to avoid winter and summer extremes. Deviations occur due to the varied and milder climates of various regions. For example, most summer vegetables can be grown successfully throughout the year in the coastal areas. Likewise, many winter vegetables are suitable for cultivation in the mountain valleys of Baluchistan and the northern areas of Pakistan during the summer. The milder weather of the autumn and spring seasons in the plains is suitable for two potato crops a year from the same land; a third crop can be grown during the summer in the mountain valleys. With this wide range of ecoregional environments, it should be possible to smooth out seasonality in vegetable supplies.

Table 1. Sowing and harvesting time, major cultivating districts, and varieties

Vegetable	Sowing time	Harvesting time	Major cultivating districts	Varieties
Cabbage (0.6)	Year-round	Year round	Not available	Chamcha, Chanun, Snow Drift
Carrot (1.9)	Sept.-Feb.	Nov.-April	Sheikhupura (22.9), Hyderabad (6.6), Lahore (6.7)	Not available
Cauliflower (2.0)	Sept.-Feb.	October-April	Sheikhupura (9.2), Faisalabad (6.7), Bhawalnagar (5.8), Gujranwala (5.0)	Not available
Chili (10.8)	Feb.-March	June-November	Mirpurkhas (55.0), Hyderabad (8.2), Sanghar (6.9), Badin (6.5)	Not available

Contd. Table 1.

Vegetable	Sowing time	Harvesting time	Major cultivating districts	Varieties
Cucurbits[1] (4.6)	Feb., Aug.	April-May, Sept.-Oct.	Not available	Faisalabad-2 long Gourd, Sialkot Round Tinda, Desi-Sialkoti-Cucumber, Marketer-Cucumber
Eggplant (1.6)	March, Aug.	June-Dec.	All over the country	Not available
Garlic (1.8)	Sept.-Oct.	March-April	Sakkar (9.4), Shikarpur (7.8), Nowshera (7.6)	GS1, Pink Garlic
Lady's finger (2.7)	Feb.-March	June-July	Hyderabad (8.4),	T-13, Uosa Green R.Y. Khan (4.7)
Melons (10.0)	Feb.-March	April-May	Not available	Not available
Onion (16.1)	Jan., April	April-July	Hyderabad (13.9), Mirpurkhas (9.0), Swat (5.7), Sanghar (4.9)	Desi Red
Pea (0.8)	Sept.-Oct.	Dec.-April	Not available	H-57, Matore, FC- 3954 Green Feast, UAR-15, Climax P-18
Potato (18.1)	Sept., Feb., May	Dec.-Jan., April-Aug.	Okara (14.6), Sahiwal (12.0), Sialkot (9.5), Kasur (9.5)	Wilja, Patrones Diamant, Ajax, Multa, Spunta, Fb13-9469, Desiree, Cardinal, Ultimus
Radish (1.8)	Year round	Year round	Sheikhupura (8.2), T.T. Singh (5.5), Sahiwal (6.5)	Desi, Shaowmai, Minno, Shmora
Spinach (1.4)	Year round	Year round	Not available	Desi, Cundyari, Kasuri
Tomato (5.5)	Dec.-Jan.	April-June	Swat (11.4), Karachi (6.0), SW agency (5.5), Sheikhupura (5.3)	T-10, Money-maker Roma, Red Top, Marglobe
Turmeric (3.1)	June-July	Nov.-Dec.	Kasur (52.8), Bannu (34.1)	Not available
Total (100) vegetables	-	-	All over the country, especially around cities. Sheikhupura (6.1), Faisalabad (4.3), Gujranwala (3.5), R.Y. Khan (3.4), Bahawalpur (3.0), Hyderabad (3.2), Pishin (2.5), D.I. Khan (4.0), Swat (2.0).	

Source: For sowing and harvesting time, Samad (1993) and Government of Pakistan (n.d); proportion of total vegetable area in major cultivating districts is estimated from unpublished agricultural data, Economic Wing, Ministry of Food, Agriculture, and Livestock, Islamabad, for the 12-month period 1993-94.

[1] The cucurbit family includes different gourd types, pumpkin, and cucumber.

Note: The figures in parenthesis indicate the percentage share of a vegetable in total area.

Major Production Pockets

Vegetable production in Pakistan is well diversified in terms of the range of vegetable species grown. More than 36 species are grown and consumed as summer or winter vegetables. The major vegetable species grown are potatoes, onions, chili, melon, tomato, and cucurbit (Table 1). Most vegetable area is concentrated in specialized districts in the peri-urban areas of big urban centers like Lahore, Karachi, and Peshawar. For example, production of potato is specialized in Okara, Sahiwal, Sialkot, and Kasur around Lahore. Table 1 also shows the varieties of major vegetables grown.

Regional Cropping Patterns

Depending on the major crops grown, cropping patterns vary from region to region. The following discussion is largely based on PARC (1989).

Irrigated Plains of Sindh and Southern Punjab

Wheat, vegetables, pulses, and fodder, such as berseem (*Trifolium alexandrinum*), compete with potatoes in the winter (*rabi*). Year-round crops such as sugarcane and bananas also compete. Rice, cotton, and chili are grown as summer (*kharif*) crops.

Irrigated Plains of Central Punjab

During winter, wheat is the dominant crop. Central Punjab has a mixed cropping pattern involving rice and sugarcane. In the north of central Punjab, rice is the dominant crop during kharif. Potato farmers tend to specialize. These farmers grow the crop at least once a year.

Irrigated Plains of NWFP and Northern Punjab

Potatoes and sugarcane are intercropped in the spring, with potatoes on the ridges and sugarcane in the furrows. Since sugarcane grows slowly during the first few months after planting, there is little competition between the two crops. Wheat is the main winter crop, competing with both spring and autumn potato, as do rape and berseem. Winter vegetables compete with potato, particularly autumn cauliflower and winter sugar beet in Mardan. Tobacco grown in the summer competes with potatoes.

Irrigated Lower Valleys of NWFP (900-1500 m)

Radish, turnips, or coriander are grown in July and August between the two potato crops. This is the only area in Pakistan where potatoes are known to be cultivated at this high altitude, enabling both crops to be harvested at periods of high seasonal prices. Vegetables and wheat are rotated with potato on the same land after every second or third year.

Rain-fed High Valleys and Hillsides (1750-2600 m)

Cropping patterns in this area are as follows:

> Upper Swat: Potato 50-95% of the area, maize 0-50%, vegetables (particularly turnips) 0-5%. The area under turnips is increasing fast.

Kaghan Valley: Above 2300 m, potato 95-100%, maize 0-5%. Below 2300 m, maize percentage increases until potatoes disappear below 1900 m.

Dir Kohistan: Thal and above, potatoes 20-30%, maize 75-80%. Between Kalkot and Thal, almost the entire area is under maize, with very few potato fields.

Valleys of Baluchistan (1600-2300 m)

The main competitors to potato include tomatoes, onions, and coriander. Coriander is nearly always intercropped with onion. Potato is sometimes followed by turnip to allow two summer potato crops, though cropping in the summer is not very common. Wheat, or sometimes barley, is grown in the winter. The cropping system can also include one or two years of fallow.

Irrigated High Valleys of Northern Areas and Chitral (2250-3000 m)

The major crops include wheat, barley, maize, broad beans (*Viciafaba*), and fodder crops, such as alfalfa and clover. Fruit trees are particularly important; trees are also grown for timber and fodder. Vegetables cultivation is widespread, but vegetables occupy a small percentage of the cropped area (except in villages specialized for seed potato). Potato is the most important vegetable.

Social Taboos Related to Vegetables

Production and consumption of vegetables can be constrained by social taboos. For example, most wealthy farmers with large holdings consider it unprestigious to specialize in vegetables, and instead cultivate less labor-intensive crops. Among small cultivators, vegetables are a specialty of hard-working Arain families, while most Jats are hesitant to grow vegetables for social reasons. Arains are called an onion-eating caste, but they resent the label. On the demand side, vegetables are avoided during illness and pregnancy, since milk and meat preparations are considered more energetic and more easily digestible than vegetables. Such taboos have weakened considerably in recent years due to the commercialization of agriculture. One can now reasonably assume that production and consumption of vegetables are mainly functions of economic factors rather than social taboos.

Trend Analysis

Production

The trends in area, production, and yield of individual and total vegetables are reported in Table 2. Total vegetable production increased quadratically (both the quadratic and linear terms were positive and significant), mainly because of a strong increase in area (4% per annum), while the overall trend in yield is stagnant, as the yield trend has a negative linear but small positive quadratic term. Only tomato, cauliflower, melon, coriander, and other vegetables experienced positive linear yield increases over the period, while onion yield increased quadratically.

Table 2. Trends in total and individual vegetable area, production, and yield, 1970-93

Vegetable	Trend equations of					
	Production		Area		Yield	
	t	t^2	t	t^2	t	t^2
Cauliflower	0.049	0.003	-	0.001	0.020	-
Chili	0.112	-0.004	0.109	-0.004	-	-
Coriander	0.089	-	0.077	-	0.013	-
Eggplant	0.032	-	0.037	-	-0.004	-
Garlic	0.093	-0.002	0.151	-0.004	-0.057	0.002
Lady's finger	0.138	-0.005	0.106	-0.003	0.031	-0.002
Melon	0.048	-	0.044	-	0.022	-
Onion	0.062	-	0.082	-0.001	-	0.0004
Potato	0.064	-	0.064	-	-	-
Pumpkin	0.358	-0.016	0.291	-0.014	0.067	-0.003
Tomato	0.128	-0.001	0.099	-0.001	0.023	-
Turmeric	0.153	-0.004	0.191	-0.006	-	-
Other vegetables	-0.025	0.003	-0.024	0.002	0.0002	-
All vegetables	0.015	0.001	0.040	-	-0.025	0.001

Source: Estimates based on data reported in Government of Pakistan (1993a, 1994a, and unpublished data from Ministry of Food, Agriculture and Livestock).

Prices

Trends in real price indices (nominal price index divided by consumer price index) of potato, onion, tomato, chili, garlic, and overall vegetables are reported in Table 3. There exist wide annual fluctuations in prices of individual and total vegetables, indicating uncertain vegetable supplies. These fluctuations obscure any systematic trend in price indices for most individual vegetable species. However, a significant (at the 10% level) negative trend is observed in potato prices, while prices of total vegetables show a significant positive trend (the total vegetable prices did not include onion, garlic, turmeric, and potato). This indicates that increases in prices of vegetables exceeded those of other consumer goods and suggests a demand pressure on vegetables and an increasing gap between vegetable demand and supply.

Table 3. Deflated retail price index (1969=100) for selected vegetables, 1969-90

Year	Potato	Onion	Tomato	Chili	Garlic	Vegetables[1]
1969	100	100	100	100	-	100
1974	137	136	88	190	-	114
1975	108	163	95	133	-	115
1976	113	128	111	166	-	149
1977	99	115	114	136	-	135

Contd. Table 3.

Year	Potato	Onion	Tomato	Chili	Garlic	Vegetables[1]
1978	100	156	123	117	-	132
1979	73	103	109	94	-	119
1980	103	147	104	88	100	126
1981	110	89	106	131	151	148
1982	67	156	97	149	91	97
1983	89	115	126	112	79	156
1984	100	75	97	93	79	134
1985	78	124	84	85	116	114
1986	82	141	104	107	117	105
1987	116	145	100	120	119	156
1988	115	81	106	198	62	157
1989	69	82	77	171	80	153
1990	98	175	128	112	186	177
Growth rate (%)	-1.21	0.14	0.30	0.46	0.58	1.25
	(1.82)	(0.14)	(0.68)	(0.55)	(0.18)	(1.79)

[1]Based on nominal retail price indices divided by the food and beverage price index.
Figures in parentheses are the t-values.
Note: To save some space, figures for 1970-73 are skipped.

Risk in Production

Table 4 reports the detrended coefficients of variation (cv) in area, production, and yield of total and individual vegetables. The deviation of yearly production of vegetables from their trend values is high and exceeds considerably that of cereals. Except in onion and lady's finger, the major share of the variation in production comes from area fluctuation, suggesting a large year-to-year variation in the prices of vegetables at the time of sowing and information sharing among farmers. Fluctuations in vegetable production were most pronounced in the case of turmeric, cabbage, chili, and pumpkin. Tomato is the only crop with a lower yield variation than cereals. The relatively low variation in the yield of tomato, eggplant, melons, and cauliflower might be due to the advanced and stable technology used in the cultivation of these crops, or the favorable environments in which these crops are cultivated.

Table 4. Detrended coefficients of variation (%) in area, production, and yield of selected vegetables, 1970-93

Vegetable	Area	Yield	Production
Cabbage	19.3	3.7	21.6
Cauliflower	6.6	2.4	6.2
Chili	17.5	8.1	20.9
Eggplant	7.5	2.3	9.3
Garlic	16.8	13.6	14.0
Lady's finger	3.5	5.3	7.4
Melons	8.0	2.2	7.7
Onion	5.6	10.9	12.9
Potato	8.7	6.8	11.4
Pumpkin	17.2	6.1	18.6
Tomato	4.1	1.9	6.9
Turmeric	25.1	15.7	22.9
All vegetables	9.3	6.1	9.3

Seasonality in Prices

Table 5 reports 10-year monthly average wholesale prices of selected vegetables. The main conclusions that can be drawn from the table are the following: 1) monthly vegetable prices tend to rise gradually in the post-harvest months and reach their highest levels in the pre-harvest period; and 2) the magnitude of price seasonality depends upon perishability, length of harvest period, and storability. For example, relatively stable prices in the case of turmeric and chili follow from their nonperishable nature relative to other vegetables. Tomatoes, being nonstorable and highly perishable, show the highest price variability. Finally, monthly prices remain considerably below the annual price for nearly six months because of overlapping harvests in Sindh and Punjab in the case of garlic and onion, and because of autumn and spring crops in Punjab in the case of potatoes.

Farm Management Practices

The Agricultural Development Bank of Pakistan (1986) provides information on technical and agronomic aspects of both winter and summer vegetables, including planting season and method, varieties, nursery culture, seed rate, land preparation, transplanting, crop culture, harvesting, yield, pests, diseases, income, cost, and net return/gross margin. As well, the Department of Agriculture (DA), Government of Punjab, periodically publishes bulletins in Urdu on most vegetables. The Pakistan Agricultural Research Council (PARC) has published material in both English and Urdu on some of the important vegetables grown in various parts of the country. However, all of these publications provide information on the recommended practices, rather than what actually happens in farmers' fields.

Table 5. Wholesale monthly prices (PKR/40 kg) of vegetables (average for 1983-92)

Months	Dry chili	Turmeric	Onion	Garlic	Potato	Tomato
July	633.5	728.6	76.0	343.2	126.4	240.3
August	594.0	734.0	119.6	470.0	133.1	244.9
September	569.2	779.9	132.5	443.0	123.6	187.4
October	552.2	789.9	137.8	477.0	125.4	282.8
November	568.2	767.9	150.5	532.8	122.4	316.5
December	639.4	781.5	139.0	516.5	76.3	235.6
January	653.3	732.9	111.5	558.0	57.4	175.0
February	674.1	683.8	89.1	595.5	59.8	215.2
March	651.3	676.4	76.9	321.0	62.8	261.4
April	690.7	684.9	79.8	257.8	78.9	247.4
May	740.0	725.5	89.2	292.0	95.7	105.9
June	692.6	768.8	87.7	362.5	107.3	102.0
Annual average	638.2	737.8	105.1	442.3	97.4	217.8
Seasonality (%)	34.0	16.8	98.0	131.0	131.9	210.3

Source: Averages based on data for 1983 to 1992 in Government of Pakistan (1993a).

The University of Agriculture, Faisalabad, has done extensive research on various aspects of vegetable production. However, the entire work is of an experimental nature with emphasis on the effect of a particular input or practice on yield, resistance against pests or diseases, etc. It may, therefore, be concluded that little research has been undertaken to understand farm-level practices, input-output relationships, marketing efficiency, gross and net incomes, etc.

Vegetable Production Systems

Peri-urban Production Systems

Peri-urban vegetable farms are characterized by year-round vegetable cultivation where summer and winter vegetables are rotated in the cropping pattern. In some cases, however, winter vegetables are followed by a summer crop of fodder, maize, sorghum, or millet. Mixed cropping and inter-cropping (e.g., onion with chili, potato with arum or cauliflower, onion with eggplant or chili, sugarcane with onion or chili) are among the popular cropping patterns of peri-urban production systems (Khan, D.A. 1993). Under these systems, vegetable production is concentrated near the consumption centers, i.e., around urban conglomerations. While most production is to supply the closest city, in some cases, surpluses from one peri-urban area are transported to other urban sites. For example, the entire Islamabad-Rawalpindi vegetable market is served by peri-urban production systems in the vicinity of Lahore and Peshawar, and a major proportion of supplies to the Karachi market is shipped from Hyderabad. These systems specialize in the production of all kinds of vegetables, depending on their demand, with emphasis on perishable species, such as cauliflower, spinach, tomatoes, radish, and cucumber. Concentration of these vegetables around cities is a function of proximity and the difficulty of transporting perishable vegetables, and the availability of sewage water and other water for irrigation.

Peri-urban vegetable farming is mainly done on holdings of less than 5 ha. Planting is mostly done by hand, mainly due to the availability of cheap labor, lack of funds for making use of machinery, and the small areas involved. Vegetables, such as eggplant and cauliflower are first sown into nursery beds then transplanted. Others, such as peas, okra, cucurbits, carrots, radish, and spinach, are direct seeded. Most vegetables are planted on ridges containing a single row. Up to now, there is no commercial nursery producing containerized seedlings. Frequent (weekly) irrigation is common in peri-urban systems. Most vegetable growers rely heavily on farmyard manure supplemented by heavy doses of chemical fertilizers, often in the ratio 150:150:75 kg NPK/ha. (National Engineering Services Pakistan (Pvt) Limited and Overseas Project Corporation of Victoria, Limited 1993).

Vegetables in Cropping Systems

Vegetables are also grown in cropping systems dominated by crops such as wheat, cotton, rice, sugarcane, or maize. Vegetables are either intercropped with the main crop or are part of a cropping sequence. Most vegetables grown in such systems are relatively less perishable and can be more easily transported over long distances. Often, the systems are relatively far away from the consumption centers. Vegetables grown in such systems include watermelon, muskmelon, peas, potatoes, wax gourd, chili, garlic, and onions.

Information on farm management practices followed in the above systems, with the exception of potato, is very scanty. Practices followed in potato cultivation are summarized in Table 6.

Kitchen Gardens

Homestead or kitchen gardens are grown all over the country, but more are found in the northern areas. The management practices for various vegetables grown in kitchen gardens in the northern areas of Pakistan are elaborated in Pokhrel (1992).

Economics of Vegetable Production

The history of estimating the economics of production for various crops starts with a field survey carried out by the Ministry of Food and Agriculture in 1977 on the cost of production of major vegetables in the selected districts of Pakistan. On the basis of this exercise, the Ministry published a state of the art report in 1978 and subsequently in 1979 (Government of Pakistan 1978, 1979). After the publication of the Ministry's reports, studies on the economics of vegetable production were undertaken by individual researchers, provincial organizations, commissions, and universities. Based on a small sample of 150 farmers, Ashraf (1989) reported data on total costs per acre of various vegetables without much detail on individual cost items. In 1993-94, Ayub Agricultural Research Institute undertook a cost-of-production study on potato on the basis of a small sample of farms in two Punjab villages.

The Agricultural Prices Commission of Pakistan has also studied the cost of production of potato and onions (Government of Pakistan 1994b,c). Similarly, Ahmad et al. (1993) estimated cost of production and profitability of major crops, including important vegetables. Estimates for major crops were based on various farm-level studies, whereas vegetable estimates were derived from consultation with experts.

Table 6. Farm management practices (per ha) for potato cultivation in Punjab, 1993

Operation/Input	Unit	Farm size	
		Small farms (n=12) (less than 10 ha)	Large farms (n=17) (more than 10 ha)
Land preparation			
Mechanical operation	Hours	30	39.5
Labor	Labor (days)	2.5	-
Seed rate	Bag	30	32
Planting			
Ridge operation	No.	1	1
Labor use with ridger	Labor (days)	2.5	2.5
Fertilizer application			
Farmyard manure (quantity)	Trolley	3.7	2.5
Farmyard manure application	Labor (days)	3.7	2.5
Urea	Bag	7.4	8.6
DAP	Bag	7.4	7.4
Potash	Bag	-	2.5
Super Phosphate	Bag	-	6.2
Transport	PKR	74	124
Fertilizer application	Labor (days)	5	7.4
Plant protection			
Chemical sprays	No.	4	6
Application	Labor (days)	10	6
Irrigation			
Water	Number of irrigations	14	14
Labor	Labor (hours)	35	35
Hoeing and earthing up	Labor (days)	0	0
Weeding (manual)	Labor (days)	0	0

Source: Ayub Agricultural Research Institute (1993a, 1993b, and 1993c) (average of the three sources).

Vegetable cultivation is relatively intensive (Table 7) and more profitable (Table 8) compared to other major arable crops, such as cotton, wheat, rice, and sugarcane.

Table 7. Level of input use per hectare for major vegetables, 1993

Vegetable studied	Regions	Fertilizer (kg) N	P	K	Pesticide (PKR)	Labor (days)	Reference
Chili	Punjab	79.1	56.8	74.1	160	157.7	Ahmad et al. (1993)
Muskmelon	Punjab	82.8	59.3	74.1	800	88.5	Ahmad et al. (1993)
Onion	Punjab	79.1	56.8	80.3	-	173.4	Ahmad et al. (1993)
Onion	Punjab	135.9	56.8	-	683	143.3	Government of Pakistan (1994b)
Potato (Small farms)	Okara Punjab	237.2	178.5	-	1532	108.5	Ayub Agricultural Research Institute (1993b)
Potato (Large farms)	Okara Punjab	265.3	226.1	61.8	2446	104.4	Ayub Agricultural Research Institute (1993b)
Potato	Punjab	158.4	113.7	80.3	800	143.3	Ahmad et al. (1993)
Potato	Pakistan	227.3	113.7	123.6	2872	88.3	Government of Pakistan (1994c)
Tomatoes	Punjab	101.3	150.7	59.3	800	195.4	Ahmad et al. (1993)
Watermelon	Punjab	129.7	59.3	74.1	800	88.5	Ahmad et al. (1993)
Rice (fine) in rice-based system	Punjab	42.0	13.0	-	45	26.0	Ahmad et al. (1993)
Sugarcane in mixed cropping system	Punjab	44.0	23.0	-	250	52.0	Ahmad et al. (1993)
Wheat in cotton-based system	Punjab	42.0	22.0	-	-	9.1	Ahmad et al. (1993)

Table 8. Economics of vegetables and major field crops in PKR/ha, 1993

Vegetable studied	Region	Total cost	Gross returns	Net benefit	Benefit-cost ratio	Reference
Chili	Punjab	22934	39085	16151	1.70	Ahmad et al. (1993)
Muskmelon	Punjab	16291	30875	14584	1.90	Ahmad et al. (1993)
Onion	Punjab	1974	30875	11701	1.61	Ahmad et al. (1993)
Onion	Punjab	28860	55598	267388	1.93	Government of Pakistan (1994b)
Potato (Small farms)	Okara Punjab	34562	N.A.	N.A.	N.A.	Ayub Agricultural Research Institute (1993b)
Potato (Large farms)	Okara Punjab	37769	N.A.	N.A.	N.A.	Ayub Agricultural Research Institute (1993b)

Contd. Table 8.

Vegetable studied	Region	Total cost	Gross returns	Net benefit	Benefit-cost ratio	Reference
Potato	Punjab	42084	69160	27076	1.64	Ahmad et al. (1993)
Potato	Pakistan	27432	58810	31378	2.14	Government of Pakistan (1994c)
Tomatoes	Punjab	21428	44658	23230	2.08	Ahmad et al. (1993)
Watermelon	Punjab	13729	17290	3561	1.26	Ahmad et al. (1993)
Cotton in cotton-based system	Punjab	12699	16006	3307	1.26	Ahmad et al. (1993)
Rice (fine) in rice-based system	Punjab	8993	8954	-39	1.00	Ahmad et al. (1993)
Sugarcane in mixed cropping system	Punjab	22889	22409	-480	0.98	Ahmad et al. (1993)
Wheat in cotton-based system	Punjab	8075	7988	-87	0.99	Ahmad et al. (1993)

Production Constraints

Despite high profitability, availability of irrigation water, and varied climatic conditions, vegetable production in Pakistan remains limited. According to a study by international consultants (Produce Studies Limited 1989) a large number of factors limit Pakistan's production and export potential of fruits and vegetables. The most common among them are poor farm management practices, lack of adequate social and physical infrastructure, such as skill development, extension, transportation, and storage facilities, absence of marketing intelligence; improper storage of seeds, lack of necessary inputs; salinity and water-logging, irregularities in domestic and international markets, lack of grading, and lack of government support.

Guiji and Pretty (1992) identified the following constraints/problems in potato production, which are very much applicable to other crops.

Seeds. i. high cost of imported seed, ii. low quality of local seed, iii. shortage of proper variety seed for an ecoregion, iv. high price of cold storage.

Fertilizer. i. non-availability of fertilizer at the appropriate times, ii. inappropriate dosage of fertilizer, iii. poor quality of fertilizer sacks, iv. high price of fertilizers.

Pest and disease treatment. i. high degree of pest and disease problems, ii. lack of accurate information on pesticides.

Irrigation. i. high cost of irrigation water, ii. uncertainty and fluctuation in the supply of electricity, iii. lack of irrigation, iv. waterlogging.

Labor. i. shortage of labor or high wage rate.

Land. i. land fragmentation, ii. small size of land holdings, iii. high cost of renting land, iv. land disputes.

Credit and loans. i. lack of access to institutional credit and loans.

Marketing. i. low prices in January-February, ii. price fluctuations across the years, iii. trouble in transporting produce to markets, iv. exploitive practices by commission agents (middlemen).

It should, however, be noted that these constraints vary from region to region and hence should be discussed in a regional context. In this respect, a study by PARC on constraints to potato production by ecological zone seems to be highly relevant (Table 9).

Table 9. Constraints to potato production in various ecological zones

Zone	Constraints
1. Irrigated Plains of Sindh and South Punjab	a) Inadequate availability of water b) Inadequate supplies of healthy seed c) Attack of early blight d) Low density of potato production e) Lack of skill
2. Irrigated Plains of Central Punjab	a) Extreme temperatures at planting and maturity stages b) Soil salinity c) Aphids and virus infection d) Attack of late blight and other soil-borne diseases, pests e) Zinc deficiency
3. Irrigated Plains of NWFP and Northern Punjab	a) Virus attack b) Use of unhealthy seed c) Zinc deficiency and inadequate application of fertilizer d) Attack of late blight
4. Irrigated Lower Valleys of NWFP (900-1500 m)	Constraints not studied
5. Rain-fed high valley and hill-side NWFP and Azad Kashmir (1750-2600 m)	a) Uncertain rainfall b) Attack of late blight c) Difficult access to some areas for extension agents
6. Irrigated higher valleys of NWFP (1750-2600 m)	a) Attack of late blight b) Lack of proper rotation, resulting in build-up of diseases c) Attack of cyst nematodes d) Infertile soil and low organic matter content e) Poor access to some areas by road

Contd. Table 9.

Zone	Constraints
7. Irrigated high valleys of northern areas and Chitral (2250-3000 m)	a) Use of virus infested local potato seed b) Poor access to potentially new production areas
8. Irrigated mid-elevation and valleys of Baluchistan (1600-2300 m)	a) Inadequate supply of water b) Strong competition from tomatoes c) Attack of various diseases d) Inefficient marketing system

Source: Pakistan Agricultural Research Council (1989).

Marketing Systems

Marketing Channels

The most common marketing channels for vegetables are depicted in Table 10 and Figure 2. Village sales are important only for the relatively less perishable vegetables, such as onions and pumpkins. After production, vegetables generally pass through three stages (i.e., commission agents, wholesalers, and retailers) before reaching consumers. Commission agents sell for a commission, while wholesalers sell through open auction to retailers in small lots. Vegetables are also sold to preharvest contractors who buy standing fields and harvest and market the produce themselves. Considerable regional variation exists in the proportion sold to different agencies and the ensuing marketing margins for the same vegetable. This variation depends upon the proximity of regulated markets, availability of institutional marketing and credit agencies, status of road links with markets, transportation facilities, and the general attitude of the farmers. It has, for example, been reported that the marketing margins per kilogram of potato did not exceed PKR 0.20 in Mardan, as compared to PKR 0.47 in Okara, PKR 0.98 in Baluchistan, and PKR 1.64 in Swat Valley (Malik 1995).

Table 10. Distribution channels for vegetables (percent of total sales)

Vegetable	Farm to village merchant	Farm to commission agent	Farm to wholesaler
Potatoes	55	-	45
Onions	18	4	78
Tomatoes	31	-	61

Source: Government of Pakistan (1988).

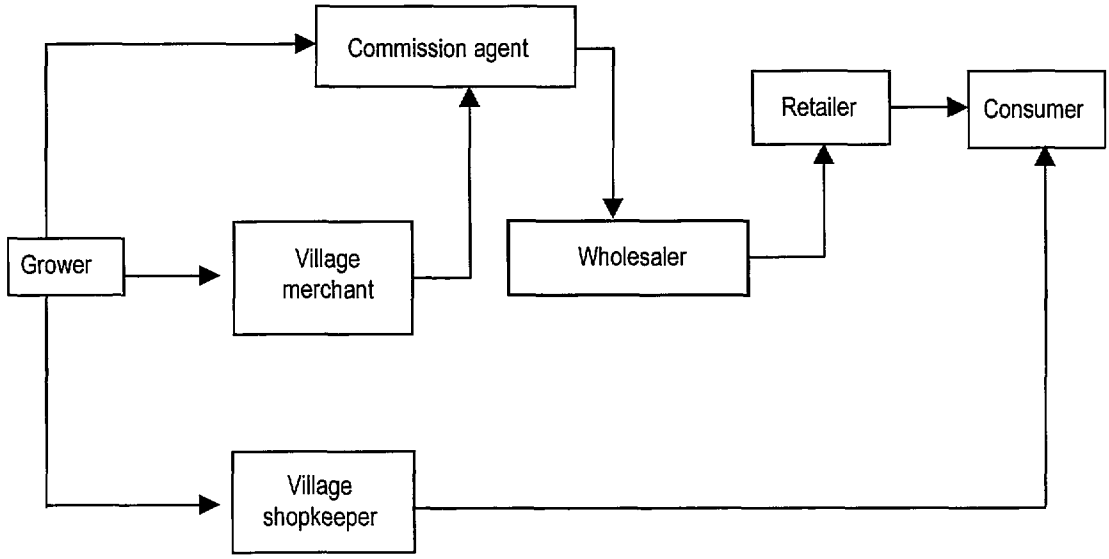


Fig. 2. Market channels for potato.

Efficiency of Marketing

Marketing problems in vegetables are linked to management practices and increased by the lack of on-farm storage, by rudimentary harvesting and packing methods, and by high variability in output from year to year. The segment that links producers to local markets or primary distribution points seems to function relatively efficiently (Malik 1995). At the wholesale marketing level the system is less efficient due to the congested and dilapidated conditions of most vegetable marketplaces, as well as the large number of relatively small transactions that take place before the commodity finally reaches the consumer. Nevertheless, it should be recognized that all these transactions are accomplished with marketing margins that are not excessive when the risk involved and the inadequacy of the facilities are taken into account. Moreover, the wholesale marketing system has shown an ability to handle a high volume of vegetables, despite the poor physical infrastructure and congestion in markets, which impose an absolute limitation on the volume of produce that can be absorbed. That said, there is considerable scope for improvement of the entire marketing system.

Wholesale marketplaces are generally poorly designed. They are too small, have no storage facilities, and are entirely located in the centers of towns and major cities. Congestion, confusion, filth, disorder, and reputed malpractice typify most wholesale marketplaces. Commission agents and wholesalers manage the wholesale markets. Auction "bidding" starts in some markets as early as 4:00 a.m. Few producers are able to enter the marketplace at the early hours of the auction. Prices can vary more than 100% within 2-3 hours. Trading is generally over for the day before 8:00 a.m. This organized confusion and congestion is to the benefit of wholesalers/commission agents who are far better informed as to prices, markets, available storage, etc., than are the small, unorganized, poorly informed producers (Kokab and Smith 1989).

Marketing margins between farm and retail level provide an understanding of the spread between producer and consumer prices. These margins are measured as the difference between the retail price of food and the payment to farmers for an equivalent quantity of farm produce. It represents the total

payments made to marketing agents for providing services, such as assembling, transporting, storing, processing, wholesaling, and retailing. Marketing margins for various vegetables were estimated by United Consultants Group Ltd. (1984), Kokab and Smith (1989), Kokab (1984), Siddique (1980), and Lodhi (1990). The estimates in these studies varied from 36% to 75% (Table 11).

Table 11. Marketing margins for various vegetables (% of consumer price)

	Potato			Onion		Tomato			Peas	Carrot	Brinjal
	Lodhi[1]	UCL[2]	Kokab & Smith[3]	Kokab[4] a	Kokab[4] b	Lodhi	UCL	Siddique[5]	Lodhi	UCL	UCL
Grower	56.0	62.1	63.7	49.1	55.0	57.0	55.5	54.9	25.0	56.9	60.6
Commission Agent	-	8.5	11.3	1.5	1.7	-	7.8	3.4	-	9.0	6.9
Wholesaler (Pharia)	-	11.5	2.1	21.0	14.8	-	10.0	16.4	-	12.8	12.4
Retailer	-	17.9	22.9	28.4	28.5	-	26.7	25.3	-	21.3	20.1
Marketing margin	44.0	37.9	36.3	50.9	45.0	43.0	44.5	45.1	75.0	43.1	39.4

a. Unstored winter onion; b. Stored winter onion; - implies that details are not available.
[1] Lodhi (1990); [2] UCL (1984); [3] Kokab and Smith (1989); [4] Kokab (1984); [5] Siddique (1980).

It is difficult to assess whether the large marketing margins are exploitative. Similar margins are observed in some of the advanced agricultural markets of western countries, although the services provided in western countries are of much superior quality. As services provided by intermediaries in Pakistan are of low quality, charges might appear high. The large margins, however, are the result of the primitive infrastructure, which causes high losses and adds considerably to the handling costs for the intermediaries.

International Trade

Net vegetable international trade to and from Pakistan was worth PKR 49.5 million in 1993, represented by PKR 235.2 million in exports and PKR 185.7 million in imports. The relative share of onion and chili in total export earnings has fluctuated over time. For example, chili contributed 91% during 1991, while onion contributed 53% in export earnings in 1993. The major imports are potato and seed of other vegetable.

Because of the erratic nature of international trade in vegetables in Pakistan, no significant trend was observed in quantities of vegetables exported. The government's sensitivity to the domestic fluctuation of vegetable prices, which causes erratic government intervention in international vegetable trade, is responsible for these results. Producers Study Limited (1989) identified a great potential to expand vegetable exports provided basic changes in the quality of produce, post-harvest handling, and transport infrastructure were made. The maximum quantity of vegetables exported was recorded in 1979. In recent years, vegetable imports have virtually matched exports (Table 12). This is another indication of the increasing gap between domestic demand and production.

Table 12. International trade in vegetables, 1973-93

Year	Total exports (Quantities 000 t)	Total exports (Value million PKR)	Exports net of imports (Quantities 000 t)	Exports net of imports (Value million PKR)
1973	10.6	18.2	10.6	18.2
1974	0.5	4.0	0.5	4.0
1975	14.2	68.4	14.2	68.4
1976	20.9	48.1	20.9	48.1
1977	63.8	136.7	63.8	136.7
1978	66.9	193.3	66.9	193.3
1979	123.7	297.6	123.7	297.6
1980	86.3	170.7	86.3	170.7
1981	39.9	91.0	39.9	91.0
1982	87.0	203.7	87.0	203.7
1983	56.1	191.0	53.1	159.4
1984	40.3	230.7	35.3	186.3
1985	81.0	268.7	75.0	197.2
1986	61.6	259.4	58.6	186.8
1987	77.3	316.1	74.3	234.0
1988	35.9	264.7	27.9	126.6
1989	108.3	343.1	107.4	259.2
1990	16.2	206.7	15.2	106.7
1991	39.8	523.0	35.4	416.8
1992	13.0	165.1	8.2	31.1
1993	37.3	235.2	32.1	49.5

Source: Government of Pakistan (1983a, 1993a and unpublished data from Ministry of Food, Agriculture and Livestock).

Supply and Demand

Availability

Average annual per capita availability of vegetables (excluding potato but including onion, garlic, and chili) derived from domestic production after deducting exports, ranged from 24 kg (65 g/day) in 1980 to 32 kg (89 g/day) in 1993 (Table 13). There was some improvement in vegetable production, although it produced little change in per capita availability, because of high population increase and a low base to start with.

Table 13. Per capita availability of vegetables at the farm level, 1980-1993

Year	Production (000 t)	Trade surplus (000 t)	Net availability (000 t)	Population (million)	Per capita availability kg/annum	Per capita availability g/day
1980	2081.1	86.3	1994.8	83.8	23.8	65.2
1981	2136.1	39.9	2096.2	86.4	24.3	66.4
1982	2610.0	87.0	2523.0	89.1	28.3	77.6
1983	2468.9	53.1	2415.8	91.9	26.3	72.0
1984	2469.4	35.3	2434.1	94.7	25.7	70.4
1985	2624.5	75.0	2549.5	97.7	26.1	71.5
1986	3063.7	58.6	3005.1	100.7	29.8	81.8
1987	3162.2	74.3	3087.9	103.8	29.7	81.5
1988	3318.9	27.9	3291.0	107.0	30.7	84.2
1989	3474.0	107.4	3366.6	110.4	30.5	83.6
1990	3431.8	15.2	3416.6	113.8	30.0	82.3
1991	3688.1	35.4	3652.7	117.3	31.1	85.3
1992	3811.8	8.2	3803.6	120.8	31.5	86.2
1993	4062.7	32.1	4030.6	124.5	32.4	88.7
Growth rate	5.0	-9.7	5.2	3.0	2.2	2.2

Source: Same as in Table 3 for production, and same as in Table 12 for trade surplus. For population, Government of Pakistan (1995). Per capita availability was calculated from the total availability divided by population.

Consumption

Vegetables are consumed both in cooked and raw form. For instance, tomato, coriander, green chili, turnip, carrot, radish, etc., are consumed both in cooked and raw form; while cucumber, watermelon, muskmelon, etc., are consumed only in raw form. Still, some other vegetables, such as potatoes, are consumed in a variety of ways in various parts of Pakistan and are more appreciated when cooked along with other vegetables and meat. Potato chips fried in vegetable oil are commonly served with tea in urban areas. Pakorra is also a famous local snack, the main ingredient of which is potatoes. Presently, different types of potato chips are being introduced in Pakistan, and entrepreneurs are now taking interest in this business. A number of large industrial processors now produce high quality packaged chips.

The Household Income and Expenditure Surveys (HIES) undertaken by the Federal Bureau of Statistics report on monthly per capita consumption and the percentage distribution of monthly household expenditure on consumables, including vegetables, such as potatoes, chili, onions, tomatoes, and other vegetables, by income group and rural-urban area.

According to the survey of 1991, Pakistanis spent about 9.6% of their food expenditures on vegetables, up from 7.2% in 1979. The increase in expenditure share for vegetables was observed across all income groups. Little difference was observed in rural and urban areas with respect to the percentage of food expenditure spent on vegetables. However, the expenditure on vegetables as a percent of food expenditure was found to be a declining function of incomes in both the urban and

rural areas; while the lowest income group allocated 9.9%, the highest income group spent only 7.6% of food expenditures on vegetables.

Average annual per capita vegetable consumption in Pakistan in 1991 was 38.7 kg, up from 23.2 kg in 1979. The increase was observed across all income groups, but a higher percentage increase was found in the middle-income groups. No significant difference in rural and urban areas with respect to vegetable consumption was noticed. However, despite the low share of expenditures on vegetables, high-income groups consumed about 19% more vegetables than did low-income groups in 1991 (Table 14).

Table 14. Annual vegetable consumption (kg/capita) by income group and urban-rural classification in 1979 and 1991

Income group	1979			1991		
	Rural	Urban	Pakistan	Rural	Urban	Pakistan
All groups	22.0 (7.2)	25.7 (7.2)	23.2 (7.2)	38.4 (9.7)	39.3 (9.4)	38.7 (9.6)
1	22.1 (7.3)	23.5 (7.6)	22.4 (7.8)	36.4 (10.1)	36.8 (9.1)	36.5 (9.9)
2	22.8 (7.2)	23.3 (7.6)	22.8 (7.3)	38.0 (11.2)	37.0 (11.1)	37.7 (11.2)
3	21.7 (6.9)	25.4 (7.8)	22.7 (7.3)	37.0 (10.4)	35.3 (11.0)	36.4 (10.6)
4	26.0 (6.6)	24.8 (7.6)	22.3 (7.1)	36.6 (10.3)	37.2 (10.8)	36.8 (10.5)
5	20.6 (6.3)	24.2 (7.3)	22.0 (6.9)	38.3 (9.9)	38.3 (10.2)	38.3 (10.0)
6	23.9 (6.0)	25.9 (6.9)	25.2 (6.6)	37.1 (9.7)	40.1 (9.7)	38.1 (9.7)
7	23.4 (5.7)	27.5 (6.8)	25.8 (6.5)	40.6 (9.0)	41.9 (9.5)	41.1 (9.2)
8	25.0 (5.7)	29.0 (6.2)	27.5 (6.3)	38.3 (8.9)	39.3 (9.3)	38.6 (9.1)
9	26.8 (5.7)	33.4 (6.5)	31.2 (6.0)	38.1 (8.2)	40.2 (8.7)	38.7 (8.4)
10	40.4 (5.9)	32.8 (6.3)	35.4 (6.2)	49.5 (9.3)	43.5 (8.9)	46.6 (9.1)
11	31.8 (4.5)	37.8 (5.5)	36.1 (5.3)	45.2 (8.1)	44.2 (7.1)	44.9 (7.6)

Source: Government of Pakistan (1983b, 1993b); The figures in parentheses are the percentage of total food expenditure spent on vegetables. The monthly per capita income (PKR) groups in the 1979 survey are 1= average of 300 and 301-400, 2=401-500, 3=501-600, 4=601-800, 5=801-1000, 6=1001-1500, 7=1501-2000, 8=2001-2500, 9=2501-3000, 10=3001-3500, 11= above 3500. In the 1990-91 survey, these groups are 1=up to 1000, 2=1001-1500, 3=1501-2000, 4=2001-2500, 5=2501-3000, 6=3001-3500, 7=3501-4000, 8=4001-5000, 9=5001-6000, 10=6001-7000, 11=above 7000.

Micro-level studies have also compared vegetable consumption across different social groups and have quantified the consumption of individual vegetable species. Aslam et al. (1982) estimated consumption of important vegetables for small farmers and non-farmers in four villages of Faisalabad district in Punjab (Table 15). Average total vegetable consumption (including potato) per capita was around 85 g/day. Non-farmer households in the rural communities were consuming less vegetables than farmer households. Khan (1988), on the other hand, reported that non-farmers were spending relatively more of their total food expenditure on vegetables (Table 16). This might be the result of the lower income of non-cultivators, or high vegetable prices that non-cultivators had to pay to buy foods from markets. In another study, Khan, M.J. (1993) reported that farm households in the irrigated areas spent more on vegetable consumption than those in barani (rain-fed) and partially barani areas (Table 16).

Table 15. Consumption of various vegetables (g/capita) in rural areas of Faisalabad

Vegetables	Farmers	Non-farmers	Both
Cauliflower	0.3	-	0.2
Cowpeas	2.7	-	1.7
Eggplant	9.4	7.0	8.5
Ginger	0.1	0.1	0.1
Gourd	25.5	17.3	22.5
Mustard leaves	8.7	15.6	11.2
Onion and garlic	15.3	12.6	14.4
Potato	16.4	13.6	15.4
Radish	2.7	6.4	4.0
Spinach	6.4	8.4	7.1
Total	87.5	81.0	85.1

- implies that the figure was not relevant or it was not available; Source: Aslam et al. (1982).

Table 16. Expenditure on vegetables

Category	Expenditures		Reference
	Percentage of foods expenditure	Percentage of all expenditure	
A.			Aslam et al. (1982)
Farmers	10.7	Not available	
Non-farmers	11.4	Not available	
Both	10.9	Not available	
B.			Khan (1988)
Farm Household			
Barani (rain-fed)	7.21	4.16	
Irrigated	7.28	4.66	
Overall	7.26	4.58	
Non-Farm Household			
Barani (rain-fed)	7.08	4.45	
Irrigated	8.46	5.45	
Overall	8.29	5.38	
C.			Khan, M.J. (1993)
Farm Household			
Barani (rain-fed)	2.74	2.00	
Partial barani	3.70	2.46	
Irrigated	9.38	5.60	
Overall	8.22	5.41	
Non-Farm Household			
Barani (rain-fed)	4.84	3.73	
Partial barani	3.37	2.72	
Irrigated	10.71	6.91	
Overall	16.15	6.91	

Demand Elasticities

Little research has been done on estimating price and income elasticities, especially for individual vegetables. McCarthy (1977) reported an own-price elasticity for vegetables for rural low-income consumers of 0.08, suggesting that the demand for vegetables with respect to price is highly inelastic, i.e., price variations do not affect the demand for vegetables much. Kokab and Smith (1989) found the correlation between income and potato consumption to be insignificant.

Burney and Akmal (1991), basing their analysis on data from the 1985 Household Income and Expenditure Survey, presented more detailed estimates of income and price elasticities of demand for vegetables, including potato, onion, and fresh vegetables, by income group and by urban-rural classification. The results of this study are summarized in Table 17.

Table 17. Income and price elasticities of demand by income group for potato, onion, and all fresh vegetables during 1984-85

Kind of elasticities and vegetable	Income group (PKR)						
	< 1000	1000-1500	1500-2000	2000-3000	3000-5000	5000-15000	All Groups
A. Income Elasticities							
Urban							
Potato	0.28	0.23	0.28	0.16	0.34	0.10	0.25
Onion	0.29	0.26	0.37	0.23	0.45	0.23	0.23
Fresh vegetables	0.38	0.37	0.42	0.39	0.40	0.37	0.39
Rural							
Potato	0.55	0.46	0.29	0.49	0.38	0.89	0.47
Onion	0.62	0.52	0.42	0.51	0.43	1.04	0.54
Fresh vegetables	0.71	0.70	0.44	0.49	0.57	0.59	0.57
B. Price Elasticities							
Urban							
Potato	-0.06	-0.11	-0.13	-0.08	-0.21	-0.05	-0.11
Onion	-0.07	-0.12	-0.17	-0.11	-0.28	-0.11	-0.11
Fresh vegetables	-0.09	-0.19	-0.20	-0.19	-0.25	-0.18	-0.18
Rural							
Potato	-0.11	-0.16	-0.07	-0.21	-0.38	-1.33	-0.16
Onion	-0.12	-0.18	-0.10	-0.21	-0.42	-1.55	-0.18
Fresh vegetables	-0.14	-0.25	-0.11	-0.21	-0.56	-0.85	-0.21

Source: Burney and Akmal (1991).

Generally, income and price elasticities of vegetables are higher in rural areas than in urban areas. While the above results suggest relatively low price elasticities for vegetables, Bouis (1991) estimated a price elasticity of demand for total vegetables which consistently exceeded 1.0, irrespective of income group. Also, income elasticity estimates in Bouis (1991) consistently exceeded those in Burney and Akmal (1991).

Seasonality

Generally, vegetables are consumed in their respective seasons of production as there is no significant carry-over, with the exception of storable vegetables. An indication of seasonal vegetable consumption was obtained from the monthly vegetable arrivals in Faisalabad market, one of the biggest markets in the country (Fig. 3). The lowest availability is in January and February, the coldest months with high frost. The availability suddenly jumps, to its highest level, in March and April. The difference in lowest and highest vegetable arrivals is about 200%. A relatively small dip in vegetable arrivals comes in May-June, the hottest period.

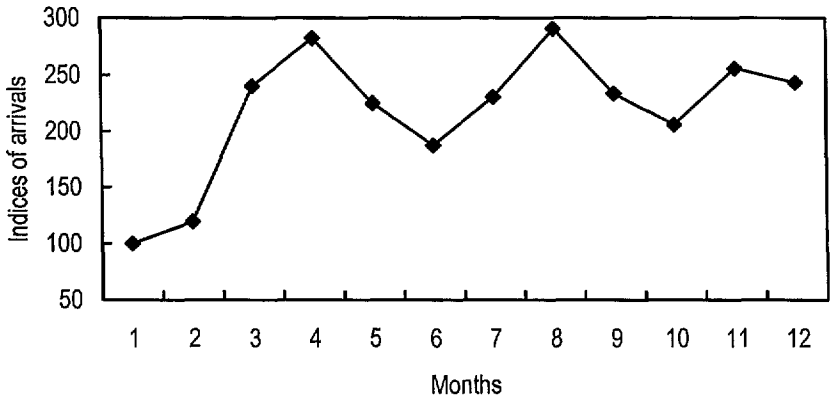


Fig. 3. Seasonality in vegetable arrivals in Faisalabad market (average 1992-94)

Micro-level studies have also indicated seasonal patterns in vegetable consumption for individual vegetables. For example, Kokab and Smith (1989) reported that average per capita consumption of potatoes in the urban areas of Pakistan in winter was more than 1.4 kg/month, while it was only 0.5 kg/month in summer, with an average consumption of 1.1 kg/month. This was mainly because of difference in availability and price of fresh potatoes. Another important factor in depressing demand during summer was the sweet taste of stored potatoes, disliked by consumers.

Consumer Preference

Except for potato, currently no study is available on consumer preferences regarding vegetables. Kokab and Smith (1989) surveyed on factors important in buying potatoes. Freshness of potatoes is considered the most important characteristic by nearly all consumers, particularly because potatoes, when left for a long time in cold storage, develop an unpopular sweet taste. In June 1989, the strong preference for fresh potatoes meant that this produce commanded three or four times the price of the autumn crop, cold-stored potatoes in the Karachi wholesale market.

Price and skin color are two other characteristics considered important by consumers when buying potatoes (Table 18). The relative weight given to price by consumers seems, however, secondary to freshness. Skin color is clearly a major determinant of consumer choice. An interesting finding is the strong preference in northern cities for red-skinned potatoes, while in the south, white-skinned potatoes are preferred; it is difficult to determine any difference in flavor, at least by consumers in general.

Table 18. Factors affecting consumer preferences (% of consumers who consider these factors important) in potato

Cities	% of consumers					
	Freshness	Price	Red skin	Damaged/diseased	Shape	Size
Karachi	100	95	98	78	85	84
Lahore	99	93	81	94	70	72
Multan	99	76	82	77	75	58
Peshawar	99	89	92	90	72	70
Quetta	100	83	83	77	49	46
Rawalpindi	97	95	92	60	78	54
Mean	99	89	87	81	71	63

Source: Kokab and Smith (1989).

Policy Issues

In presenting the analysis of various issues confronting the vegetable industry, the major objective is to facilitate the production of high quality vegetables on a sustained basis. The following are some of the important issues that need the immediate attention of both policy makers and researchers.

Yield Stagnation

Although improved seeds and better cultural practices have been selectively introduced over the last two decades, vegetable yields have tended to stagnate. Some serious efforts will be required to break existing yield ceilings through a pragmatic multidimensional and multidisciplinary approach. The extension system in Pakistan has traditionally been centered around the major crops. There is, therefore, a need to devote more resources to institutional development in the vegetable sector to ensure that inputs and advice are easily available to small farmers. The existing network of Adaptive Research Institutes should undertake verification trials and monitor varieties of various vegetable species with regard to their susceptibility to pests and diseases, and adaptability to soils and climatic conditions. Both quantity and quality should be emphasized in vegetable breeding research. Finally, farm-level diagnostic surveys and studies are needed to identify major constraints to vegetable production.

Availability of Quality Seed

Shortage of quality seed is a major constraint to vegetable production in Pakistan. There is no organized seed production scheme. Most of the cross-pollinated seed varieties, and 100% of the hybrid seed, is imported. Significant quantities of this imported seed are smuggled into the country (NESPAK & OPCT 1993). In recognition of its importance, efforts need to be made at the national level to increase the production and availability of high quality seed. Many northern areas, especially Baluchistan, could be exploited more effectively for this purpose (Samad 1993). However, cost-benefit analyses are needed before starting such an exercise to see if domestic production is cheaper than importing seed, and to identify factors that can help reduce the cost of domestic production.

Inefficient Marketing

The vegetable marketing system in Pakistan is not well developed. The perishable nature of most

vegetables, compounded by rough handling and a lack of storage, processing, packing, and transportation facilities, results in considerable losses. These losses have been estimated to be in the range of 20 to 40% (Kokab and Smith 1989). Appropriate standards and modern technologies needed at various stages of marketing should be introduced to develop an efficient marketing system. Vegetable marketing could be partly improved by encouraging farmers' cooperatives encompassing supply of inputs and credit, harvesting, storing, processing, packaging, and transportation. In view of seasonality in vegetable production, price fluctuation is more of a problem than is level of prices, both for consumers and producers. In this context, there is strong logic for improving marketing intelligence to producers, rather than implementing price intervention schemes. Production technologies that enable crops to tolerate stress, improved marketing infrastructure and crop forecasting methods could be of great help in this regard. Comprehensive studies on these issues could suggest ways and means to smooth out the cyclical gluts and shortages, with their corresponding periods of low and high prices. They would also assist policy makers in their planning.

Export Drive

In addition to widening domestic production opportunities, the option of exporting vegetables on a sustainable basis needs serious consideration. However, international markets are highly competitive and demand high quality and an assured supply of produce. Pakistan has a poor reputation in most export markets (Produce Studies Limited 1989). At the producer, trader, and government levels, a number of measures need to be taken to achieve the necessary quality improvements. Pakistan cannot take the export market for granted. Therefore, grade and quality requirements and preferences of different foreign markets must be studied and arrangements made to meet these standards. For this purpose, the private sector would need to play an active role in developing export markets, while the government's role should be to establish the necessary infrastructure. Without an integrated problem-solving approach at various stages of production, marketing, packaging, grading, and storage, prospects for a breakthrough in vegetable exports from Pakistan will at best remain dim (Produce Studies Limited 1989).

Subsidies and Taxes

At present, producer subsidies are given on agricultural inputs, especially on fertilizer, tube wells, and agricultural machinery. Similarly, services for heavy earth moving equipment are being subsidized by 35 to 70%. Subsidies on deep tillage equipment, reapers, etc., have also been announced. But all of these subsidies are not exclusively for vegetable.

A substantial transfer of resources from the agriculture sector to the non-agriculture sector through direct and indirect taxes, such as land revenue, surcharges, and sales taxes has been reported (Government of Pakistan 1988, 1993c). No comprehensive study is available to evaluate the effect of these taxes and subsidies on vegetable production, consumption, and distribution, including the environmental and health effects of these policies.

Trade Restrictions and Government Regulations

Trade in agriculture, especially in major commodities, is highly regulated. Generally, exportable commodities are procured by the government at low prices from farmers and sold at high prices on the international market. On the other hand, there are no significant restrictions or trade regulations regarding vegetables. However, periodically government does buy surplus to stabilize prices,

especially in potato and onion. But attempts to sell the surplus abroad have failed to create sustained markets.

In the long run, the volume of production and consumption of vegetables is bound to grow because of increased population and prosperity. However, for vegetable producers to enjoy the benefits, modern production and marketing technology must be adopted by farmers, and better marketing intelligence must be provided by government. Vegetables could be an important source of income for farmers, source of food for consumers, and source of foreign exchange for the government.

Research Achievements and Information Gaps

Achievements

Past vegetable research efforts can be divided into breeding and economic research. The goal of the former was to develop high-yielding varieties (HYVs) and that of the latter to suggest institutional adjustments to enhance efficiency in production, distribution, and marketing. As a result of the growing emphasis on breeding research, there are at least 29 research institutes, departments, stations, and substations that are specialized in some aspect of breeding (Hussain 1990). The breeding goals are to achieve resistance to certain pests, diseases, and viruses, reduce the growing period, obtain late or early maturity, and achieve higher yields with plants better suited to climatic conditions. Most vegetables already possess some of these characteristics – each species has more than one variety, and the number can be as large as 12, as is the case for potato (Hussain 1990 and Khan 1993).

As for economic research, many studies have focused on cost of production, marketing channels, and margins, and, in recent years, on production constraints (Ashraf 1989 and Hussain and Hanif 1990), vegetable research (Banaras et al. 1990 and Hussain 1990), production and policy (Assi 1990 and Rana and Rao 1993), and export potential (Produce Studies Limited 1989).

It is not clear, however, if past research has had a significant impact on vegetable production and consumption. For example, despite the emphasis on breeding research, yields of most vegetables remain stagnant. The contribution of economic research also seems unclear. The yield potential of most vegetables remains unexploited. Experimental data in Pakistan have shown that potato and onion yields can reach 40-50 t/ha, yet yields in farmers' fields hardly exceed 10 t/ha (Rana and Rao 1993). Socioeconomic factors contributing to this large yield gap are not very clear.

Information Gaps

The vegetable subsector, despite its importance in nutrition and farm profitability, suffers from information gaps at various stages of production, consumption, and trade. Although data on vegetable area, production, and yields are published annually, doubts about their accuracy are widespread. For example, Hussain and Hanif (1990) have argued that the published official statistics considerably understate potato production, as reported potato yields in independent studies are substantially higher (about 20 t/ha) than official estimates (10 t/ha).

Vegetables are grown in specialized growing areas adjacent to large urban centers. They are also grown in cropping systems dominated by other crops. The relative contribution of each system to total vegetable production is unknown, although it is commonly believed that peri-urban cultivation accounts for most of the total production.

There is a dearth of precise information on farm management practices followed in the production of different vegetables in various regions. Although vegetables have high private profitability as revealed by cost of production studies, their social profitability remains unknown. Given the potentially high rates of return on vegetables relative to field crops, it is not clear why farmers, especially under the assumption of economic rationality, are not shifting to vegetable cultivation to a larger extent. It is not clear whether this should be attributed to inefficiencies of the marketing system, failure of the input delivery system, or to relatively high risks involved in vegetable production. Therefore, there is a need to conduct research which quantifies and prioritizes vegetable production constraints.

There is a need to explain the low adoption rate of modern varieties and technologies by farmers. As far as vegetable consumption is concerned, the Household Income and Expenditure Surveys are the only source of vegetable consumption data. Being minor relative to the consumption of other commodities, individual vegetables are lumped as a group. The income elasticities of demand for vegetables, estimated from these data, reported mixed results. Some show very low, while others very high price elasticities of vegetables. Therefore, more studies are needed in order to have reliable estimates.

Summary, Conclusions, and Suggestions

This study has tried to quantify trends in vegetable production, consumption, and trade and to review the existing literature on various vegetable related issues in Pakistan. Starting with the environment for vegetable production, it is agreed that Pakistan has a good environment for vegetable production. Its diverse climatic conditions, topography, and availability of irrigation water permit year-round cultivation of a wide variety of vegetables. Although certain social taboos against vegetable production and consumption exist, they are only of minor importance. Yearly per capita vegetable availability, mostly from domestic sources, is about 32 kg, or 89 g per day.

Production of various kinds of vegetables has reflected varying trends, and so has trade and per capita consumption. Although total vegetable production (and that of potato) increased significantly over the past two decades, the main contributing factor to these increases came from area increase, while yields remained almost stagnant.

A large part of total vegetable production takes place under traditional management practices. Heavy dependence on farmyard manure, as well on chemical fertilizers, is common. Despite mechanization of some tillage operations, sowing, hoeing, and harvesting remain manual operations. At the same time, most cost of production studies point out that vegetable cultivation is a highly profitable enterprises both in absolute and relative terms (e.g., compared to the field crops). In relative terms, profit rates for vegetables can be 5-10 times those of field crops, depending on the particular vegetable and field crop under consideration. Moreover, since vegetables are short-duration crops, the above figures might understate the relative returns of vegetable cultivation.

Despite potentially high profitability, vegetable production in Pakistan remains limited. A number of factors seem to limit Pakistan's production potential. The most important among them include a lack of physical and social infrastructure, absence of market intelligence, use of improper seed, high infestation of pests and diseases, salinity and water logging, irregularities in domestic and

international markets, and lack of government support. The defective marketing system, in particular, impinges on farm-level profitability, as prices received by farmers are less than half of the prices paid by consumers.

Apart from population growth, family income and consumer prices are the major determinants of aggregate vegetable consumption. After accounting for population growth of 3.0%, income and price trends were responsible for just 2% of the annual growth rate in vegetable availability. Despite the improvement, availability is far below the required minimum level.

Research should try to fill serious information gaps. Specifically, the following issues need immediate investigation.

First, the efficacy and efficiency of the vegetable breeding research system needs to be assessed in order to provide recommendations for improvement. While the former should deal with the question of the current number of research stations, the staff employed, and the available equipment relative to what is needed, the latter should focus on the efficiency of researchers per unit of time. Depending on the findings, the study should suggest how the system should be improved, and what type of research should and should not be carried out.

Second, the data collection system for vegetables in the country needs to be overhauled. Scientific sampling techniques need to be used in generating these data. A field survey of area, production, and yields, along with inputs used in representative districts, seems essential. As part of the survey, questions about constraints could also be included. For an elaborate exploration, these constraints must be divided into production constraints, such as input availability, including seed, labor, fertilizer, manure, insecticides, etc., and post-harvest constraints. Such a study should also generate information on costs and the returns from vegetable cultivation by ecoregion. Technology requirements for alternative vegetable production systems in different ecoregions should be evaluated.

Third, Pakistan's vegetable marketing system suffers from serious inefficiencies. Study is needed into how to reform the system, with clear specifications and justifications for marketing margins of various intermediaries.

Fourth, consumption of vegetables is clearly an unexplored area in Pakistan. To plan the future course of production and trade, estimates of future consumption based on population growth and income and price elasticities would be highly desirable. Detailed consumption statistics by income, locality, vegetable variety, etc., would be worthwhile.

Fifth, in recent years Pakistan has been striving towards diversification and promotion of exports, and has entered the vegetable export market without adequately assessing its prospects. Pakistan faces intense competition in foreign markets, and at times has been out-competed by other producers. A rational strategy for export promotion must be based on relative efficiency and comparative advantage in the production of vegetables. Despite the potentially high private profitability of most vegetables, Pakistani farmers might not possess the comparative advantage in vegetable production needed to enter into foreign trade on a sustainable basis. A study on comparative advantage of vegetables based on domestic resource costs is needed for informed efforts in diversification and export promotion.

Finally, availability of quality vegetable seed is crucial in any program aimed at improving vegetable production. A comprehensive study that focuses on production, availability, constraints, and prospects for quality vegetable-seed production would be a step in the right direction. As a large percentage of seed for certain vegetables is imported, prospects for producing nucleus seed from domestic sources in the various regions of Pakistan should receive special attention in such a study.

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PHILIPPINES

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Introduction

The Philippines is an archipelago of 7100 islands on the western rim of the Pacific Ocean between Taiwan and Borneo, extending about 1851 km north to south and with a maximum breadth east to west of 1070 km. It lies between latitudes 4° 23' and 21° 25'N and between longitudes 116° and 127°E. It is bounded by the Pacific Ocean to the east, the Celebes Sea to the south, the Sulu Sea to the south-west, the South China Sea to the west, and the Bashi Channel to the north. The country has a total area of 300,000 km^2 and a total coastline of 17,461 km.

The population of the Philippines in 1994 was 67 million with about 45% of the people living in urban areas. Average population density was 223 persons per km^2. Between 1980 and 1990 the annual population growth rate was 2.35%. The annual per capita income in 1994 was US$945 (NSCB 1995).

Rice, the single most important crop, occupied 27.9% of the total cropped area in 1994. Other crops grown in the country are corn and coconut grown on 23.0% and 23.4% of the area, respectively, in 1994. Vegetables were cultivated on 216,100 ha, covering 2% of the cropped area in 1994. Total production of all vegetables in that year, including mungbean, onion, and garlic, but excluding potato, was 2.0 million t, worth 23 billion pesos (about 15% of the value of all cereal production). Average vegetable yield was 9.2 t/ha. It is estimated that the per capita availability of fresh vegetables at the farm level, after deducting post-harvest losses, is about 30 kg per year. Annual per capita consumption of processed vegetables is relatively small at only 0.8 kg.

In 1993, average per capita food consumption in the Philippines was about 980 g/day, of which cereals constituted 30.5%, non-cereal plant food 35%, fruits and vegetables 25%, and livestock products 9.5% (NSCB 1994). Food consumption is heavily dominated by rice, which makes up 24.6% of the diet.

Topography

The Philippines has a varied topography, with lofty highlands and lush valleys. The four major lowland production areas are the Central Plain and Cagayan Valley in Luzon, and Agusan and Cotabato Valley in Mindanao. These lowlands contrast sharply with the adjacent highland areas of

Central and East Cordillera and the Zambales mountains. There are also several plateaus, among them the Bukidnon and Lanao plateaus in Mindanao.

The Sierra Madre and the Cordillera of Luzon are mountain ranges that run almost parallel. The Sierra Madre extends from the north-east of Cagayan to a point east of Laguna Lake. The Cordillera runs along the western side of Luzon. The highest peak in the Philippines is Mount Apo in Mindanao, with an elevation of 2954 m.

Regions

The Philippines is divided into three major island groups (Fig. 1): Luzon, with an area of 141,395 km^2, the Visayas (area 56,606 km^2), and Mindanao (area 101,999 km^2). These three groups are further divided into regions, provinces, cities, municipalities, and barangays (villages). In 1994 there were 15 regions, including Metropolitan Manila, 73 provinces, 60 cities, 1532 municipalities, and 40,904 barangays.

Climate

The Philippines has a generally mild tropical climate characterized by relatively high temperatures, high humidity, and abundant rainfall. The country has four main types of climate, classified according to the presence or absence of a dry season and the duration of the rainy period:

Type I Two pronounced seasons: dry from November to April and wet the rest of the year. The western parts of Luzon, Western Mindanao, Negros, and Palawan have this type of climate.

Type II No dry season, with most of the rain falling from November to January. Catanduanes, Sorsogon, the eastern part of Albay, the eastern and northern parts of Camarines Norte and Camarines Sur, and a large portion of eastern Mindanao have this type of climate.

Type III Seasons are not very pronounced: relatively dry from November to April and wet the rest of the year. The maximum rainfall periods are not very pronounced, but the short dry season lasts only from one to three months. This type of climate is found in the western parts of Cagayan, Isabela, Nueva Vizcaya, the eastern portion of Mountain Province, southern Quezon, Masbate, Romblon, eastern Negros, central and southern Cebu, part of Northern Mindanao, and most of eastern Palawan.

Type IV Rainfall is more or less evenly distributed throughout the year, such as in the area of Batanes, north-eastern Luzon, the south-eastern part of Camarines Norte, western parts of Camarines Sur and Albay, eastern Mindanao, Marinduque, western Leyte, northern Cebu, Bohol, and most of Central and Southern Mindanao.

The mean temperature in the Philippines is 27°C. January is the coolest month, with a mean temperature of 25°C, while the warmest month is May, with a mean temperature of 28°C. Baguio, with an elevation of more than 1500 m, has a mean annual temperature of 18°C.

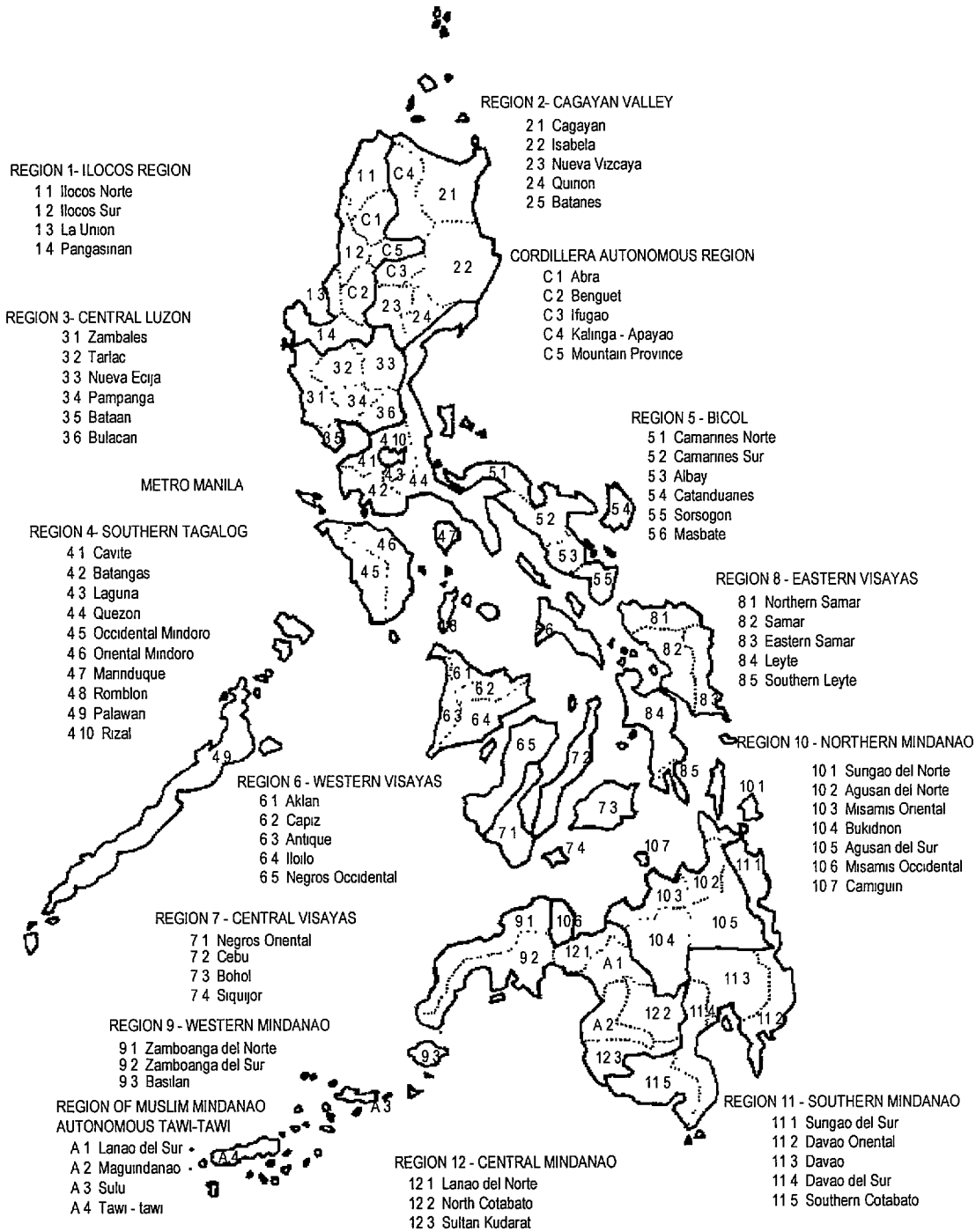

Fig. 1. Regional map of the Republic of the Philippines

Typhoons are frequent from July to November; on average about 20 typhoons occur every year. Conditions are often made worse by monsoon rains which cause flooding in low-lying areas.

Major Vegetables

Of the many types of vegetables grown in the Philippines, leafy/stem vegetables are preferred; in 1994, they were grown on almost 16% of the total vegetable area and accounted for about 43% of total production. Among individual vegetables, the area in mungbean is the largest. Other major vegetables are tomato and eggplant (Table 1).

Table 1. Vegetable area, production, and yield, by kind of vegetable, 1994

Vegetable	Area ('000 ha)	Production ('000 t)	Yield (kg/ha)
Cabbage	7.8 (3.6)	86.5 (4.3)	11090
Eggplant	19.3 (8.9)	123.6 (6.2)	6404
Garlic	5.6 (2.6)	16.1 (0.8)	2875
Mungbean	34.1 (15.8)	24.1 (1.2)	707
Onion	7.7 (3.6)	60.2 (3.0)	7818
Other fruit-bearing vegetables	74.9 (34.7)	559.3 (28.1)	7469
Other legumes	10.0 (4.6)	29.6 (1.5)	2960
Other leafy/stem vegetables	34.0 (15.7)	861.1 (43.2)	25326
Tomato	17.3 (8.0)	147.8 (7.4)	8543
Watermelon	5.4 (2.5)	84.1 (4.2)	15574
All vegetables	216.1 (100.0)	1992.4 (100.0)	9220

Source: NSCB (1995).
Figures in parentheses are percentages of the total.

Geographical and Semestral Production

Different vegetables require different soil and climatic conditions, so production of particular vegetables is often concentrated in certain locations. Table 2 shows the regional and semestral distribution of vegetable area, production, and yield of different vegetables. The availability analysis is based on two semesters, i.e., January to June (first semester) and July to December (second semester).

In general, vegetables are produced year-round, but in greater quantities during the first semester due to favorable dry and cool weather (cabbage is an exception). Production of some types of vegetables is concentrated in particular regions.

Table 2. Regional vegetable area ('000 ha), production ('000 t), and yield (t/ha) in the Philippines, 1990

Vegetable/ region	1st Semester			2nd Semester			Total		
	Production	Area	Yield	Production	Area	Yield	Production	Area	Yield
Cabbage									
Cordillera	25.9	1.9	13.4	25.7	1.9	13.8	51.6	3.8	13.6
Philippines	34.6	3.3	10.5	33.7	3.1	10.7	68.3	6.4	10.6
Eggplant									
Ilocos	27.9	3.2	8.7	4.4	1.1	3.8	32.3	4.4	7.4
S. Tagalog	13.5	1.1	11.8	8.2	0.9	8.9	21.7	2.2	10.4
C. Luzon	13.4	1.9	7.0	4.0	0.8	5.2	17.5	2.7	6.5
Philippines	78.0	10.4	7.5	34.6	6.1	5.7	112.7	16.4	6.9
Garlic									
Ilocos	11.1	4.8	2.3	-	-	-	11.1	4.8	2.4
S. Tagalog	5.1	1.1	4.7	0.7	0.2	4.2	5.8	1.3	4.1
Philippines	17.1	6.1	2.8	0.8	0.2	4.0	17.9	6.3	2.2
Mungbean									
Ilocos	10.9	11.7	0.9	0.3	0.5	0.6	11.2	12.2	0.9
C. Luzon	3.1	4.8	0.7	0.1	0.1	0.4	3.1	4.9	0.6
Cagayan Valley	0.9	1.4	0.6	0.6	1.1	0.5	1.5	2.6	0.6
W. Visayas	2.4	3.8	0.6	0.5	0.8	0.6	2.9	4.6	0.6
C. Visayas	0.2	0.5	0.5	0.6	1.3	0.5	0.8	1.8	0.5
C. Mindanao	1.4	1.8	0.8	1.9	1.9	0.9	3.0	3.6	0.8
Philippines	21.4	27.8	0.8	5.3	8.9	0.6	26.7	36.7	0.7
Onion									
C. Luzon	32.9	3.2	10.2	0.5	0.1	7.7	33.4	3.3	10.2
Ilocos	19.5	1.7	11.8	6.4	1.0	3.2	25.9	2.6	9.9
Philippines	54.2	5.3	10.2	7.3	1.1	1.2	61.5	6.4	9.6
Tomato									
Ilocos	43.6	4.2	10.3	20.8	1.9	10.8	64.4	6.2	10.5
C. Luzon	21.7	3.0	7.5	1.9	0.4	4.8	24.6	3.4	7.2
S. Tagalog	19.9	2.0	9.9	3.8	0.7	5.2	23.8	2.7	8.7
W. Visayas	19.2	0.9	21.8	3.9	0.5	7.6	22.9	1.4	16.7
N. Mindanao	10.7	0.8	14.3	11.7	0.8	15.5	22.5	1.5	14.9
Philippines	134.2	14.0	9.6	49.8	8.0	8.3	184.0	20.0	9.2

Source: BAS (1992)
Note: C=Central; E=East; W=West; N=North; S=South

Trend Analysis

Production

The results of the trend analysis in area, production, and yield of major vegetable crops are reported in Table 3. Between 1975 and 1994, the total area devoted to vegetables decreased from 240,000 to 216,000 ha, and total production remained at around 2.2 million t. The production did increase in the earlier years, but declined in the later years of the study period as is evident from the negative quadratic term. The same is true for yield, as it fluctuated between 8 and 9 t/ha.

Table 3. Trends in vegetable area, production, and yield in the Philippines, 1975–94

Vegetables	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
Cabbage	-0.040	0.002	0.023	-	0.070	-0.002
Eggplant	-0.047	0.002	0.048	-0.001	0.095	-0.003
Fruit vegetables	0.061	-0.003	0.012	-0.004	0.024	-
Garlic	0.091	-0.004	-0.004	-	0.081	-0.003
Leafy vegetables	0.011	-	0.063	-0.002	0.063	-0.003
Legumes	-0.062	0.003	0.116	-0.004	0.178	-0.007
Mungbean	-0.012	-	0.063	-0.003	0.072	-0.002
Onion	-0.086	0.003	0.011	-	0.061	-0.001
Tomato	0.001	-	0.040	-0.001	0.949	-0.002
All vegetables	0.012	-	0.031	-0.001	0.031	-0.001

- implies that the coefficient is not significant at the 5% level.
Source: Estimated from data obtained from official files of the Bureau of Agricultural Statistics, Quezon City, Metro Manila.

With few exceptions, stagnation or even decline in the yield of most individual vegetables between 1975 and 1994 is apparent by the negative quadratic terms. Production of most of the individual vegetables also faced stagnation after increasing in the earlier years. Trends for area for the individual vegetables were mixed; some vegetables decreased in earlier years but started picking up in the later years, and vice versa for others; in some cases the area showed a linear trend.

The trend in area under eggplant cultivation was characterized by a generally declining trend, from 19,290 ha in 1973 to 14,270 ha in 1983, and then a generally increasing trend up to 1994. Total production, on the other hand, went up quite rapidly between 1973 and 1982 (by 50%), after which it generally followed a declining trend. Eggplant yield peaked at 8.50 t/ha in 1982, but this level was not achieved again. By 1994, the yield was down to 6.40 t/ha, which is almost the same as the average yield of 6.39 t/ha during the whole period of 1973–94.

Three periods can be distinguished with respect to the changes in area devoted to cabbage during 1973-94: (1) 1973 to 1978, when area increased from 6730 to 9360 ha; (2) a declining trend from 1978 to 1984, when area was down to less than 6000 ha; and (3) an increasing trend from 1984 to 1993, when area reached 7786 ha. The second peak, however, was less than the area planted to cabbage in 1974. Yield showed an upward jump from 7.2 t/ha in 1979 to 10.5 t/ha in 1982, and remained almost stagnant for the remainder of the period.

Onion production reached a peak of 84.7 million t in 1978, while onion acreage reached a peak of 12,700 ha in 1975. In 1979, both area and production plunged to less than one-half of the previous year's level. After this, production exhibited an upward trend, but up to 1993 it had not reached the 1978 level. Yield of onion doubled from 4.53 t/ha in 1973 to 9.31 t/ha in 1993.

Mungbean showed an increasing trend in area planted and production from 1974 to 1980. Area increased by 34%, while production doubled due to a rise in yield from 0.43 t/ha to 0.65 t/ha. However, this was followed by a sharp decline in area, by about 16,000 ha, resulting in production decreases of 7500 t, despite the continued increase in yield from 0.65 t/ha to 0.74 t/ha. After 1981, mungbean production leveled off due to stagnant yields in the 1980s and early 1990s.

Prices

The nominal long-term price trends in wholesale and retail prices of vegetables for the period 1975–94 are shown in Table 4; the trend in the consumer price index (CPI) is also shown, for comparison.

Table 4. Growth rates (%/annum) in selected vegetable prices in the Philippines, 1975–94

Vegetable	Wholesale price		Retail price	
	Nominal	Real[b]	Nominal	Real[b]
Ampalaya	10.7	-1.2	11.4	-
Cabbage	11.4	-	13.5	1.7
Celery	9.3	-2.6	12.7	0.9
Chayote	11.7	-	13.7	1.8
Eggplant	14.5	2.6	11.7	-
Garlic	13.4	-	13.4	-
Ginger	12.4	-	13.1	-
Onion	12.4	-	12.9	-
Pechay (Baguio)	9.1	-2.8	11.5	-
Pechay (native)	11.3	-	12.6	0.7
Pepper	12.2	-	12.6	0.7
Squash	10.8	-	12.1	-
Tomato	9.6	-2.3	9.6	-2.2
Upo	12.1	-	11.9	-
All vegetables[a]	12.3	-	12.2	-
CPI	12.6	-	12.6	-

- implies that the growth rate is not significant at the 5% level.

[a]The "all vegetables" prices were estimated by taking the weighted average prices of tomato, eggplant, cabbage, onion, garlic, pechay (average of Baguio and native), amalaya, squash, and pepper. Weighted averages were estimated from the relative shares of each vegetable in the total production of these vegetables.

[b]The real prices are estimated by dividing the nominal prices by the Consumer Price Index (CPI).

The nominal retail prices of cabbage, celery, chayote, peachay (native), and pepper increased more than the CPI, so their real prices increased during the study period. The retail prices of onion,

eggplant, pechay (Baguio), ginger, ampalaya, squash, and upo increased at almost the same rate as the CPI, so their real prices did not have any significant trend. Only the tomato price increased less than the CPI, so its real price showed a decreasing trend.

In general, there is no trend in the real weighted average prices of all vegetables at either the retail or wholesale levels. The wholesale nominal price of most individual vegetables increased at a rate less than or equal to the CPI, so the real wholesale vegetable prices either declined or the trends remained insignificant during 1975–94, except for eggplant price, which increased more than the CPI.

Seasonality

Evidence from Macro-level Data

Prices of most vegetables are higher during the May–July and during the last quarter of the year than they are during February–April (Table 5). The fact that mungbean has the lowest seasonality in prices is a reflection of the fact that it can be easily stored.

Table 5. Seasonal wholesale price index of major vegetables in the Philippines, by monthly average, for 1982–94

Vegetable	Month												Season-ality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	
Ampalaya	100	99	87	85	99	121	134	116	118	142	159	149	87
Cabbage	100	92	97	106	125	143	136	120	134	143	150	141	64
Celery	100	101	100	102	155	168	183	174	165	195	153	167	96
Chayote	100	105	107	106	133	136	148	137	120	116	143	150	50
Eggplant	100	91	86	82	85	93	107	101	98	109	136	130	67
Garlic	100	91	73	70	75	78	89	121	91	94	103	116	74
Ginger	100	102	94	101	114	123	138	142	146	139	126	128	46
Gourd	100	95	86	82	93	103	104	109	123	118	143	137	75
Mungbean	100	100	98	99	95	97	100	104	107	112	112	116	23
Onion	100	87	62	47	48	57	69	74	80	90	107	117	146
Pechay (Baguio)	100	97	103	107	127	144	135	121	137	146	150	142	56
Pechay (Native)	100	105	95	93	116	133	125	118	125	145	144	135	56
Squash	100	107	104	102	111	117	115	124	120	119	123	144	44
Tomato	100	92	76	81	112	141	179	171	163	180	222	230	203

Evidence from Micro-level Studies

The above conclusion of high seasonality in vegetable prices can be confirmed from micro-level studies. These studies found vegetable price indices to be generally lowest in March to May (during the dry season) when major harvests occur, and higher from September to December, reflecting greater demand relative to supply (Table 6).

Table 6. Review of literature on price variation in vegetables

Crop/ Place of study	Period	Minimum	Maximum	Source
Cabbage				
Benguet	1977	August	September	Buaser 1978
Eggplant				
Philippines	1980s	April - May	na	Pabuayon et al. 1988
Ilocos, S. & N. Mindanao	1980s	Aug. - Oct.	na	Pabuayon et al. 1988
Cebu	1979-80	June-July	August, February	Valiente et al. 1980
Garlic				
Iloilo (wholesale)	1973-1980	April	March	Hormilla 1982
Iloilo (retail)	1973-1980	March-April	January	Hormilla 1982
Laoag (wholesale)	1973-1980	March	February	Hormilla 1982
Laoag (retail)	1973-1980	March-April	January	Hormilla 1982
Mungbean				
Philippines	1967-1977	March - April	Sept. - Dec.	BAEcon 1978b
Ilocos, Luzon	1960s-1980s	Jan. - June	na	Pabuayon et al. 1988
Tomato				
Benguet	1977	March	September	Buaser 1978
Luzon	1980s	Jan. - May	na	Pabuayon et al. 1988
Northern & S. Mindanao	1980s	July - Sept.	na	Pabuayon et al. 1988
White Potato				
Benguet	1977	April - Oct.	December	Buaser 1978

However, seasonal variation in prices depends upon the occurrence of typhoons, and regional variations in climate.

Risk in Production

Detrended coefficients of variation (CV) for vegetable area, production, and yield are reported in Table 7 (with the detrended CV for rice included for comparison). CVs for vegetables are higher than for rice, indicating the relatively higher risk in vegetable production.

For all vegetables together, leafy/stem vegetables, and eggplant, variability in yield is much higher than variability in area, implying that technological innovations aimed at stabilizing vegetable yields in these crops would help to stabilize vegetable production in the Philippines. By contrast, for cabbage, garlic, onion, potato, and tomato, variability in area is higher than variability in yield, suggesting that the policy environment, especially output prices, which farmers consider when making their decisions about acreage allocation to each vegetable, varies considerably from year to year.

Variability in vegetable production leads to variability in their prices. The detrended CVs of wholesale and retail vegetable prices are reported in the last two columns in Table 7. Annual average vegetable prices fluctuate considerably. The highest variation in prices is for garlic, at the wholesale and retail levels.

Table 7. Detrended coefficients of variation in area, production, yield, and prices of selected vegetables, 1973–94

Vegetable	Area	Yield	Production	Prices	
				Wholesale	Retail
Cabbage	11.8	7.8	8.3	20.6	18.2
Eggplant	9.6	14.3	9.2	13.3	18.9
Garlic	17.5	11.7	12.8	38.0	34.1
Onion	24.2	7.9	23.0	29.2	29.1
Potato	8.2	7.5	11.1	12.2	11.8
Tomato	7.9	5.7	9.4	12.0	21.4
Other fruit vegetables	10.6	10.1	11.4	11.8	16.1
Other leafy and stem vegetables	3.2	10.6	9.7	10.5	15.0
All vegetables	4.4	7.5	9.1	-	-
Rice[a]	3.7	3.8	3.9	2.1	1.8

Sources: Same as in Table 3.

[a]The CV for rice is estimated from data taken from IRRI (1995), but the available time series in this source is only for 1973–90. The prices of other fruit vegetables are the average prices of squash, ampalaya, and sweet pepper, while the prices of leafy and stem vegetables are the average prices of pechay (Baguio), pechay (native), and celery.

Farm Management Practices

Table 8 shows the growing season, ecology, and major varieties grown for selected vegetables as reported in the literature.

Table 8. Planting/growing season, ecology, and varieties of selected vegetables

Vegetable	Growing season	Ecology*	Variety
Bitter gourd	Year round. Cultivation in October-December and harvesting in May-July is best	Upland	Sta. Rita, Makiling, Jade Star A, Jade Star L.
Bush snap beans	November - January	Highlands	Improved Tender Green Cheroke wax, Blue Lake Cape, Win
Cabbage	Year round, but best season is the cool months of September to February	Highlands	Scorpio, Rareball Globe Ring, Green Express, Marion Market, Copenhagen.
Celery	Year round	Upland	na
Chinese cabbage	Year round	All elevations but best in highlands	Reyna Elena, F1 Tropicana
Cucumber	Year round. Cultivation in October - December and harvesting in May-July is best	Highlands and lowlands with irrigation facilities	UPL Cu1, UPL Cu2 Explorer (pickling variety)
Eggplant	Year round	Upland	Dumaguete Long Purple, E.G. Long Purple

Contd. Table 8.

Vegetable	Growing season	Ecology*	Variety
Garlic	November - February December - March	Upland	Ilocos White Batangas Purple
Ginger	June-January and February-November	Upland	Red Native, Hawaiian, Imugan
Green onion	Year round	Highlands and upland	Not available
Mungbean	December - March	Highlands and upland	Native, MG-50, Taiwan Green, Pag-asa 2
Onion (bulb type)	October - February	Upland with low rainfall	Yellow Granex, Red Creole, Tropicana Hybrid, Dingras Red Globe, Native
Peas	Year round	Upland	Chinese Variety Kalantao Variety
Pechay	Year-round, but heavy planting in March and harvesting in May-July	Upland	Wongbok Black Bohi
Pole snap beans	Year round	Highlands	Sunrise Kentucky, Alno Beans, Kentucky Wonder, BSU Selection #1
Potato	Year round, but most favorable season is April-July.	Upland Lowland	Cosima, Greta, Red Pontiac, Granola, Mexican Var, Kennebec Cosima, Berolina, Kennebec
Processing tomato	November - January are best planting months	Lowland	Mapula
Soybean	October - December	Upland and lowland	Clark 63, UPL-Sy2 (CES 16-17), BPI Sy2, BPI Sy4, UPL Sy4
Squash	Year round but the best planting is in October-December	Upland	Rizalina, Native
String beans	Year round, but most profitable when grown in June-July and harvested in December-January	Upland	EG Pole Sitao DES Pole Sitao
Sweet pepper	Year round	Upland	California Wonder, Yelo Wonder
Table tomato	September-February	Upland and lowland	Pinagulan, Bonanza, Marilag, Marikit, BPI Claveria, VCII-I UG, VC48-I, CA 633, CA 530
Winged bean (Sigarillas)	September - October	Upland	Claveria #1 EG Seguidillas Selection

Source: Prepared from reviews of studies and discussions with experts in the Horticulture Section of Philippines Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD).

* Highland represents areas at relatively high altitude with cooler temperature, while upland represents areas with good drainage irrespective of the altitude.

Planting Time

Chinese cabbage and cabbage are year-round crops mostly grown on highlands, while tomato is a dry-season crop. Caldwell and Newsom (1984) reported that less than 5% of all farmers frequently plant tomato between March and August. Pole snap beans, eggplant, peas, celery, and green onion are mostly highland or upland crops and are grown year-round. String beans are most profitable when harvested during December-January (PCARRD 1983). However, Manipon and Carada (1980) reported two harvests of the crop: the first harvest in May-June, the second in August-September.

Pechay, squash, and bitter gourd are upland crops grown throughout the year, but each crop has a specific best planting time (Table 8). Cucumber is normally considered an upland or highland crop, but in the Philippines it is also grown in lowlands. Garlic and ginger are upland crops, and are highly seasonal. This seasonal characteristic heightens the need for storage facilities (Planas 1975).

Potato production in Benguet is an all-year crop. Harvest runs 3-4 months. The most popular planting period for potato is April to July; the least popular harvesting period is February to April (Lizarondo et al. 1979). Mungbean is a subsistence crop usually planted at the end of December and harvested in March. In the Ilocos region, mungbean on irrigated farms is planted in November - March and harvested in January-May. For rain-fed farms, the crop is planted in August-March and harvested in October-May. Soybean is planted throughout much of the year in the Ilocos region.

Vegetable Varieties

New tomato varieties, such as Pinagulan and Bonanza, that can be planted during the rainy season, are available and are being adopted by farmers. Other varieties have been developed at the University of the Philippines Los Baños (UPLB) and the Bureau of Plant Industry (BPI). The Asian Vegetable Research and Development Center's Mapula variety was introduced for processing purposes (Velmonte 1988).

Wet season potato cultivars in Benguet include Ancheta, Cosima, and Greta, while Coseria was popular among cooperators in the local RP/German Seed Potato Program (Potts et al. 1983). The dry season cultivar is known as Red Pontiac. Francisco et al. (1990b) reported that Granola is the most popular cultivar in the area because of its high yield and resistance to late blight. Old cultivars, such as the Mexican varieties, are still in use. Growers like these cultivars because of their resistance to late blight and water stress and the cheapness of their seed tubers, despite relatively low yields.

The Wongbok variety of pechay commanded a higher price than the native pechay variety (Mosuela and Asuncion 1986).

Cultivation Practices

Vegetables are grown as a secondary crop in rice-producing areas, especially in Central Luzon. Most specialized vegetable production is found in mountain areas (Tiongson 1976), but recently, vegetable production on a commercial scale has started in the highland areas of Southern Tagalog, Cebu, Negros, and Mindanao.

Cabbage is usually planted after potato, carrots, and garden peas, especially in the Benguet and Mountain Province areas. All farmers in these areas practice multiple cropping (Francisco et al. 1990a).

Diamondback moth is the most destructive insect pest on cabbage crops (Francisco et al. 1990a). Apart from excessive insecticide and fungicide use, several indigenous crop protection technologies are practiced, such as the use of tobacco leaves, hot pepper, pangutate leaves, waka and crude oil. Weeds are generally controlled manually.

Cabbage is harvested when heads are firm and compact. The two methods of harvesting cabbage are one-time (once-over) and the more popular selective harvesting two to four times per crop.

Highest plant survival in tomato is attained on plots treated with 20 t/ha compost and with complete fertilizer. The fertilizer treatment produces more and larger fruits (higher yield) than the use of compost (Salamatin 1981).

Francisco et al. (1990b) evaluated current production practices of potato farmers in Benguet and Mountain Province. All farmers interviewed use organic and inorganic fertilizers; organic fertilizer is applied once as a basal application 2–5 days before planting, and inorganic fertilizer (the most popular mixture is 14-14-14) is generally applied as a side dressing during hilling-up. Seed tubers are still the most popular planting material. To reduce seed costs, farmers cut seed tubers during planting. To protect the cut tubers from attack by insects and diseases, they are either dipped in chemical solutions or ashes, or are allowed to soberize by drying. Desprouting (removal of sprouts that are too long to be planted) is also practiced. Some farmers use chemicals, such as Progibb and Berelux, to break seed dormancy.

Late blight is controlled by fungicides, such as Dithane, Curzate, and Manzate, applied at 3–4-day intervals during the wet season and at 7–10-day intervals during the dry season. The most commonly used insecticides are metamidophos and fenvalerate, applied every 3–4 days during the wet season and at 7-day intervals during the dry season. The most common insect pests in the area include aphids, tuber moth, cutworms, thrips, and white fly.

Francisco et al. (1990b) also concluded that use of improved potato cultivars, planting of whole seed tubers, use of diffused light storage, and multiple cropping are all profitable.

It was noted by Gonzales (1974) that the average seeding rate in soybean cultivation in Davao is lower than in South Cotabato, thus resulting in a lower plant population and lower per hectare yields. The low yields in Davao are also attributed to the use of local varieties. The yield is low but more stable due to high degree of adaptability of varieties to the local conditions.

Economics of Production

Input Use

Table 9 summarizes some published studies on major inputs used for producing various vegetables. Generally, vegetables are more input-intensive than cereals, and there are indications of excessive input use. Potts et al. (1983) report that chicken manure's beneficial effect is most marked on dry soils or sites with shallow sub-soils.

Table 9. Major input use per ha in vegetables

Crop	Region	Fertilizer (kg)				Pesticide	Farm manure	Labor (days)			Reference
		N	P	K	Total			Hired	Family	Total (t)	
Bush sitao	Philippines	-	-	-	-	-	-	79	37	116	Mosuela & Afunggol 1986
Cabbage	Benguet	471	165	127	763	16[a],12[b]	6.7	-	-	-	Francisco et al. 1990a
Garlic	Batangas	19.3bags[c]				1.17 [d]	-	179	79	258	Sungcaya et al. 1981
Mungbean	Ilocos	-	-	-	49	-	-	21	39	60	Sayaboc et al. 1977
Potato	Benguet	201	160	152	513	14[a], 30[e]	6.0	-	-	-	Francisco et al. 1990b
Soybean	Davao	77	45	18	140	68[f]	-	130	410	540	Gonzales 1974
Rice		92	25	10	127	-	-	88	30	118	IRRI 1995[g]

[a] liters of insecticide; [b] kg of fungicide; [c] nutrient content not known; [d]quarts; [e] liters of fungicide; [f]Ounces; [g]average of different irrigated environments (gravity and deepwell); a dash (-) implies that information is not available.
Some recommended fertilizer application rates are a maximum of 360 kg/ha (240 N, 60 P, and 60K) for cabbage, 420 kg/ha (140 N, 140 P, 140K) for table potato, and 360 kg/ha (120N, 120P, 120K) for seed potato (Francisco et al. 1990b). Recommended rates of pesticide application for cabbage and potato are 9–11 liter/ha.

Farm-level Profitability

Table 10 summarizes information available in the literature regarding profitability in the cultivation of different vegetables. Because these studies were done over a span of 20 years on different sites, it is difficult to compare and contrast results, due to differences in cultivars used, farm management practices, prevailing market prices of outputs and inputs, and cost items included in these studies. Moreover, profitability can vary because of differences in environmental conditions, definition and number of inputs included in the estimation, and whether the estimates are under farmer's or experiment conditions. However, it can be concluded that returns on vegetables are positive in most cases.

Table 10. Review of literature on the economics of vegetable production in the Philippines

Crop/Place of study (species)	Year	Yield (t)	Gross return (000 pesos)	Total cost (000 pesos)	Net profit (000 pesos)	Profit-cost ratio	Cost/ kg	Reference
Black pepper								
Philippines	1985	0.70	2.22	2.32	-0.11	-0.05	3.31	Parado & Valdellon 1986
Batangas	1985	0.51	37.39	18.75	18.65	0.99	36.75	Tanyag & Afunggol 1986

Contd. Table 10.

Crop/Place of study (species)	Year	Yield (t)	Gross return (000 pesos)	Total cost (000 pesos)	Net profit (000 pesos)	Profit-cost ratio	Cost/ kg	Reference
Cabbage								
Philippines	1979	7.04	145.66	4.43	10.14	2.29	0.63	BAEcon 1982
Philippines	1974	6.03	110.67	2.10	8.58	4.09	0.35	BAEcon 1978c
Benguet & Mt. Prov	1985	24.40	65.57	35.60	29.91	0.84	1.46	Francisco et al. 1990a
Southern Tagalog	1977	18.22	11.17	8.55	2.43	0.28	0.47	Tanyag et al.1977
Carrots								
Benguet	1978	-	-	9.10	-	2.49	-	Lizarondo et al. 1979
Misamis Or.	1984	4.20	15.40	8.34	7.28	0.87	1.34	Lucido and Villegas 1986
Celery								
Benguet	1978	-	9.70	7.80	1.90	0.24	0.20	Lizarondo et al. 1979
Cucumber								
Batangas	1985	4.17	12.97	4.83	8.14	1.92	0.49	Cea & Basilio 1986
Eggplant								
Philippines	1977	-	2.81	1.43	1.38	0.96	-	BAEcon 1978a
Philippines	1985	-	28.19	14.40	13.76	0.95	0.47	Parado & Valdellon 1986
Garlic								
Ilocos (White Shank)	1984	1.69	-	-	24.06	1.35	-	Asuncion & de Luna 1986
Batangas (Red Shank)	1984	2.61	-	-	55.28	3.18	-	Asuncion & de Luna 1986
Philippines	1974	-	6.41	1.67	4.73	2.83	-	BAEcon 1982
Ilocos (White Shank)	1984	7.07	41.92	17.86	24.04	1.35	-	Batang et al. 1986
Ilocos Norte	1976	0.54	3.43	1.25	2.18	1.74	-	Cabebe & Domingo 1976
Ilocos Norte & Sur	1977	3.26	8.69	0.16	1.58	9.98	-	Medina et al. 1978
Batangas	1980	1.84	56.08	27.15	28.92	1.07	-	Sungcaya et al. 1981
Gourd								
Batangas (bitter gourd)	1985	9.25	17.97	10.69	7.28	0.68	0.16	Cea & Basilio 1986
Batangas (sponge gourd)	1985	9.11	58.99	49.97	9.02	0.18	5.49	Cea & Basilio 1986
Lettuce								
Benguet	1978	-	20.16	1.24	0.92	0.37	-	Lizarondo et al. 1979
Onion								
Philippines	1974	7.60	7.20	1.90	5.30	2.79	0.25	BAEcon 1978c
Luzon	1974	9.57	8.58	5.93	2.65	0.45	0.62	Tanyag et al.1977
Pechay								
Philippines	1974	2.90	1.99	1.19	0.80	0.67	0.42	BAEcon 1978c
Philippines								
(Wongbok var.)	1983	-	-	4.60	-	0.48	-	Mosuela& Asuncion 1986
(native var.)	1983	-	-	4.60	-	1.14		Mosuela& Asuncion 1986

Contd. Table 10.

Crop/Place of study (species)	Year	Yield (t)	Gross return (000 pesos)	Total cost (000 pesos)	Net profit (000 pesos)	Profit-cost ratio	Cost/ kg	Reference
Squash								
Batangas	1985	5.76	17.68	3.59	14.09	3.92	0.62	Cea and Basilio 1986
Misamis Or.	1984	4.20	5.02	2.48	3.07	1.24	0.59	Lucido and Villegas 1986
Sweet peas								
Benguet [small farmer]	1978	-	9.08	7.73	1.82	0.17	-	Lizarondo et al. 1979
Benguet [large farmer]	1978	-	11.27	5.17	3.44	0.48	-	Lizarondo et al. 1979
Sweet pepper								
Cebu	1985	-	-	6.80	-	1.16	-	Lucido & Lizarondo 1986
Philippines	1985	4.13	53.80	9.40	44.40	4.72	2.38	Parado & Valdellon 1986
Tomato								
Philippines	1977	5.99	3.46	1.35	2.10	2.85	-	BAEcon 1977
Philippines	1974	3.03	2.79	1.25	1.54	1.23	0.41	BAEcon 1978c
Cebu	1985	18.45	-	9.40	1.33	0.14	0.51	Lucido & Lizarondo 1986
Philippines	1985	7.83	13.07	7.11	5.96	0.83	0.91	Parado & Valdellon 1986
Vegetable legumes								
Mungbean								
Philippines	1978	0.38	1.53	0.85	0.68	0.80	2.24	BAEcon 1978b
Philippines	1976	0.41	0.27	0.36	0.91	2.52	0.88	Cabebe & Domingo 1976
Philippines (HYV)	1985	0.30	1.94	0.98	0.96	0.99	3.27	Gabito & Almeda 1986
Philippines (traditional)	1985	0.28	1.66	1.00	0.66	0.66	3.57	Gabito & Almeda 1986
Pangasinan, Ilocos Sur, & La Union	1977	0.36	1.64	1.66	-0.01	-0.01	4.61	Sayaboc et al. 1977
Soybean								
Philippines	1976	0.89	1.83	1.16	0.67	0.57	0.37	Medina et al. 1977
Philippines (Unusually heavy rains)	1986	-	-	4.17	3.43	0.82	-	PCARRD 1987
Beans								
Philippines (hebitchuelas)	1974	1.93	3.67	1.19	2.49	2.09	0.62	BAEcon 1978d
Philippines (string beans)	1974	3.92	4.15	2.14	2.02	0.94	0.55	BAEcon 1978d
Regions I, II, III & XI (sitao)	1977	2.18	1.39	1.52	0.88	0.58	0.70	BAEcon 1978d
Philippines (string beans)	1978	-	4.64	2.38	2.26	0.95	0.61	Lizarondo et al. 1979
Philippines (bush sitao)	1983	1.04	12.00	4.79	7.21	1.51	-	Mosuela & Afunggol 1986
Philippines (string bean)	1980	-	12.00	8.70	3.32	0.38	-	PCARRD 1983
Philippines (pole snap bean)	1980	-	12.00	8.40	3.50	0.42	-	PCARRD 1983
Philippines (lima bean)	1980	-	10.00	7.70	2.31	0.30	-	PCARRD 1983
Philippines (cowpea)	1980	-	6.00	3.00	3.00	1.00	-	PCARRD 1983
Philippines (bush string beans)	1980	-	7.00	3.00	4.00	1.30	-	PCARRD 1983

Contd. Table 10.

Crop/Place of study (species)	Year	Yield (t)	Gross return (000 pesos)	Total cost (000 pesos)	Net profit (000 pesos)	Profit-cost ratio	Cost/ kg	Reference
White potato								
Benguet, Mt. Province	1985	15.10	69.02	50.22	18.80	0.37	3.33	Francisco et al. 1990b
[on high elevation with modern technology]								
Bukidnon	1977	-	16.82	9.72	7.10	0.73	0.89	Manto et al. 1978a
Luzon	1977	-	12.69	9.20	3.49	0.38	1.13	Manto et al. 1978b
Cebu	1978	0.36	3.82	3.66	0.16	0.04	18.17	Olgado et al. 1978
Benguet, Bukidnon, Cebu, Davao, South Cotabato	1978	-	17.69	8.59	4.09	0.48	1.05	Olgado et al. 1979

Dash (-) implies data are not available.
Note: The cost in all of these studies includes both cash and non-cash costs and includes the value of family resources such as family labor and land.

Factor Share

The factor shares of different inputs in the total cost, as reported in different studies, are summarized in Table 11. Factor shares vary across vegetables, but generally labor is a major input for all vegetables, as are chemicals, including fertilizer.

Table 11. Factor share of different inputs (%) in vegetables

Vegetable	Labor	Fertilizer	Pesticide	Seed	Manure	Others	Reference
Beans	46	(24% - fert., pesticides & seed)			-	30	BAEcon 1978d
Cabbage	35	32	13	7	-	13	BAEcon 1982
Cabbage	-	-	34-44	-	-	-	Rola 1989
Cabbage	30	(70% - fert., pesticides & seed)			-	-	Lizarondo et al. 1979
Eggplant	30	(34% on fertilizer and chemicals and 36% on fixed costs)					BAEcon 1982
Garlic	21	7	1	38	-	33	Asuncion & de Luna 1986
Ginger	62	(3% - fert., pesticides & seed)			35	-	BAEcon 1978c
Mungbean	40	1	6	10	-	43	BAEcon 1978b
Onion	51	(20% - fert., pesticides & seed)			-	29	BAEcon 1978e
Soybean	37	19	7	9	-	28	PCARRD 1987
Soybean	46	12	7	9	-	26	Gonzales 1974
String beans	65	(12% - fert., pesticides & seed)			-	23	BAEcon 1978d
Tomato	36	(26% - fert., pesticides & seed)			38	-	BAEcon 1977

Comparative Advantage and Protection

The Philippines is known to have a comparative advantage in garlic production (Batang et al. 1986).

According to the same source, the Philippines will maintain its comparative advantage in onion production over imports, even if onion yields drop to 4.96 t/ha. There is a need to study the comparative advantage for individual vegetable species and identify the areas most suitable for their production.

Production Constraints

In general, vegetable yield per unit area in the Philippines is considered far below potential, as achieved by the best farmers or at experiment stations, and the quality of production has much to be desired. Some of the constraints in vegetables, as described in different studies, are summarized in Table 12. Panganiban (1976) summarized these constraints as: 1) unavailability of quality seed; 2) poor cultural practices; 3) excessive insect and disease damage; 4) limited knowledge of proper post-harvest handling of vegetables; 5) inadequate marketing systems; 6) limited transportation, processing, and storage facilities; and, 7) inadequate number of trained and dedicated extension workers.

Table 12. Constraints in vegetable production

Vegetables studied	Place of study	Vegetable production constraints											Reference
		1	2	3	4	5	6	7	8	9	10	11	
Asparagus		-	-	X	-	-	-	-	-	-	-	-	Salamero 1986
Cabbage	Ilocos	-	X	-	-	-	-	-	-	-	-	-	Caldwell and Newsom 1984
Cabbage	Benguet	X	X	-	-	-	-	-	-	-	-	-	Francisco et al. 1990a
Cabbage	Nueva Ecija	-	X	-	-	-	-	-	-	-	-	-	Tanyag et al. 1977
Cucurbits	Negros Occ.	-	X	-	X	-	-	X	-	X	-	-	Arancello and Cea 1986
Eggplant	Laguna	-	-	-	X	-	-	-	-	-	-	-	Salamatin 1981
Garlic	Philippines	-	-	X	X	X	-	-	-	-	-	-	Batang et al. 1986
Gourd	Misamis Or.	-	X	-	-	-	-	-	-	-	-	-	Lucido and Villegas 1986
Legumes	Philippines	-	-	X	X	X	X	-	-	-	-	-	Escueta 1984
Legumes	Philippines	-	-	X	-	-	-	-	-	-	-	-	Pantastico and Lavadia 1982
Onion	Nueva Ecija	X	X	-	X	-	-	-	-	-	-	-	Tanyag et al. 1977
Potato	Benguet	-	-	X	-	-	-	-	-	-	-	-	Baniqued and Balanoing 1987
Potato	Benguet	-	-	X	-	-	-	-	-	-	-	-	Francisco et al. 1990b
Potato	Philippines	X	-	X	-	-	-	-	-	-	-	-	Perez and Almeda 1983
Soybean	Nueva Ecija	-	X	-	X	-	-	X	-	-	-	X	Manuel et al. 1987
Soybean	Philippines	-	-	-	-	-	-	X	-	-	-	-	Caldwell and Newsom 1984
Soybean	Philippines	-	-	-	-	-	-	X	-	-	-	-	Ibuki and Abarientos 1972
Soybean	Philippines	-	-	-	-	-	-	-	-	-	-	X	PCARRD 1981
Tomato	Ilocos	X	X*	X	-	-	-	X	-	-	-	-	Caldwell and Newsom 1984
Vegetables	-	-	X	X	X	-	X	-	X	-	-	-	Panganiban 1976

Constraints: 1 = high input cost or low output price; 2 = losses to pests and diseases (*fungal diseases are more serious); 3 = lack of seeds or planting materials; 4 = institutional constraints, including lack of capital, inputs, or information, poor extension, research, roads, suboptimal use of inputs, etc.; 5 = lack of post-harvest and storage facilities; 6 = inadequate marketing systems, resulting in low product prices, price instability, high margins, etc.; 7 = biological constraints, including poor plant growth and poor fruit setting; 8 = poor cultural practices; 9 = excessive rains, flooding or bad weather; 10 = lack of appropriate variety; 11 = policy constraints, including size of land holding, subsidies, and taxes, etc.
Dash (-) implies that the constraint was not studied, it was not important, or information was not available.

Marketing Systems

Marketing arrangements for vegetables vary widely from region to region and depend on the type of production system involved. Homestead production of vegetables is widespread, but has little importance from a marketing viewpoint.

The choice of a market outlet is influenced by the prices offered and the existence of alternatives. Other considerations include the perishability of the product, urgent need of money for farm operations, credit tie-up arrangements with buyers, and farmers' attitudes (Librero et al. 1987).

Many farmers have some form of credit tie-up with their buyers resulting in the latter's dominance in price determination at transaction time. Middlemen purchase vegetables from farmers on a cash-and-carry basis (Mugot 1972).

Marketing Channels

Most vegetables pass through wholesalers and retailers before they reach consumers. Most often, the wholesaler is responsible for assembling and retailing the produce, and financing production and marketing. The following marketing channels have been identified in vegetables in different studies:

(I) Three-layer channels

farmer→wholesaler/retailer→consumer
farmer→retailer→consumer

(II) Four-layer channels

farmer→wholesaler/retailer→retailer→consumer
farmer→wholesaler→retailer→consumer
farmer →local buyer→retailer→consumer

(III) Five-layer channels

farmer →assembler/wholesaler→financier/wholesaler→retailer→consumer
farmer→wholesaler→wholesaler/retailer→retailer→consumer
farmer →local buyer→wholesaler→retailer→consumer
farmer→agent/wholesaler→processor/financier→retailer→consumer
farmer→agent→wholesaler→retailer→consumer
farmer→agent→wholesaler/retailer→retailer→consumer
farmer→assembler/wholesaler→wholesaler/retailer→retailer→consumer

(IV) Six-layer channels

farmer→assembler/wholesaler→wholesaler→wholesaler/retailer→retailer→consumer
farmer→local buyer→wholesaler→wholesaler/retailer→retailer→consumer
farmer→wholesaler→middlemen→processor→retailer→consumer
farmer→agent→wholesaler→wholesaler/ retailer→retailer→consumer

(V) Seven-layer channels

farmer→agent→financier/wholesaler/shipper→wholesaler→ wholesaler/retailer/shipper→wholesaler/retailer→consumer
farmer→agent/wholesaler→assembler/wholesaler→wholesaler→wholesaler/retailer →retailer→consumer
farmer→agent→assembler/wholesaler→wholesaler→wholesaler/retailer→retailer→ consumer

(VI) Eight-layer channels

farmer→agent→assembler/wholesaler→financier/wholesaler/shipper→wholesaler→ wholesaler/retailer→retailer→consumer

(VII) Nine-layer channels

farmer→agent→contract buyer→contract buyer/agent/wholesaler →agent/wholesaler →wholesaler→wholesaler/retailer→retailer→exporter/consumer

The vegetable distribution system in the Philippines is rarely the simple three- or four-layer channel; channels III and IV are the most common (Table 13).

Table 13. Marketing channels for selected vegetables in the Philippines

Crop	Study year	Place of study	Market channel	Source
Baguio beans	-	Claveria	III, II, IV	Valiente et al. (1981b)
Cabbage	-	Luzon-M. Manila	III, I, II	Faylon et al. (1981)
Cabbage	-	Luzon-provincial	I, II	
Cabbage	1971-80	Philippines	IV	BAEcon (1982)
Cabbage	1989	S. Mindanao	IV	Angelica (1989)
Cabbage	1981	Claveria	V	Valiente et al. (1981b)
Cucurbits	-	Misamis Or.	III, I	Lucido and Villegas (1986)
Eggplant	-	Luzon-M. Manila	II, I	Faylon et al. (1981)
Eggplant	-	Provincial	III	
Eggplant	1989	Southern Mindanao	III	Angelica (1989)
Garlic	1977-78	Ilocos Region	VII	Medina et al. (1978)
Onion	-	-	IV, I	Faylon et al. (1981)
Onion	-	-	III	BAEcon (1978e)
String beans	-	Southern Mindanao	III	Angelica (1989)
Tomato	-	Luzon-M. Manila	II, III, V	Faylon et al. (1981)
Tomato	-	Luzon-provincial	I, II	
Tomato	1989	S. Mindanao	IV	Angelica (1989)
White potato	1978	Cebu	III	Olgado et al. (1978)
White potato	1977-78	Bukidnon	V	Manto et al. (1978a)
White potato	1977-78	Cordillera	VI	Manto et al. (1978b)
White potato	1978	Philippines	VI	Olgado et al. (1979)

No set channel for vegetable distribution can be observed, and a vegetable can have a different channel in different areas.

Output Flow in Alternative Marketing Channels

Generally, the wholesalers (or a variation, such as wholesaler/financier, wholesaler/retailer, assembler/wholesaler) dominate the market, and get the major share of vegetable output from farmers (Table 14). However, upland farmers, who usually grow vegetables in an agroforestry system, generally trade with retailers directly. Calderon and Diza (1986) found 79% of volume sold directly to retail markets.

Table 14. Volume sold by producers to different market channels (%)

Crop/Place of study	Agent	Contract buyers	Assembler/ Wholesaler	Processor/ Financier/ Cooperator/ Shipper/ Exporter	Whole-saler	Whole-saler/ Retailer	Retailer	Source
Baguio beans								
Claveria	5.0[a]	-	-	6.0[b]	19.0	68.0	2.0	Valiente et al. 1981b
Cabbage								
Philippines	-	-	58.0	-	29.0	9.0	4.0	BAEcon 1982
Claveria	18.0	-	55.0	-	24.0	1.0	2.0	Valiente et al. 1981b
Eggplant								
S. Mindanao	-	-	56.0	-	-	37.0	7.0	Angelica 1989
Philippines	-	-	-	-	79.0	4.0	17.0	BAEcon 1982
Garlic								
Ilocos	-	-	-	45.0[c]	31.0	-	24.0	Castro et al. 1986
Ilocos Region	18.7	3.8 0.7[e]	35.0	2.2[d] 3.6[f]	28.0	2.4	5.6	Medina et al. 1978
Mungbean								
Tarlac	-	-	-	-	55.0	19.0	26.0	Maron & Lizarondo 1981
Pechay								
S. Mindanao	-	-	51.0	-	36.0	-	13.0	Angelica 1989
Sitao								
S. Mindanao	-	-	-	-	65.0	31.0	4.0	Angelica 1989
Soybean								
S. Mindanao				74[g], 26[h]				Medina et al. 1977
String beans								
S. Mindanao	-	-	30.0	-	26.0	24.0	20.0	Angelica 1989
Tomato								
S. Mindanao	-	-	48.0	-	36.0	8.0	8.0	Angelica 1989

Contd. Table 14.

Crop/Place of study	Agent	Contract buyers	Assembler/ Wholesaler	Processor/ Financier/ Cooperator/ Shipper/ Exporter	Whole-saler	Whole-saler/ Retailer	Retailer	Source
White potato								
Cebu	-	-	-	-	61.0	25.0	14.0	Olgado et al. 1978
Bukidnon	5.0	-	-	64.0[i] 10.0[j]	11.0	10.0	-	Manto et al. 1978a
Cordillera	44.0	-	9.0	31.0[i]	11.0	4.0	1.0	Manto et al. 1978b
Philippines	28.0	-	9.0	40.0[k]	12.0	9.3	1.7	Olgado et al. 1979
Batangas	53.0[a]	-	-	-	-	41.0	6.0	Sungcaya et al. 1981

The following market channels are implied for each superscript: [a]=agent/wholesaler; [b]=assembler; [c]=farmers themselves; [d]=exporter; [e]=contract buyer/assembler/wholesaler; [f]=institutional consumer; [g]=feed processor; [h]=tokwa processor; [i]=financier/wholesaler/shipper; [j]= financier/wholesaler/retailer/shipper; [k]=financier/wholesaler. The slash (/) represents the double or triple function of the same agent.

Marketing Efficiency

Most studies judge marketing efficiency using any one, two, or three of the following criteria:

i) Marketing cost as a proportion of consumer price (MCPCP), where marketing cost includes labor in hauling, grading, and packaging the product, and other cost items, such as market fees, packaging materials, rent, depreciation, and transportation, and product losses during marketing. However, marketing cost does not include the profit of the marketing agent. The greater the MCPCP, the less efficient the market is considered to be.

ii) Gross margin of the marketing agents as a proportion of consumer price (GMPCP), where gross margin includes marketing costs as above, and profit, losses, and value added. Naturally, GMPCP is always higher than MCPCP.

iii) Marketing costs as a proportion of gross margins (MCPGM). A low MCPGM means that the traders get higher margins, while a high MCPGM implies that most of the traders' margins go towards marketing costs.

Table 15 shows comparisons of marketing efficiencies at different marketing levels in the Philippines.

Table 15. Comparison of marketing efficiency criteria at different marketing levels

Crop/ Place of study	Type of market inefficiency	Agent	Contract buyers	Assembler/ Wholesaler	Processor/ financier/ Cooperator/ Shipper/ Exporter	Wholesaler	Wholesaler/ retailer	Retailer	Average total margin	Source
Baguio beans										
Misamis Or.	iii)	58.00	-	-	-	41.0	2.0	-	-	Valiente et al. 1981b
Cabbage										
S. Mindanao	i)	-	-	1.33	-	2.54	0.48	2.91	7.24	Angelica 1989
	ii)	-	-	2.58	-	3.72	4.98	9.56	20.84	
	iii)	-	-	51.76	-	68.28	9.74	30.42	-	
Claveria	i)	-	-	2.99	-	1.70	-	0.66	5.35	Valiente et al. 1981b
	ii)	-	-	21.62	-	8.69	13.51	11.20	55.02	
	iii)	-	-	13.84	-	19.56	-	0.05	-	
Eggplant										
S. Mindanao	i)	-	-	0.78	-	-	0.77	2.34	3.89	Angelica 1989
	ii)	-	-	4.29	-	-	5.89	15.86	24.04	
	iii)	-	-	18.00	-	-	13.00	15.00	-	
Garlic										
Ilocos Region	i)	0.08	2.80, 2.49[a]	0.86	7.17[b]	0.55	0.55	2.26	14.27	Medina et al. 1978
	ii)	1.01	3.27, 2.85[a]	4.05	11.29[b]	2.49	2.73	13.24	20.08	
	iii)	7.69	85.7, 86.5[a]	21.15	63.45[b]	21.87	20.00	17.06	-	
Batangas	i)	-	1.96	-	-	-	0.16	0.52	2.64	Sungcaya et al. 1981
	ii)	-	28.10	-	-	-	10.19	11.04	49.33	
	iii)	-	6.99	-	-	-	1.59	4.70	-	
Batanes	i)	-	28.00	-	-	-	10.00	-	38.00	Puno 1993
Mungbean										
Nueva Ecija	ii)	-	3.48	-	-	6.06	5.27	-	14.81	Balingit 1983
Tarlac	i)	-	-	-	-	0.36	2.25	4.15	4.76	Maron &
	ii)	-	-	-	-	6.76	-	-	4.76	Lizarondo 1981
	iii)	-	-	-	-	5.26	-	-	-	
Tomato										
S. Mindanao	i)	-	-	1.30	-	1.29	1.20	0.72	4.57	Angelica 1989
	ii)	-	-	4.55	-	4.74	7.10	6.38	22.77	
	iii)	-	-	28.50	-	27.27	16.83	11.36	-	
White potato										
Bukidnon	i)	14.95	-	-	5.93[c], 3.61[d]	0.26	1.55	1.29	23.98	Manto et al.
	ii)	34.26	-	-	15.21[c], 12.89[d]	9.79	13.40	11.80	84.46	1978a
	iii)	43.61	-	-	38.98[c], 28.00[d]	2.63	11.54	11.11	-	
Cordillera	i)	3.07	-	3.32	-	1.12	0.15	3.60	11.24	Manto et al. 1978b
	ii)	7.73	-	6.96	-	10.05	7.99	17.78	50.51	
	iii)	39.77	-	47.74	-	11.13	1.87	20.23	-	

Contd. Table 15.

Crop/ Place of study	Type of market ineffi-ciency	Agent	Contract buyers	Assembler/ Wholesaler	Processor/ financier/ Cooperator/ Shipper/ Exporter	Whole-saler	Wholesaler/ retailer	Retailer	Average total margin	Source
Cebu	i)	-	-	-	-	2.32	1.80	-	4.13	Olgado et al. 1978
	ii)	-	-	-	-	20.36	18.04	16.49	54.89	
	iii)	-	-	-	-	11.39	10.00	15.62	-	
Philippines	i)	4.26	-	4.35	4.01[e]	1.15	0.16	1.76	15.69	Olgado et al. 1979
	ii)	10.24	-	8.91	12.03[e]	7.35	8.91	13.81	61.25	
	iii)	41.54	-	48.87	33.31[e]	15.64	1.77	12.87	-	

The following market channel or agents are implied for each superscript: [a]= contract buyer/assembler/wholesaler; [b]= exporter; [c]= financier/wholesaler/shipper; [d]= financier/wholesaler/retailer/shipper; [e]=financier/wholesaler. For the definitions of the different market efficiencies (i, ii, iii), please see the text.

Generally, high MCPCP leads to high GMPCP, indicating that more marketing investment by middlemen earns higher gross margin. For example, the highest MCPCP was obtained by the retailer among all the other agents of cabbage in south Mindanao, and the retailer also had the highest GMPCP. With few exceptions this is true for all vegetables at 21 sites, reviewed in Table 15. It should be noted, however, that the reverse is not true, i.e., the lowest MCPCP among all the agents involved in a channel does not lead to the lowest GMPCP. Apparently this indicates some inefficiency in the marketing system. However, the higher GMPCPs of some agents, unrelated to their MCPCPs, might be due to the higher risks they have to shoulder in their channel.

Generally, MCPGM is lower for the retailer/wholesaler than the wholesaler, except for white potato in Bukidnon. The higher profit of the wholesaler/retailer compared to the wholesaler might be due to the wholesaler/retailer's duel function. There is no particular agent who is most efficient in all commodities with respect to MCPGM.

Marketing Constraints

Lack of reliable market information and poor transportation facilities result in low prices to producers. Other marketing constraints in the Philippines include low and fluctuating prices and unreliable outlets (Lizarondo et al. 1982).

Due to a disorganized market in the Philippines (PCARRD 1991), marketing inefficiency of mungbean is high. Thus, it is cheaper to import mungbean from Thailand than to buy it from Mindanao.

As financiers provide the necessary inputs for onion production, farmers have to sell the produce to them at their dictated prices, thus reducing market efficiency (Faylon et al. 1981). Another problem is that buyers have precise size requirments for onions (Coloma 1980).

In general, there is a considerable amount of intra-agent flow of tomato at the wholesaler and wholesaler-retailer levels in Luzon (BAEcon 1982), and at the assembler/wholesaler, wholesaler, and wholesaler/retailer levels in Visayas-Mindanao (Valiente et al. 1980, 1981a, c). A considerable flow of eggplant between market agents of the same type is also observed, i.e., from wholesalers to wholesaler and retailer to retailer, making the marketing system quite complicated (BAEcon 1982). This is also an indication of imperfect information about prices.

Supply and Demand

Per Capita Availability

Total annual per capita vegetable availability in 1994 was estimated to be 30.2 kg, down from the highest level of 45.9 kg in 1981. Availability declined at the rate of 2.4% per year during this period (Table 16). The across-the-board decline in availability of almost all vegetables in the Philippines is a serious concern for policy makers and a challenge for researchers.

Per Capita Consumption

Consumption studies on vegetables are not as common as studies on production and marketing. Most of the consumption studies were done in the 1970s when Darrah and Associates conducted a series of surveys on food consumption patterns among Philippine households. These surveys were conducted by the Special Studies Division (SSD) of the Philippine Ministry of Agriculture in different regions of the Philippines from 1970 until 1979 (Dosayla and Darrah 1973; Santos et al. 1975, 1976; Aviguetero 1976). Aside from the SSD household survey data, several more recent studies done by the Food and Nutrition Research Institute (FNRI) and by others (Torres 1977; Lantican 1990) are available. Demand analysis of several vegetables is a topic of several graduate theses (Aure 1982; Piadozo 1982).

Table 16. Per capita availability of fresh vegetables (kg/capita/year) by species, 1978–93

Year	Mung bean	Tomato	Eggplant	Cabbage	Onion	Garlic	Water melon	Leafy & yellow vegetables	Legume pods	Other fresh vegetables	Total
1978	0.46	2.15	2.12	1.55	0.63	0.24	1.00	23.81	0.83	7.39	40.18
1979	0.47	2.14	2.14	1.43	0.66	0.22	1.01	26.72	0.91	9.33	45.02
1980	0.46	2.01	2.17	1.36	0.66	0.22	1.02	27.19	1.05	9.22	45.36
1981	0.44	1.94	2.24	1.26	0.45	0.24	1.02	24.81	0.93	9.57	42.91
1982	0.49	2.06	2.17	1.24	0.83	0.29	1.03	18.06	0.57	7.85	34.58
1983	0.48	2.62	2.01	1.16	1.01	0.25	1.03	19.52	0.63	7.75	36.47
1984	0.47	2.63	1.96	1.14	0.98	0.28	1.04	19.03	0.60	8.48	36.60
1985	0.47	2.38	1.90	1.16	0.96	0.28	0.75	19.23	0.62	8.81	36.56
1986	0.45	2.54	1.90	1.31	0.96	0.27	0.77	20.13	0.50	9.08	37.91
1987	0.46	2.59	1.89	1.23	1.05	0.24	1.53	17.78	0.49	8.20	35.47
1988	0.42	3.00	1.88	1.28	0.77	0.29	1.40	15.99	0.46	7.72	33.21
1989	0.44	3.02	1.85	1.12	1.07	0.29	1.28	14.31	0.43	10.04	33.86

Contd. Table 16.

Year	Mung bean	Tomato	Eggplant	Cabbage	Onion	Garlic	Water melon	Leafy & yellow vegetables	Legume pods	Other fresh vegetables	Total
1990	0.40	2.84	1.67	1.21	0.99	0.20	1.21	13.66	0.44	9.33	31.95
1991	0.36	2.59	1.73	1.30	0.95	0.18	1.38	13.49	0.42	9.18	31.59
1992	0.36	2.12	1.71	1.32	0.85	0.19	1.41	13.51	0.43	9.50	31.41
1993	0.36	2.22	1.86	1.30	0.91	0.24	1.26	13.19	0.45	8.41	30.20
Annual growth rate (%)											
	-1.77	-0.77	-2.40	-1.64	0.35	ns	2.5	4.9	-5.27	0.52	-2.4

Source: BAS, various years.

From data collated by Urbino et al. (1972) in the SSD surveys, Librero and Nasol (1974) computed daily per capita consumption of selected vegetables by income group (Table 17). For all vegetables except the roots/bulbs/tubers group, vegetable consumption by the high income group was 50 to 90% higher than vegetable consumption by the low income group. These conclusions are broadly consistent with those in Torres (1977). However, surveys conducted by FNRI in 1993 suggest much less difference (below 20%) in vegetable consumption by income group. Zipagang (1975) concluded that an increase in income led to a decrease in consumption of mungbean, enabling consumers to shift to other foods, such as meat and fish.

Table 17. Consumption of vegetables (g/capita/day) by income group

Type of vegetable	Vegetable consumption (g/capita/day)				
	Very low	Low	Medium	High	All groups
Fruit type	58	70	85	97	73
Leafy and yellow	37	43	53	56	45
Leguminous	16	20	26	30	21
Roots/bulbs/tubers	42	45	49	45	45
All vegetables	153	178	213	228	184

Source: Librero & Nasol (1974).

The types of vegetables most widely consumed seem to differ by income group (Dosayla and Darrah 1973; Santos et al. 1973). Cabbage and pechay are most preferred by the higher income groups, whereas lower income groups consume more sweet potato tips and swamp cabbage (kangkong) (Torres 1977).

Apart from the differences in vegetable consumption levels and patterns across income groups, wide regional differences can also be seen (Table 18).

Table 18. Vegetable consumption (g/capita/day) by region, 1993

Region	Green, leafy and yellow vegetables	Other vegetables	Total vegetables
Southern Tagalog	22	85	107
Bicol	27	74	101
Western Visayas	33	44	77
Central Visayas	30	30	60
Eastern Visayas	19	41	60
Western Mindanao	49	68	118
Northern Mindanao	38	74	112
Southern Mindanao	47	71	118
Central Mindanao	52	68	121
Philippines	77	30	107

Source: FNRI (Food and Nutrition Research Institute), official files.

Over-time comparison of available consumption studies again suggests a decline in vegetable consumption (Table 19).

Table 19. Average consumption (g/capita/day) of different types of vegetables, by year

Type of vegetable	Period						Percent increase (decrease)
	1973[a]	1975[b]	1978[c]	1982[c]	1987[c]	1993[c]	
Fruit type	67	56	-	-	-	-	-
Leafy and yellow	41	34	34	37	29	-	(21.6)
Leguminous	19	13	-	-	-	-	-
Roots, bulbs, tubers	50	60	37	42	22	-	(47.6)
Other vegetables	-	-	111	93	82	-	(11.8)
Total	177	163	182	172	104	106	(41.2)

Source of basic data: [a]Dosayla and Darrah (1973); [b]Santos et al. (1976); [c] FNRI (Food and Nutrition Research Institute) official file data.

Variations in vegetable consumption are evident among different households classified not only by income level, but also by sector, i.e., farm and non-farm. Farm households consume more vegetables than do non-farm households (Lantican 1990). Also, households engaged in diversified farming show greater vegetable consumption than do their monoculture counterparts. Vegetable consumption by high-income households in the coconut-based farming system and non-farming sectors was nearly twice that of the low-income groups and 17% higher than by the rice farmers (Isabelita and Lantican 1986). A recent study by AVRDC also found vegetable farmers consuming more vegetables than non-vegetable farmers.

Seasonal Consumption

Because the SSD surveys were carried out in different months of the year, seasonal variation in

patterns of consumption can be determined. An example of a within-year variation in vegetable consumption is presented in Table 20. The consumption of all fresh vegetables together is highest during the first quarter and lowest (30% less) during the last quarter of the year. This conclusion is consistent with the earlier analysis concluding that vegetable prices are highest during the last quarter and lowest during the first quarter of the year.

Table 20. Vegetable consumption (g/capita/day) by quarter, 1977

Item	1st quarter	2nd quarter	3rd quarter	4th quarter
Total fresh vegetables	183	152	144	128
Leafy and yellow vegetables	29	35	37	33
Fruit vegetables	51	52	53	45
Leguminous vegetables	8	9	16	9
Roots/bulbs/others	94	56	38	41

Source: Santos (1979)

Valiente et al. (1980) noted that in Cebu, sweet potato sales are highest in January-March, while July has the lowest level of purchases. The same source also reported that the highest levels of purchases of pechay in Cebu were in December-January, and the lowest were in July. Similar seasonal variations in consumption of vegetables were reported in a study conducted by AVRDC in Illocos Norte (AVRDC 1999).

Implications of Low Vegetable Consumption

Low vegetable consumption results in micronutrient deficiency (Table 21). Micronutrients, such as iron, calcium, thiamin, riboflavin, niacin, and ascorbic acid, are all deficient, and the deficiency level in each case is much higher than the deficiencies in energy and protein. Micronutrient deficiencies have serious health consequences. For example, Bouis (1991) found a significant negative relationship between the incidence of fever and consumption of carotene and vitamin C in the Philippines.

Table 21. Per capita nutrient intake in the Philippines, 1993.

Nutrient	Philippines	All urban	Metro Manila	Other urban	Rural	Average recommended
Energy (Kcal)	1684	1673	1651	1681	1696	1922
Protein (g)	50	51	52	50	49	47
Calcium (g)	0.39	0.39	0.41	0.39	0.39	0.58
Iron (mg)	10	10	10	10	10	16
Vitamin A (μg RE)	392	457	583	410	327	445
Thiamin (mg)	0.67	0.70	0.74	0.69	0.65	0.98
Riboflavin (mg)	0.56	0.61	0.70	0.58	0.51	0.98
Niacin (mg)	16	17	17	16	16	18
Ascorbic acid (mg)	47	45	42	46	49	64

Source: FNRI (Food and Nutrition Research Institute), official files data.

Elasticities

Income Elasticities

A summary of income elasticities estimated from consumption survey data and from other studies is presented in Table 22. Consumption of all and individual vegetables is generally income-inelastic. Expenditure elasticities are higher than income elasticities for all and individual vegetables.

Table 22. Review of income elasticities

Vegetables	Expenditure elasticity (Dosayla & Darrah 1973)[a]	Income elasticities[b]			
		Dosayla & Darrah (1973)	Santos et al. (1975)	Orogo (1976)	Ferrer (1976)
Fresh vegetables (all)	0.41	0.22	-	0.22	0.30
Leafy, yellow (all)	0.47	0.27	-	0.27	0.24
Cabbage	0.70	0.65	0.74	-	-
Camote tops	0.00	-0.02	-0.06	-	-
Kangkong	0.05	-0.07	0.03	-	-
Pechay	0.54	0.43	0.62	-	-
Fruit vegetables (all)	0.38	0.27	-	0.27	0.20
Eggplant	0.21	0.13	0.16	-	-
Tomatoes	0.51	0.39	0.49	-	-
Squash	0.31	0.22	0.31	-	-
Upo	0.49	0.34	-	-	-
Leguminous vegetables (all)	0.41	0.35	-	-	-
Baguio beans	0.76	0.66	-	-	-
Mungbean	0.29	0.25	0.38	-	-
Sitao	0.32	0.30	0.41	-	-
Roots, bulbs, tubers (all)	0.37	0.05	-	-	-
Garlic	0.48	0.36	-	-	-
Irish potatoes	0.87	0.79	-	-	-
Onions	0.51	0.38	0.54	-	-
Sweet potatoes	-0.14	-	-0.26	-0.24	-

[a] Income elasticity is the percent change in vegetable quantity consumed with a 1% change in income.
[b] Expenditure elasticity is the rate of change in vegetable expenditure relative to changes in income.

Income elasticities by income group were estimated by Aviguetero et al. (1978) from the same data set, and Orogo (1976) estimated income elasticities for rural and urban households (Table 23). The medium income group had the highest income elasticity, and the lowest income group had the lowest income elasticity. Only small differences between urban and rural income elasticities were observed.

Table 23. Income elasticity of vegetables by income group and household type

Item	Income group[a]			Household type[b]		
	Lowest to medium low	Medium low to medium high	Medium high to highest	Overall	Rural	Urban
All vegetables	0.21	0.25	0.22	0.22	0.20	0.23
Leafy, yellow	0.13	0.29	0.18	0.27	0.24	0.19
Fruit vegetables	0.18	0.34	0.16	0.27	0.18	0.25
Leguminous veg.	0.31	0.34	0.31	-	-	-
Roots, bulbs, tubers	0.26	0.11	0.02	-	-	-

Sources: [a]Aviguetero et al. (1978); [b]Orogo (1976)

Price Elasticities

Own-price elasticities, as reported in various studies, are summarized in Table 24. A comparison of income and price elasticity in Tables 23 and 24 reveals that vegetables respond more to changes in prices than to changes in income, an observation first noted by Aure (1982) for fruit vegetables. Piadozo's (1982) estimates also show that demand for leafy and yellow vegetables responded more to changes in price than to changes in income. Cabbage and carrots, and carrots and peas, are complementary commodities, as their cross-price elasticities are positive.

Table 24. Review of own-price elasticities

Commodity	Price elasticity	References
Fruit vegetables	–0.75	Orogo (1976)
Leafy vegetables	–0.60	Orogo (1976)
All vegetables	–0.85	Orogo (1976)
Ampalaya	–4.00	Aure (1982)
Squash	–1.37	Aure (1982)
Tomato	–0.28 to –0.32	Aure (1982)

Consumers' Preferences

There is very little information available in the literature on consumers' preferences for different vegetable types. Magampon (1986) found that 41% of respondents preferred leafy and yellow vegetables over other types, and also preferred medium-sized and loose (rather than packaged) vegetables.

Tiosejo-Derige (1985) likewise noted that most consumers prefer ungraded vegetables. Ungraded vegetables have lower prices and consumers are free to select the size and quality they want. Those consumers who preferred graded vegetables mentioned saving the time and expense required in bargaining about quality and price. No study is available that quantifies the contribution of various quality characteristics of vegetables to their price.

Problems encountered by consumers in purchasing vegetables included instability of prices, a failure of the quality of the vegetables in the market to meet their tastes and preferences, and a limited supply of vegetables in the market from which to select (Tiosejo-Derige 1985).

Vegetable Processing

Very little vegetable processing is done in the Philippines. Only tomatoes, potatoes, and soybeans are processed in any large quantities (Table 25). About 24% of the total tomato output is processed into tomato sauce, ketchup, and other products.

Table 25. Quantity (000 t) of vegetables processed, by species, in the Philippines, 1978–93

Year	Tomato	Potato	Soybean
1978	20.79	6.00	11.00
1979	21.19	9.00	14.00
1980	20.44	9.00	14.00
1981	20.20	10.00	22.00
1982	20.86	11.00	31.00
1983	20.72	8.00	28.00
1984	22.86	11.00	8.00
1985	23.15	14.00	8.00
1986	25.87	16.00	19.00
1987	26.02	17.00	11.00
1988	27.22	19.00	21.00
1989	29.25	20.00	24.00
1990	27.59	18.00	19.93
1991	26.55	15.50	22.52
1992	24.74	17.00	40.81
1993	23.83	13.37	19.62
Average growth rate (% per year)	2.19	8.20	7.45

Source: BAS, various years.

International Trade

The quantities of vegetables traded in international markets in the Philippines are reported in Table 26. The Philippines has negative balance of trade and balance of payment during most of the years in the 1980s and early 1990s. Onion is the most important export: exports in 1990–92 amounted to about 12% of the total production.

Table 26. International trade in vegetables (t), Philippines, 1983–92

Vegetable	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Exports										
Asparagus (fresh or chilled)	-	-	-	1	5	6	42	205	-	-
Beans, red (dried)	263	352	36	142	18	-	89	18	115	88
Cucumber & gherkins	494	565	161	210	42	161	168	194	-	-
Garlic (fresh or chilled)	1662	40	-	1	12	-	-	-	-	-
Onions (fresh or chilled)	-	17,440	7756	7614	10,115	3567	7337	8239	6982	6325
Mungbean (green or yellow), dried	-	-	-	5	9	9	24	14	-	-
Tomatoes (fresh or chilled)	160	693	120	21	962	99	18	71	-	-
Total exports	2579	19,090	8073	7994	11,163	3842	7678	8741	7097	6413
Imports										
Asparagus (preserved)	106	55	81	31	76	316	96	92	134	149
Beans, red (dried)	468	423	303	60	0.04	278	423	932	228	510
Beans, white (dried)	714	857	260	813	1733	1351	2147	2568	2393	1845
Garlic (dehydrated)	28	11	26	42	130	167	174	198	-	-
Mungbean (green/yellow)	-	-	1048	1124	6891	8571	23,037	17,300	11,335	14,331
Mushrooms (preserved)	35	73	65	67	73	131	54	182	-	-
Onions (dehydrated)	74	12	20	61	79	138	188	183	486	26
Peas, chick (garbanzos)	516	401	246	279	315	483	953	1320	365	576
Peas, green (frozen)	268	280	213	378	540	645	652	472	339	585
Peas, green (chicharo)	2790	818	2427	2325	4109	4092	11,778	12,498	7930	14,376
Potato flakes	120	15	37	42	97	208	352	595	-	-
Potato flour or meal	48	-	4	1	41	92	506	6241	-	-
Seed potatoes	-	-	1	24	78	-	40	-	1	1
Tomatoes (preserved)	14	3	65	68	26	56	32	14	800	600
Total imports	5181	2948	4796	5315	14,188	16,528	40,432	42,595	24,011	32,999

Source: CRC, various issues.
- indicates no data.

Policy Analysis

Studies on policy analysis related to vegetables are very scarce. Most of the available studies look at policy regarding seeds as a production input. Another study (Feliciano 1974) investigated the impact of marketing laws and regulations on fruit and vegetable marketing.

Seed Industry

The Philippine Government has failed to make the country self-sufficient in vegetable seed production. For the period 1970–86, vegetable seed production declined at a rate of 635 kg annually. Since 1987, efforts by private seed companies have led to increased seed production, but despite this

improvement, and the high profitability of seed production (Table 27), the demand–supply gap for vegetable seeds was estimated at 101,516 kg for 1989. Depositario (1988) sought to determine the effects of government policies on the incentive structure in the vegetable seed industry and the relative competitiveness of domestically produced and imported vegetable seeds. The measures of production incentives used were nominal protection rate, implicit tariff, and effective protection rate. The study revealed that despite positive implicit tariffs on the import of some vegetable seeds, effective protection rates (EPRs) on pechay, radish, and mustard seed production in the country are negative.

The study recommended that:

- tariffs on seed importation should continue for a limited time
- the government should give encouragement to local seed producers, and regulate importation
- continued efforts by private vegetable seed producers are required to increase their current yield levels.

Table 27. Economics of seed production ('000 Pesos/ha) of various crops, 1990

Vegetable	Gross returns	Total costs	Net income
1. Ampalaya	242.5	21.6	220.9
2. Bush sitao	60.0	16.9	43.1
3. Cabbage	107.8	24.8	83.0
4. Cowpea	70.0	17.2	52.8
5. Cucumber	82.7	19.9	62.8
6. Eggplant	30.3	21.4	8.9
7. Lima beans	66.0	22.7	43.3
8. Mungbean	17.6	11.8	5.8
9. Mustard	132.0	18.6	113.4
10. Okra	32.0	17.5	14.5
11. Pattola	30.0	16.9	13.1
12. Pechay	49.8	14.7	35.1
13. Pole sitao	82.5	16.4	66.1
14. Radish	165.0	16.6	148.4
15. Snap beans	92.8	26.2	66.6
16. Soybean	19.0	13.2	5.8
17. Squash	44.8	17.2	27.6
18. Sweet pepper	148.5	22.2	126.3
19. Tomato	27.5	20.1	7.4
20. Upo	100.0	22.1	77.9

Source of data: Official files of Bureau of Plant Industry, Manila.

Excessive Input Use in Vegetable Production

Input use in vegetables can be excessive, especially in the case of fertilizer and pesticides. Francisco et al. (1990a) attribute the negative marginal benefit-cost ratio for the use of pest control chemicals to two reasons:

- farmers apply insecticides even if they are no longer effective for pest control.
- severe infestation may already have caused yields to decrease.

Other reasons might include damage to natural predators and untargeted use of insecticide.

Externalities due to excessive use of inputs in vegetable production have not been well studied in the Philippines. A study by Rola (1989) on the effects of pesticides on vegetable farmers' health found that as farmers were more exposed to pesticides, health problems increased. The study also attributed the amount of pesticide residues in vegetables to farmers' crop protection practices.

The pesticide residue problem arises when the maximum allowable quantity for safety is surpassed. For some pesticides and for some food items, the FAO has set maximum residue limits (MRL—the maximum concentration of a pesticide residue that is allowable by the *Codex Alimentarius* and legally permitted in or on a food commodity). It has been reported that the MRL for methyl parathion, a pesticide, was exceeded by 19% on cabbage and in 22% on tomato (Antazo 1986).

Achievements of Research

Much literature has been produced by social scientists to highlight the potentials and constraints in vegetable production, consumption, and distribution, and to suggest institutional adjustments for improving efficiency. Tables 28 and 29 give an overview of vegetable studies by location, period, and by topic of study. Most studies reviewed investigate more than one vegetable in more than one location.

Table 28. Number of studies, by vegetable and research topic, 1970–93

Vegetable type	Production only	Marketing only	Consumption only	Production/ Marketing	Production/ Consumption	Marketing/ Consumption	Policies/ Programs
Leafy vegetables	-	-	23	2	-	2	2
Cabbage	4	24	1	6	1	-	-
Celery	-	2	-	-	-	-	-
Lettuce	-	1	-	1	-	-	-
Others	2	10	-	5	1	-	-
Pechay	4	4	1	3	-	-	-
Total	10	41	25	17	2	2	2

Contd. Table 28.

Vegetable type	Production only	Marketing only	Consumption only	Production/ Marketing	Production/ Consumption	Marketing/ Consumption	Policies/ Programs
Fruit vegetables	-	-	20	1	-	2	-
Ampalaya	2	1	1	4	-	-	-
Cucumber	1	-	-	1	-	-	-
Eggplant	9	9	1	5	-	-	-
Hot pepper	2	-	-	2	-	-	-
Okra	4	2	-	5	-	1	-
Squash	2	2	1	3	-	-	-
Sweet/bell pepper	4	-	-	3	1	-	-
Tomatoes	8	17	1	10	1	1	-
Others	10	9	1	6	-	-	-
Total	42	40	25	40	2	4	-
Leguminous vegetables	2	1	20	2	-	3	-
Baguio beans	1	7	-	1	-	-	-
Chinese/sweet peas	1	1	-	1	-	-	-
Mungbean	8	11	-	4	1	-	-
Pole sitao	7	3	-	1	-	-	-
Soybeans	5	1	-	8	1	-	-
Others	7	-	-	1	-	-	-
Total	31	24	20	18	2	3	-
Roots, bulbs, & tubers	-	-	20	1	-	2	-
Carrots	1	5	1	1	-	-	-
Garlic	4	8	-	7	-	-	-
Ginger	1	5	-	1	-	2	-
Onions	3	11	-	5	-	2	-
Sweet potato	1	3	-	-	-	-	-
White potato	10	17	-	10	1	-	-
Others	-	3	-	2	-	-	-
Total	19	47	20	26	1	6	-

Each study addresses many topics and for many crops, thus horizontal and vertical totals cannot be taken.

Table 29. Frequency of studies (%) by vegetables type and location, 1970-1993

Vegetables/Location	1970 -75	1976-80	1981-85	1986-90	1991-93	Total
Leafy and yellow vegetables	29	26	14	8	-	77 (25.0)
Philippines	16	11	9	4	-	40 (13.0)
Luzon	11	13	2	3	-	29 (9.4)
Visayas	1	2	1	-	-	4 (1.3)
Mindanao	1	-	2	1	-	4 (1.3)

Contd. Table 29.

Vegetables/Location	1970 -75	1976-80	1981-85	1986-90	1991-93	Total
Fruit Vegetables	19	29	17	10	2	77 (25.0)
Philippines	12	13	5	6	-	36 (11.7)
Luzon	3	13	7	2	2	27 (8.8)
Visayas	1	2	2	-	-	5 (1.6)
Mindanao	3	1	3	2	-	9 (2.9)
Legumes	28	20	15	5	-	68 (22.1)
Philippines	15	10	8	1	-	34 (11.0)
Luzon	9	7	4	4	-	24 (7.8)
Visayas	1	1	1	-	-	3 (1.0)
Mindanao	3	2	2	-	-	7 (2.3)
Roots, Bulbs, and Tubers	21	31	23	8	3	86 (27.9)
Philippines	13	13	7	6	-	39 (12.7)
Luzon	7	15	13	2	3	40 (13.0)
Visayas	-	2	1	-	-	3 (1.0)
Mindanao	1	1	2	-	-	4 (1.3)
Total	97	106	69	31	5	308 (100)

Figures in parentheses are relative frequencies (%).

A total of 182 studies on vegetables were reviewed. About 55% of the studies were related to marketing. Government policies and programs were least evaluated by these studies. Most consumption studies took all vegetables into account, and most of these were nationwide in scope.

Summary, Conclusions, and Information Gaps

As the population of the Philippines has continued to increase, the stagnation in vegetable production has caused a decline in per capita vegetable consumption from what was already a low level relative to recommended level. The average rate of decline is 1.5% per annum. This decline has also been confirmed by micro-level studies on consumption.

Not only is vegetable consumption low, but strong seasonality has been observed in the availability, prices, and consumption of vegetables. Prices are high during the last quarter of the year and low during the first quarter of the year. Correspondingly, vegetable consumption during the last quarter of the year drops by about 30% below first-quarter consumption. The seasonality in vegetable availability can partly be resolved by encouraging trade between regions. For example, when Benguet vegetables cannot be made available in Metro Manila, Bukidnon vegetables could fill this supply gap. However, the seasonality problem can also be tackled by generating technologies and management practices for stressful environments. An example is tomato, where the seasonality problem is being addressed by technology development, such as alternative cultural management practices and appropriate varieties.

Apart from seasonal fluctuations, strong annual fluctuations have been observed in vegetable production and prices. This is because vegetable production is sensitive to environmental conditions. The coefficients of variation in individual vegetable species and for all-vegetables production are higher than for cereal crops, like rice. The high variation in vegetable production causes high variation in their prices, and makes vegetable availability and consumption, as well as farmers' income, uncertain.

Vegetable consumption also varies across regions, income groups, and farm/non-farm households. Generally, income and vegetable consumption are positively related (i.e., income elasticity is positive), except for roots, bulbs, and tubers. However, income elasticities are lower than price elasticities. Therefore, lower prices through enhanced vegetable supplies brought about by the adoption of cost-reducing or production-enhancing technologies could play a stronger role in increasing vegetable consumption than induced consumption via enhanced incomes.

Only a few studies have reported farm management practices in vegetables. Therefore, there is a need to focus economic studies on the management practices adopted by farmers in different environments and with different cropping patterns in order to tackle different constraints faced by farmers.

There is a file of micro-level studies on costs and returns in vegetable cultivation. However, these studies were conducted at different times and in different regions and thus have limited use in defining the relative competitiveness of different vegetables in different regions or for looking at the changing patterns in vegetable costs and returns. Cost of production needs to be estimated simultaneously in different regions for major vegetables; this can only be attempted by government agencies. As profitability varies across regions, ecoregional costs and returns will help to identify the most profitable vegetables and regions for which the government incentive structure should be focused to enhance vegetable production.

Analyses of costs and returns show that vegetable cultivation is highly profitable. Of 59 studies reviewed, 57 report positive returns from vegetable cultivation, and 50 found returns of more than 30%. However, given that only 4.7% of the cropped area is under vegetables and their supply is less than the minimum required by the population, things other than profitability constrain their production. Although technical constraints vary from crop to crop in different regions, high output losses due to insect pests and diseases, low quality and degenerated seeds, unsuitable varieties, and substandard management practices, are considered to be the main technical constraints. High annual variation in producers' prices and high input costs are the main economic constraints.

The very few policy studies available show that there is still a large gap between demand and supply of vegetable seed, and that certain measures have to be taken to liberalize seed importation. Lately, there have been moves to liberalize seed importation, which would benefit vegetable farmers by improving the availability of high quality vegetable seed.

Vegetable production is notorious for the overuse of inputs, especially fertilizer and pesticides. One study showed even a negative marginal benefit-cost ratio from the use of pest-control chemicals in vegetables. Some studies on pesticide residues in vegetables indicate that the level is higher than recommended by FAO. However, there is increasing interest in studying the impact of high pesticide use and high pesticide residue on vegetables as it affects consumers' and farmers' health, the environment, and the sustainability of agricultural resources.

Most commercial vegetables have marketing channels with five to six levels. However, minor crops, or those produced on a low scale, have less complicated marketing systems. Wholesalers, contract buyers, agents, assemblers, and retailers are identified as the most important marketing agents. However, the wholesaler, who plays a multiple role—providing inputs, including credit, to farmers, and getting most of their output, and in addition spending some time working as assembler, shipper, etc.—is the dominant marketing agent and gets the lion's share of vegetable output in most cases. At least 21 marketing channels were identified for vegetables. No marketing agent seemed to be efficient in all vegetables in terms of marketing cost and gross margin. However, it is a recognized fact that the fewer the number of intermediaries, the more efficient is the marketing channel. Despite this fact, no cooperative marketing is observed in vegetables.

One of the unique features of vegetable marketing in the Philippines is that most farmers have some form of preharvest agreement with a creditor who supplies cash inputs. In this arrangement, the creditor has the dominant position in determining the price of the produce. Thus, providing farmers with easy access to credit at reasonable interest rates would substantially increase the share of the consumers' price received by farmers.

The Philippines is a net importer of vegetables The export base of vegetables is very limited. Onion is the only vegetable exported in large quantities. The potential for other vegetable exports needs to be explored. For this, vegetable production in the Philippines needs to be encouraged in the favorable vegetable growing areas, keeping in view the seasonal pattern of vegetable supplies in neighboring countries and other potential customers.

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SRI LANKA

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Introduction

Sri Lanka is an island located between 6° and 10° north of the equator, at the southern tip of the Indian sub-continent. The country has a land area of 6.56 million ha, and a population of 17.6 million (Department of Census and Statistics 1994b). Most people live in rural areas, as the urban population accounts for just 22%. The country's population growth rate is 1.2%, and its per capita income US$652. According to the 1981 census, Sri Lanka has the highest overall literacy in South Asia at 87%. The literacy rate among females is especially impressive at 83%. Agriculture plays a major role in the country's economy. Approximately 21% of the gross domestic product and 23% of the total export earnings are derived from agriculture. It also accounts for 44% of all employment (Central Bank of Sri Lanka 1994). The crop subsector has a large number of small farmers on 1.8 million small holdings. Nearly half of the holdings are less than 0.5 ha (Department of Census and Statistics 1985).

Rice is the dominant crop grown on approximately 732 thousand ha. Other important crops are corn (32,000 ha), mungbean (22,000 ha), cowpea (20,000 ha), groundnut (10,000 ha), and potato (7,000 ha). During 1993, vegetables, including chili and onion but excluding potato and those not reported in the statistics, are grown on 117 thousand ha, producing an output of 656 thousand t worth LKR 7.5 billion (US$156 million). Both tropical and temperate vegetables are grown throughout the year under varying climatic conditions. In addition to the conventional vegetables, tubers such as potato and local yams, pulses such as lentils mungbean, and cowpea, as well as many varieties of green leaves are consumed as vegetables.

In 1993, average per capita food availability in the country was about 800 g/day, of which cereals constituted 45%, vegetables 13%, fresh fruits 1%, livestock products 12%, roots and tubers 6%, oil and fat 12%, and others 10%. Rice is the staple food, accounting for 34% of total consumption (Department of Census and Statistics 1994a). In 1993, average annual per capita availability of vegetables was about 40 kg or 110 g/day, about half the 73 kg/year or 200 g/day recommended by AVRDC.

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General Information

Climate

The temperature variation through the year is low with the mean ranging between 21.1 and 31.7°C. The rainfall pattern in Sri Lanka is bimodal with two periods of monsoonal precipitation resulting in two distinct cultivation seasons. The major cultivation season, called Maha, is in October-February. The precipitation during this season comes from the northeast monsoon of October-December. The harvesting period of crops cultivated in Maha is at the end of January, usually a dry period. The second crop season is called Yala and extends from May to July. The rains in this season come from the southwest monsoon during mid-April to June. The remaining months of the year are dry, and almost no cultivation occurs during this period.

Zones and Regions

With in the two main rainy seasons, rainfall distribution across the country is determined by topography. The whole island benefits from the northeast monsoon. The southwest monsoon is intercepted by the central mountains resulting in 2000-5000 ml of rain per year in the highlands and southwest part of the island. This is the ''wet" zone of the country covering 1.53 million ha. The "intermediate" zone covering 4.17 million ha receives 2000-2250 ml of rainfall per year, and is hotter than the "wet" zone. The dry zone receives only 900-1000 ml of rain, with the highest temperatures ranging between 28 and 30°C. It covers 0.8 million ha (Table 1).

Table 1. Environmental parameters of major physiographic regions

Zone/region	Elevation (m)	Temperature (°C)	Mean rainfall (mm)
Wet zone			
Up-country	1000-2400	10-15	2500-5000
Mid country	500-1000	15-20	2000-3000
Low-country	0-500	20-25	2000-3000
Intermediate zone			
Up-country	1000-1500	15-22	1500-2250
Mid country	350-500	24-26	1500-2250
Low-country	0-350	25-29	2000-2200
Dry zone			
Low-country	0-300	28-30	900-1000

Source: Perera (1989).

Depending upon the elevation and temperature, these zones can be classified into three distinct physiographic regions. These are lowland, middle, and up-country peneplain. The range of elevation in each region depends upon the rainfall pattern (Table 2).

The soils of Sri Lanka have been surveyed and mapped. Nine soil orders are found in the country. Based on the soil, elevation, and rainfall data, 22 agroecological regions have been identified (Fig. 1). As the combination of soil, rainfall, elevation, and irrigation facilities vary across the regions, it is possible to grow a wide range of vegetables in the country.

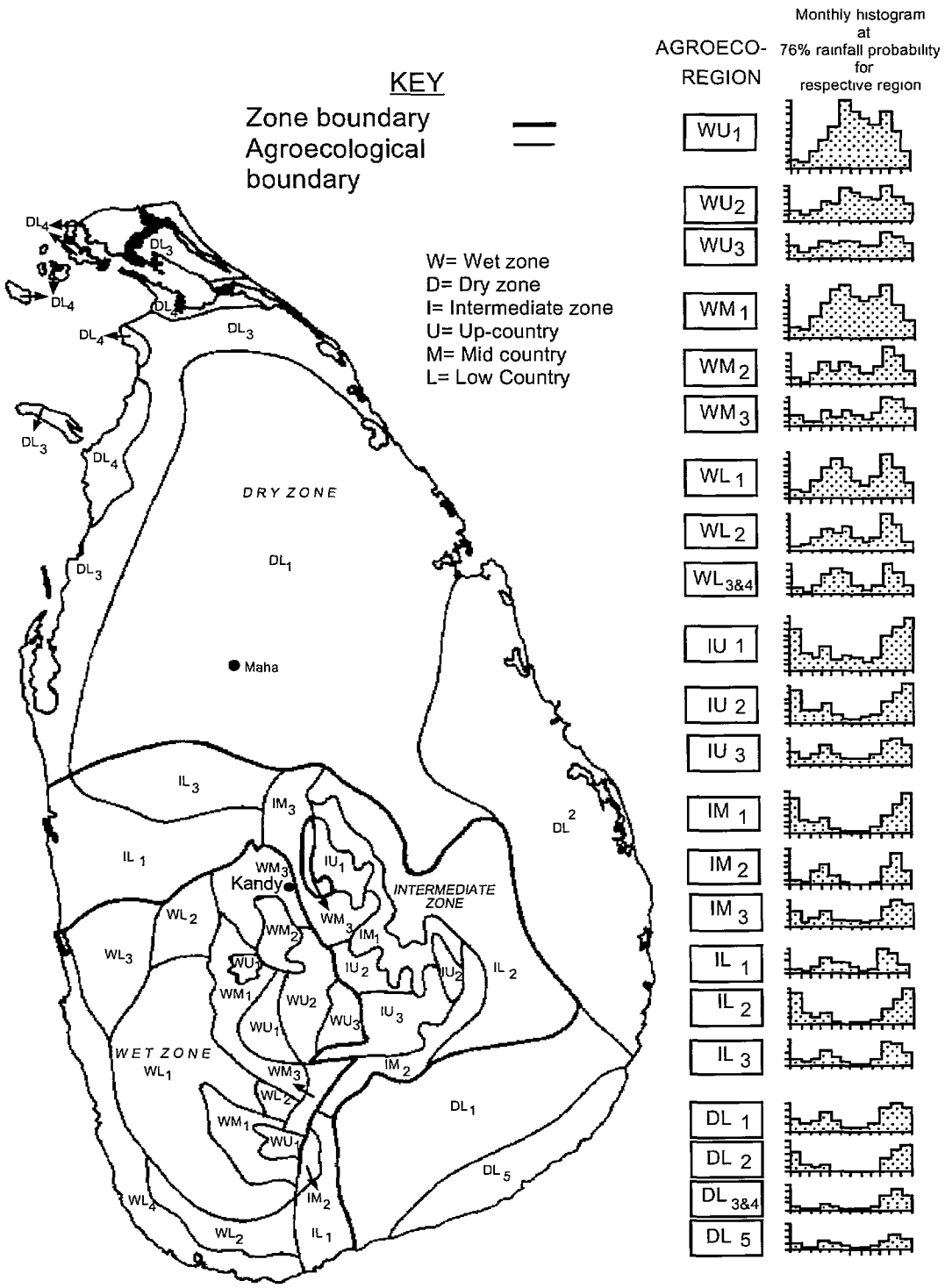

Fig. 1. Agroecological map of Sri Lanka.

Zonal Distribution of Vegetables

Leek, carrot, and radish are dominate vegetables in the wet zone; beans and tomato are dominant crops in the intermediate zone; while ash pumpkin and red pumpkin are dry zone crops. Beetroot, knol-khol, and cabbage are grown about equally in the wet and intermediate zones, while bitter gourd, cucumber, eggplant, lady's finger, and snake gourd are equally distributed across all regions (Table 2).

Table 2. Regional distribution (% of the total) of vegetables, 1993

Vegetable	Wet zone	Dry zone	Intermediate zone
Ash pumpkin	19.0	65.0	16.0
Beans	34.9	4.1	60.9
Beetroot	48.9	9.5	41.7
Bitter gourd	32.9	39.9	27.2
Cabbage	49.8	4.9	45.2
Carrot	69.6	2.2	28.2
Cucumber	19.5	35.2	45.3
Eggplant	28.2	43.6	28.2
Knol-khol	43.9	1.2	54.9
Lady's finger	36.0	40.0	24.0
Leek	69.7	0.7	29.6
Radish	53.1	7.9	39.0
Red pumpkin	11.4	53.1	35.4
Snake gourd	24.9	40.7	34.3
Tomato	16.8	30.1	53.0

Source: Estimated from official file of Department of Census and Statistics data.

Vegetable Classification

Vegetables in Sri Lanka are classified in different ways. One grouping, based on vegetable type, has four major categories, namely, leafy vegetables, fruit vegetables, roots and tubers, and seeds (Table 3).

Another form of classification is by origin of the varieties. The more traditional and indigenous types are grouped as tropical types, or, as they are popularly known, "low-country" vegetables, because they are commonly cultivated in lowland and midland peneplains. Those introduced from other countries are called exotic vegetables, or temperate vegetables, or, popularly, as "up-country" vegetables. They are usually cultivated in the cooler climates of the up-country peneplain. This classification is shown in Table 3.

Table 3. Classification as low-country and up-country vegetables

Botanical Name	Common Name	Peak production months	Major growing districts	Eating type
Low-country Vegetables				
Abelmoschus esculentus	Lady's finger	Jan.-March, July-Sept.	Matale, Anuradhapura, Kurunegala, Hambantota	Fruit
Allium cepa	Big onion	Jun.-July	Matale, Kalawewa	R&T
Allium cepa	Red onion	Jun.-July	Jaffna, Puttalam	R&T
Alternanthera sessilis	Mukunuwenna (Alternanthera)	Year round	All wet zone districts	Leafy
Amaranthus tricolor	Amaranth	Year round	All wet zone districts	Leafy
Artocarpus altilis	Bread fruit	Aug.-Sept.,Jan.-Feb.	Matale, Anuradhapura, Kurunegala, Hambantota	Fruit
Artocarpus heterophyllus	Jack fruit	Year round	All wet and intermediate zone district	Fruit
Basella alba	Spinach	Year round	All wet zone districts	Leafy
Beta vulgaris	Beetroot	Feb.-March, Aug.	Matale, Kurunegala, Hambantota	R&T
Capsicum spp.	Chili	Jun.-July	Anuradhapura, Kalawewa, Kurunegala	Fruit
Centella asiatica	Gotukola (Asiatic penny wort)	Year round	All wet zone districts	Leafy
Coleus rotundifolius	Innala (Hausa potato)	Jan.-March	All districts	R&T
Cucumis sativus	Cucumber	Jan.-July	All districts	Fruit
Cucurbita maxima	Pumpkin	Jan.-Aug.	Matale, Anuradhapura, Kurunegala, Hambantota	Fruit
Dioscorea alata	Wellala (Yam)	Jan.-April, July-Sept.	Galle, Kalutara	R&T
Ipomoea aquatica	Kangkong	Year round	All wet zone districts	Leafy
Ipomoea batatas	Sweet potato	Jan.-Feb., Aug.-Sept.	All districts	R&T
Lagenaria seceraria	Bottle gourd	Jan.-July	All wet and intermediate zone district	Fruit
asia spinosa	Kohilala (Spinyelephantsear)	Year round	All wet zone districts	R&T
Luffa acutangula	Luffa	Jan.,July-Sept.	Matale, Anuradhapura, Kurunegala, Hambantota	Fruit
Lycopersicon esculentum	Tomato	Aug.-Sept.	Matale	Fruit
Manihot utilissima	Manioc (Cassava)	Year round	All districts	R&T
Momordica charantia	Bitter gourd	Jan., July-Sept., Dec.	Matale	Fruit
Moringa oleifera	Drumstick tree	May-June, Oct.-Nov.	All wet zone districts	Leafy
Musa sapientum	Ash plantain	Jan.-May, Sept.-Oct.	Matale, Kurunegala,	Fruit
Phaseolus vulgaris	Beans	July-Oct.	Kandy, Badula, Nuwar Eliya	Fruit

Contd. Table 3.

Botanical Name	Common Name	Peak production months	Major growing districts	Eating type
Psophocarpus tetragonolobus	Winged bean	Jan.-Feb., Dec.	Matale, Kurunegala, Hambantota	Fruit
Raphanus sativus	Radish	Jan.-Nov.	Matale, Kurunegala, Hambantota	R&T
Sesbania grandiflora	Kathurumurunga (Sesbania)	Year round	All wet zone districts	Leafy
Solanum melongena	Eggplant	Jan.-Feb., May-Dec.	Kurunegala, Hambantota	Fruit
Trichosanthes anguina	Snake gourd	Jan., July-Sept., Dec.	Matale, Anuradhapura, Kurunegala, Hambantota	Fruit
Vigna radiata	Mungbean	Feb.-April, July-Aug.	Hambantota, Kurunegala, Monaragala	Seed
Vigna unguiculata	Cowpea	Feb.-April, July-Aug.	Kurunegala, Puttalam, Anuradhapura	Fruit
Up-country Vegetables				
Allium porrum	Leek	Jan.-Feb., Apr.-June, Sept.-Dec.	Nuwara Eliya, Badulla Nuwara Eliya, Badulla	Leafy
Beta vulgaris	Beetroot	Feb.-May, Aug.-Sept.	Nuwara Eliya, Badulla	R&T
Brassica oleracea	Cabbage	Jan., Apr.-Dec.	Nuwara Eliya, Badulla	Leafy
Brassica oleracea	Cauliflower	Jan., April, Dec.	Nuwara Eliya, Badulla	Fruit
Capsicum annuum	Sweet/hot pepper	May-Sept.	Nuwara Eliya, Badulla	Fruit
Dancus carota	Carrot	Feb.-Nov.	Nuwara Eliya, Badulla	R&T
Lactuca sativa	Lettuce	Jan., Apr.-Dec.	Nuwara Eliya, Badulla	Leafy
Phaseolus vulgaris	Beans	Jan.-April	Nuwara Eliya, Badulla	Seed
Raphanus sativus	Radish	Jan.-Nov.	Nuwara Eliya, Badulla	R&T
Solanum tuberosum	Potato	Sept.-Nov.	Nuwara Eliya, Badulla	R&T

Source: Personal communication with vegetable scientists in the country.
*R&T implies root and tuber type of vegetables.

Cultivation Time

Most vegetables are grown about equally in both Maha and Yala, except for some up-country vegetables, such as onion, which are mainly grown in the Yala season, and tropical vegetables, such as chili, which are mainly grown in the Maha. Total production of vegetables in Maha is slightly higher than that in Yala (Table 4). No significant difference in the yield of most vegetables grown in Maha and Yala was observed.

Important Vegetables

Chili, onion, ash plantain, eggplant, lady's finger, beans, red pumpkin, and tomato are major vegetables (Table 4). Although chili contributes more than one third to the total vegetable area, its contribution in production is small. On the other hand, cabbage is grown on only 2.3% of the area while its contribution to production are 6.8%.

Table 4. Vegetable area (ha) and production (t) by season, 1992

Vegetable	Maha			Yala			Total			Contribution in total*	
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production
Ash plantain	7185	51256	7.1	5164	32618	6.3	12349	83874	6.8	10.6	12.6
Ash pumpkin	394	3665	9.3	325	3016	9.3	719	6681	9.3	0.6	1.0
Beans	3619	19987	5.5	3118	15494	5.0	6737	35481	5.3	5.8	5.3
Beetroot	624	6949	11.1	778	8007	10.3	1402	14956	10.7	1.2	2.2
Bitter gourd	1772	9202	5.2	2017	12935	6.4	3789	22137	5.8	3.2	3.3
Cabbage	1398	23581	16.9	1312	21768	16.6	2710	45349	16.7	2.3	6.8
Carrot	1015	13718	13.5	829	11720	14.1	1844	25438	13.8	1.6	3.8
Chili	22426	9200	0.4	18140	19800	1.1	40566	29000	0.7	34.8	4.8
Cucumber	1129	11317	10.0	969	6185	6.4	2098	17502	8.3	1.8	2.6
Eggplant	5126	35338	7.3	3897	25193	6.5	9023	60531	6.9	7.7	9.4
Knol-khol	645	5731	8.9	752	6452	8.6	1397	12183	8.7	1.2	1.8
Lady's finger	3719	18814	5.1	3690	19085	5.2	7409	37899	5.1	6.4	5.7
Leek	339	5040	14.9	457	7467	16.3	796	12507	15.7	0.7	1.9
Onion	4916	50827	10.4	5634	63550	11.3	10500	114377	10.9	9.0	17.2
Radish	1051	9257	8.8	1047	9655	9.2	2098	18912	9.0	1.8	2.8
Red pumpkin	3647	38308	11.5	2202	23122	10.5	5849	65430	11.2	5.0	9.8
Snake gourd	1337	11628	8.7	1452	11403	7.9	2789	23031	8.3	2.4	3.5
Tomato	2284	16625	7.3	2281	18080	7.9	4565	34705	7.6	3.9	5.2
All vegetables	62576	340443	5.6	54064	315550	5.8	116640	655993	5.7	100.0	100.0

Source: Data provided by the official file data of Department of Census and Statistics.

*A vegetable task force set by the Ministry of Agriculture found that ash plantain is cultivated on only 3400 ha, rather than on 12,349 ha, and its production is 52,000 t rather than 83,900 t. To the extent that the later estimates are correct, the contribution of ash plantain is overestimated, and contributions of other vegetables are underestimated. Moreover, to the extent that task force figures are correct, total vegetable production will also be overestimated. However, we keep the data provided by the Department of Census and Statistics as no other reliable time series data are available.

Vegetable Production Systems

Vegetables are cultivated under various farming systems throughout the year in different regions of the country. Broadly they can be grouped as follows:

Low-country Peneplain

Vegetable production in the lowland peneplain is characterized by large areas and poor technology adoption. The application of fertilizers and use of improved cultivars are not widespread. The exception, however, is the northern-most part of the country where vegetable cultivation is relatively advanced. The bulk of the lowland vegetable production comes during the Maha season with little or no supplementary irrigation.

Rainfed cultivation is popular in the dry and intermediate zones on well-drained soils. Many food crops, such as maize and millet, as well as cowpea, soybean, and mungbean, are intercropped with vegetables such as tomato, cucumber, eggplant, luffa, bitter gourd, capsicum, lady's finger, and pumpkin.

Up-country Peneplain

In the cool highlands, where land is scarce and the climate is favorable throughout the year, monocropping, multiple cropping, and relay cropping are practiced in vegetable production. The cropping intensity and the level of technology adoption is high, often with overuse of inputs. Vegetable growers are competent and marketing of inputs and the produce is well organized.

Highland vegetable cultivation is commercialized. Average plot size is small and cultivation is undertaken continuously with intensive labor, organic and chemical fertilizers, and high levels of agrochemicals. The output is dispatched to the wholesale markets in Colombo and Kandy.

Mid-country Peneplain

The midlands have varying altitude, temperature, and rainfall, and the nature of vegetable production varies accordingly. In higher altitude and wet areas, more intensive production, somewhat similar to the highland systems, can be observed, especially in home gardens. In the drier parts of the midlands, extensive cultivation of vegetables is carried out in a fashion more similar to the lowland system. The crops cultivated are a mixture of both up-country and low-country vegetables.

Home Gardens

Another important site of vegetable production is the home garden. Most home gardens, in both rural and urban areas, have at least a few popular vegetables, especially in areas where both monsoons prevail. Definite statistics on production and consumption from such units are not available.

Home gardens also have permanent vegetable trees, such as jackfruit and breadfruit in the wet and intermediate zones and drumstick in the dry zone. Ash plantain and kathurumurunga are also common in wet and intermediate zone home gardens. Many leafy vegetables grow wild in backyards. Gotukola and mukunuwenna grow under shade and among the planted trees or natural grass. Kangkong is common in water stagnant patches of homesteads in the wet lowlands and also on many marshy lands. Amaranth grows wild even on wastelands.

Rice-based Vegetable Systems

In the dry zone, vegetables are grown during the Yala season in paddy fields only if supplementary irrigation is available. The popular crops are chili, capsicum, tomato, and onion. In the mid- and up-country regions during the Yala season, terraced paddy fields located around 1500 m asl are cultivated with potato, beans, tomato, and cabbage. Vegetables cannot be cultivated in paddy fields during the Maha season due to stagnant water.

Peri-urban System

The peri-urban production system is a specialized form of market gardening near major cities (especially Colombo) which consists of usually very intensive cultivation of leafy vegetables to supply the needs of the urban and semiurban populations. Both organic and inorganic fertilizers are used in large quantities. As green leaves are an important component of the Sri Lankan rice- and curry-based diet, there is a ready demand for these vegetables. The most popular leafy vegetables are gotukola, amaranth, spinach, mukunuwenna, and kangkong.

Trend Analysis

Production

The trends in area, production, and yield of vegetables during the period 1981-1993 are given in Table 5. Both quadratic and linear functions have been tested to obtain the best-fit. The area, production, and yield of total vegetables have stagnated during the last couple of years in the reference period, as the quadratic term is negative and significant.

Table 5. Trends in area, production, and yield of major vegetables, 1981-93

Crop	Area		Production		Yield	
	T	T^2	T	T^2	T	T^2
Ash plantain	-	-	0.2896	-0.0232	0.2320	-0.0165
Ash pumpkin	-	-0.0052	-	-0.0045	0.1572	-0.0108
Beans	0.0082	-	0.2369	-0.0144	0.2011	-0.0124
Beetroot	0.0084	-	0.1968	-0.0120	0.2170	-0.0142
Bitter gourd	0.0181	-	0.0314	-	-	-
Cabbage	-0.0030	-	-0.0060	-	-0.0030	-
Carrot	-	0.0054	0.1500	-	0.0788	-
Chili	-	-	0.1739	-0.0103	0.1165	-0.0085
Cucumber	-0.0042	-	0.1062	-0.0085	-	-
Eggplant	-0.0144	-	0.2545	-0.0178	0.2976	-0.0200
Knol-khol	0.0100	-	0.0413	-	0.0313	-
Lady's finger	-0.0010	-	0.2539	-0.0163	0.2555	-0.0163
Leek	-0.0100	-	0.0264	-	0.0368	-
Onion (big)	0.1952	-	-0.2289	0.0218	-0.4239	0.0153
Potato	0.2191	-0.0177	0.2869	-0.0245	-	-0.0019
Radish	-0.0226	-	-0.0081	-	0.0145	-
Red pumpkin	-0.0256	-	0.3369	-0.0245	0.3403	-0.0228
Snake gourd	-0.0193	-	0.1350	-0.0093	0.1641	-0.0101
Tomato	0.0004	-	0.0437	-	0.0433	-
Total (excl. potato)	0.0117	-0.0007	0.1681	-0.0116	0.1564	-0.0109

Source: Estimated from the official file data of the Department of Census and Statistics.
- implies that the coefficient is not significant at least at the 5% level.

With few exceptions, area under most vegetables is either stagnant, or decreasing linearly or quadratically. Quadratic decrease in area was observed in ash pumpkin, while the opposite was observed for carrots.

Most vegetables show rising production trends in the earlier years because of similar rising yield trends, however, as yield trends turn negative so do the production trends. In cabbage, both yield and production showed linear declining trends, while leek, carrot, knol-khol, and tomato showed linear positive trends throughout the period. The yield of radish increased and its production declined at linear rates (Table 5).

Prices

There was an upward pressure on the real (or deflated) retail prices of all vegetable during 1985-95. These prices increased at an average rate of 1.8% during this period (Table 6). The real wholesale prices, on the other hand, first increased more than the retail prices, but then declined, and the index became almost equal to that for retail in 1994. During 1995, there was a downward swing in wholesale prices. Therefore, overall real prices at the wholesale level remained almost stagnant during the period (Figure 2).

Individual vegetable prices at the retail level generally increased more than the consumer price index (CPI), resulting in an increase in the real vegetable prices at this level. On the other hand, the real wholesale prices of only knol-khol, snake gourd, and tomato showed increase, while the prices for cucumber, drumstick, long beans, and pumpkins showed significant decline (Table 6). Rising retail prices are curbing demand, and stagnant or declining wholesale prices are discouraging production.

Table 6. Growth rates (%) in the nominal and deflated prices of selected vegetables in Colombo market, 1985-95

	Nominal		Deflated	
Vegetable	Wholesale	Retail	Wholesale	Retail
Ash plantain	13.5	14.7	ns	2.6
Bandakka	11.0	11.8	ns	ns
Beetroot	12.6	14.1	ns	2.1
Bitter gourd	12.5	13.5	ns	1.5
Butter beans	11.9	13.0	ns	1.0
Cabbage	14.4	13.1	ns	1.0
Capsicum	12.3	13.9	ns	1.8
Carrot	10.8	12.3	ns	0.2
Cucumber	10.3	11.9	-1.8	ns
Drumstick	7.6	10.0	-4.5	-2.0
Green beans	12.5	13.0	ns	0.9
Green chili	12.4	13.2	ns	1.2
Knol-khol	13.5	14.9	1.4	2.8
Leek	11.5	12.7	ns	0.6
Long beans	8.7	12.9	-3.3	0.9
Luffa	12.2	13.1	ns	1.0
Mungbean	11.5	13.6	ns	1.5
Pumpkin	7.8	10.4	-4.2	ns
Radish	12.0	13.5	ns	1.5
Snake gourd	13.7	14.7	1.6	2.6
Tomato	14.3	14.9	2.3	2.8
Overall[a]	12.2	13.6	ns	1.8
Consumer price index (CPI)	-	11.7	-	-

[a] This is a Layspare price index of individual vegetable prices.
Source: Estimated from the data of Agrarian Research and Training Institute, various issues[b] (from 1985 through 1995).

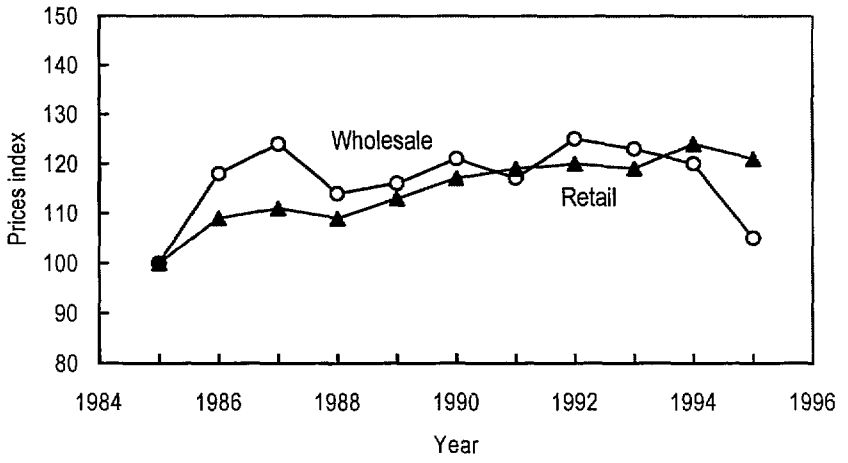

Fig. 2. Trend in deflated vegetable price index in Colombo market in Sri Lanka, 1985-95

Seasonality

Seasonal indices of wholesale and retail vegetable prices are plotted in Figure 3. All vegetables show strong bimodel price seasonality. The wholesale and retail prices move in similar fashion. Prices are normally low in January-April and August-October, and high in November-December and May-July.

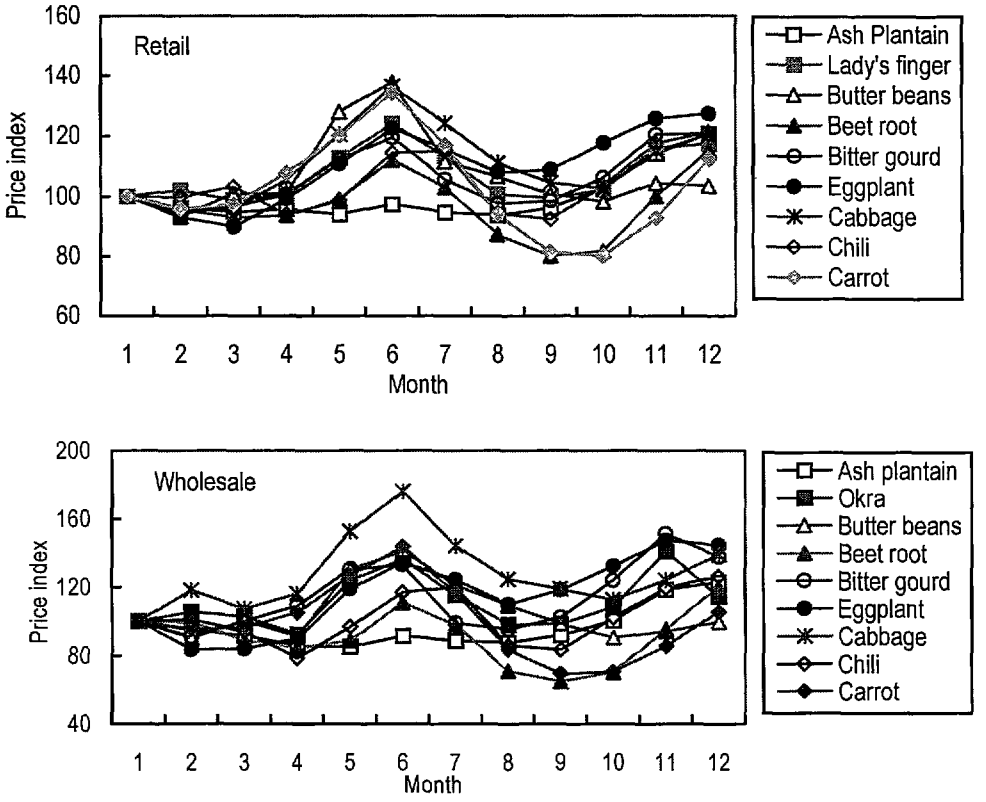

Fig. 3. Seasonality in the individual vegetable prices in Colombo market (average 1985-92)

The months in which prices of a vegetable are highest and lowest and the extent of seasonality at both the retail and wholesale levels are reported in Table 7. Generally, seasonality in wholesale prices is higher than in retail prices.

Table 7. The maximum and minimum vegetable price month, and extent of seasonal price variation in Colombo market (average of 1985-92)

Vegetable	Maximum price months	Minimum price months	Extent of seasonality(%)	
			Wholesale	Retail
Ash plantain	December	May	44	29
Beetroot	December	September	85	44
Butter beans	June	February	44	48
Butter gourd	November	February	67	28
Cabbage	June	March	76	42
Capsicum	December	April	61	31
Carrot	June	October	104	67
Cucumber	May	September	79	-
Eggplant	November	February	77	42
Green beans	June	April	61	-
Lady's finger	November	April	53	26
Leek	June	September	77	-
Long beans	May	August	38	-
Luffa	June	August	77	-
Pumpkin	May	February	82	-
Radish	December	February	61	-
Snake gourd	May	September	59	-
Tomato	December	August	112	-

Note: The maximum and minimum price months at wholesale and retail levels were the same in most cases, so only the peak months at wholesale level are reported in the table; - implies that data are not available.
Source: Estimated from the data of Agrarian Research and Training Institute, various issues[b] (1985 through 1992).

Risk in Production

Most vegetables are more risky to produce than field crops, such as rice (Table 8). The variability in yield of all individual and total vegetables is 2-3 times more than the variability in rice yield. However, with few exceptions, variability in vegetable area is very similar or even lower to that in rice area. The area of total vegetables is actually far less variable than that of most individual vegetables, suggesting that figures for vegetable area move in opposite directions, thus reduce the variability in total vegetable area.

Table 8. Detrended coefficient of variation in vegetable and rice during 1981-1995

Crop	Area	Yield	Production	Prices[a]	
				Wholesale	Retail
Ash plantain	7.6	22.7	28.4	14.4	8.6
Ash pumpkin	13.6	17.1	30.7	-	-
Beans	6.7	14.5	16.9	12.0	5.8
Beetroot	6.1	22.2	19.8	13.3	13.7
Bitter gourd	2.2	13.8	12.9	10.5	8.9
Cabbage	3.5	9.3	11.7	14.2	11.6
Carrot	11.7	18.8	24.8	8.9	9.8
Chili	14.3	15.1	21.5	10.3	6.7
Cucumber	8.4	15.6	14.4	7.6	6.0
Eggplant	4.9	23.0	22.0	10.4	7.5
Knol-khol	7.7	12.7	15.2	9.4	9.9
Lady's finger	3.8	19.0	18.8	-	-
Leek	10.4	22.8	30.8	8.9	9.9
Onion	16.6	17.3	26.0	-	-
Potato	22.7	10.5	28.0	-	-
Radish	6.5	15.6	22.7	7.6	7.6
Red pumpkin	7.1	27.9	33.6	10.3	6.9
Snake gourd	4.1	13.2	13.2	15.2	11.7
Tomato	7.2	15.2	15.6	12.5	8.5
Total (excl. potato)[a]	4.0	14.3	14.6	7.9	5.6
Rice	7.7	5.9	9.8	10.2	12.7

[a] The detrended coefficient for vegetable prices are for 1985-95 in Colombo market, while in rice it is for 1983-93 in the whole country. For the total vegetables, the detrended price variation is for the Layspare price index.

Source: Detrended coefficient for area, yield, and production were estimated from the official file data of the Department of Census and Statistics, and for prices the coefficients were estimated from Agrarian Research and Training Institute, various issues[b].

The higher variability in vegetable yields compared to field crops makes their production more variable as well. This suggests that technological innovations that can stabilize vegetable yield are more important to overcome inherent risk in vegetable production than policy related factors that can stabilize vegetable area in Sri Lanka.

The variation in vegetable production leads to variation in their prices (Table 8). Variation in individual vegetable prices are higher than variation in rice prices in most cases. However, total vegetable prices are less risky than those of cereal crops. Again, individual vegetable prices move in opposite directions, compensating for the high price of one vegetable with the low price of another.

For most vegetables, wholesale-level variation in prices is higher than variation at the retail level. Thus, retailers help to reduce the variation in prices by adjusting their margins. These variations at the wholesale level vary from 15.2% for snake gourd to 7.6% for radish and cucumber. At the retail level, variation ranges from 13.7% for beetroot to 5.8% for beans.

Economics of Cultivation

The Socioeconomics and Planning Centre of Department of Agriculture conducts studies into the costs and returns of vegetable cultivation. The following discussion is derived from the data furnished in these studies.

Input Use

Input use for selected vegetables is reported in Table 9. For comparison, the input use for rice is also included. Generally, labor use in vegetables is much higher than in rice. This suggests that vegetable cultivation can generate more employment. Fertilizer application in vegetable cultivation is also higher than in rice. In many cases, high chemical fertilizer applied is also supplemented with high compost manure. If fertilizer, compost manure, and lime applications are combined, vegetable crops are shown to be even more input-intensive than field crops, such as rice (Table 9). This suggests that vegetable cultivation needs stronger agricultural business links.

Table 9. Input use (ha^{-1}) in selected vegetables, 1992-93

Vegetable Crop/season	Place of study	Labor (days)			Seed (kg)	Fertilizer (kg)				Compost (t)	Lime (t)
		Hired	Family	Total		N	P	K	Total		
Maha season											
Carrot	N. Eliya	341	138	479	3	163	179	237	579	27.2	-
Pole beans	Badulla	109	207	316	39	130	195	130	455	1.1	-
Potato	Badulla	114	245	359	1791	220	240	320	780	-	-
Sweet potato	Ratnapura	145	152	297	3087 (seedling)	49	50	65	164	-	-
Tomato	Badulla	94	242	336	1	183	127	91	401	3.0	-
Rice	Kandy	40	168	208	102	79	37	38	154	-	-
Yala season											
Bush beans	Matale	48	162	210	30.1	134	52	35	221	-	-
Cabbage	N. Eliya	264	79	343	0.2	-	-	-	-	1.7	2.5
Pole beans	Badulla	141	308	449	46.5	256	225	150	631	-	-
Potato	N. Eliya	427	123	550	2224	208	229	302	739	33.7	-
Tomato	Matale	24	205	229	0.5	124	65	46	235	-	-
Rice	Kandy	58	118	176	100	93	22	37	152	-	-

Source: Socioeconomic and Planning Centre (1994).

Factor Shares

Factor shares of different inputs in the total cost of vegetable and rice cultivation are reported in Table 10. Labor and fertilizer are the major costs in vegetable cultivation. Labor cost claims more than half of the total cost in most cases. Power claims an insignificant proportion of the total cost in all crops. Despite excessive use of fertilizer, its share in total cost remains about 20%, except in carrot and cabbage. Similarly, with the exception of tomato, the share of pesticide is also less than 15%.

Table 10. Factor share (%) of different inputs in the total cost of selected vegetables, 1992-93

Crop/season	Place of study	Labor	Seed	Fertilizer	Pesticide	Power
Maha season						
Carrot	N' Eliya	40	4	38	9	8
Pole beans	Badulla	56	17	21	5	0
Tomato	Badulla	51	3	22	24	0
Yala season						
Bush beans	Matale	53	15	15	12	4
Cabbage	N' Eliya	42	9	30	18	0
Pole beans	Badulla	64	14	19	3	0
Tomato	Metale	61	4	19	14	2

Source: Estimated from the data obtained from the Socioeconomics and Planning Centre (1994).

Returns from Vegetable Cultivation

Per-hectare yield and gross and net return on vegetable and rice cultivation are reported in Table 11. Total cost of vegetable cultivation is higher than that of rice, and such is the case for gross and net return. While net benefit in vegetable cultivation is positive and benefit-cost ratios are in the range of 56-303%, net return in rice cultivation is negative, as is the benefit-cost ratio, in both Maha and Yala seasons. Despite high profitability, area under vegetable cultivation in the country is limited and not sufficient to meet the daily requirement of the population. The serious constraints limiting the expansion of vegetable area need to be studied.

Table 11. Returns from vegetable cultivation, 1992-93

Crop/season	Study place	Yield (kg/ha)	Price (LKR/kg)	Gross income (LKR/ha)	Total cost (LKR/ha)	Net income (LKR/ha)	Benefit-cost ratio	Cost (LKR/kg)
Maha season								
Carrot	N. Eliya	21349	10.50	224165	111924	112241	100	5.24
Pole beans	Badulla	10200	12.00	122400	46924	75476	161	4.60
Potato	Badulla	11391	28.48	324416	180828	143588	79	15.87
Sweet potato	Ratnapura	12857	4.30	55285	30715	24570	80	2.39
Tomato	Badulla	10956	12.50	136950	59675	77275	129	5.45
Rice	Kandy	3089	7.00	21623	24600	-2977	-12	7.96
Yala season								
Bush beans	Matale	2733	18.21	49768	31802	17966	56	11.64
Cabbage	N. Eliya	37302	5.76	214860	68249	146611	215	1.83
Pole beans	Badulla	9627	16.30	156920	61726	95194	154	6.41
Potato	N. Eliya	16395	31.85	522181	281447	240734	86	17.17
Tomato	Matale	7082	16.79	118907	29504	89403	303	4.17
Rice	Kandy	2575	7.50	19313	22937	-3624	-16	8.91

Source: Socioeconomics and Planning Centre (1994).

With few exceptions, the cost of production per kilogram of vegetable output is almost equal or lower than the cost of producing one kilogram of rice.

Marketing

Vegetable marketing in Sri Lanka is primarily in the hands of the private sector. The following are descriptions of different marketing agents, types of vegetable markets, marketing channels, and marketing functions and services in the country.

Marketing Agents

Major vegetable marketing agents in the country are as follows (Perera et al. 1991; Gunawardena 1992):

a. Assembly agents. Agents or brokers who collect the produce from farmers for the trucker-buyer or commission agents. They usually keep about 5% market margin.

b. Trucker-buyer. Traders who come in lorries and purchase the produce through the assembly agents or direct from the producers. They could be retailers or wholesalers.

c. Commission agents. These are wholesale traders at major wholesale markets who sell vegetables for the farmers or assembly agents on a commission basis. They usually keep a 10% margin as their sale commission.

d. Retailers. Retail traders who sell vegetables in vegetable stalls, general grocery shops, and at the roadside.

Types of Marketing

The following are the type of markets through which vegetables pass from producers to consumers.

a. Local periodic markets (weekly fairs). Periodic markets or weekly fairs are common in many rural towns and also in some semi urban communities. They are held once a week in a common place, such as an open wasteland belonging to the local council, or the waysides. Producers from the local area bring produce and traveling traders transport goods from one fair to another.

b. Retail outlets. Private retailers include stall-holders at market centers and fairs, pavement vendors, and village boutique owners. The retailers get vegetables from produces, assembly agents, or wholesalers. Some retailers are also producers, primary level collectors, or wholesalers.

c. Wholesale markets: Wholesale markets can be found in every main city. They obtain vegetables mostly from assembly agents. Retailers, including wayside vendors, buy from the wholesale markets. Some wholesale markets procure direct from producers.

Marketing Channels

The following alternative marketing channels through which vegetables reach consumers have been studied.

1. Producer →commission agent → retailer → consumer.

2. Producer → assembly agent → trucker/retailer → consumer.

Marketing Functions and Services

Important market functions and services are discussed below (Gunawardena 1992).

Cleaning

Farmers do not clean their produce thoroughly before selling. Cleaning is mostly limited to removal of spoilage and visible extraneous matter (except vegetables destined for highly commercialized markets).

Grading

Vegetable collectors usually pay a flat rate for produce and are not particular about grades. Very little grading is undertaken, even at major wholesale markets. Retailers who purchase in bulk get vegetables in the form sent by the producers.

Most farmers, therefore, are not keen on grading before selling. In up-country, where vegetable cultivation is highly commercialized, some producers have formed their own societies, where members grade certain vegetables, such as capsicum and tomato, before selling. The prices vary for different grades in these cases.

However, grading is practiced in all types of retail trade, from supermarkets to pavement vendors. It is undertaken based on cleanliness, size, appearance, and freshness of the produce. Prices differ accordingly.

Packing

Transport of vegetables from production areas to the terminal markets usually takes 1 to 1 1/2 days. Vegetables are transported in various containers, such as gunnies, polysacks, wooden crates, or simply wrapped in any available material, such as old gunny cloths or woven coconut leaves.

Producers minimize the cost of containers by packing the maximum possible weight. Traders and transport agents also overload vehicles. This has resulted in considerable loss of quality and produce in transit and handling.

Farm Financing

It is a well established practice for commission agents to provide credit to producers, agents, and retailers. Producers favor this informal credit arrangement and take loans for cultivation as well as to cover family expenses. While the producers get the benefit of easy credit, the commission agents on the other hand develop a close relationship with the producers, and they are assured supply of vegetables. The loans are free of formal interest, but the agents often pay their farmers less than the market price for their output, thus charging interest higher than that in the formal sector.

Provision of Marketing Information

Radio and newspapers are the main sources of price information available to vegetable growers.

Producers regularly get feedback on prevailing wholesale prices in major cities at the time they receive cash for the produce they have sold to commission agents. Personal communications with traders and neighboring producers are the other sources.

Marketing Margins

Macro-level Analysis

Marketing margin can be estimated from the retail- and wholesale-level prices. The margins estimated this way suggest that these vary across vegetable and over time. Generally, the margin in vegetable trade varies from 31% to over 70% (Table 12).

Marketing margins increased during 1986-92 in all the vegetables studied (Table 12). It is not clear whether the monopolistic power of the middlemen increased or the cost of some inputs (say labor or capital) increased over the period. The increasing margins explain the increasing retail prices, while the wholesale prices fluctuate around a stagnant trend.

Table 12. Changes in marketing margin for selected vegetables in Colombo market and its suburbs, 1986-95

Vegetable	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Ash plantain	38	31	38	38	41	43	38	40	46	51
Bandakka	47	48	52	49	47	54	51	54	53	60
Butter beans	32	31	33	34	34	36	34	38	37	45
Beet root	39	42	43	46	46	46	48	49	48	49
Bitter gourd	47	45	46	46	46	51	49	49	48	56
Eggplant	49	51	53	51	52	61	53	57	60	59
Cabbage	54	52	60	55	56	61	70	62	62	67
Chili	36	36	38	38	38	40	46	42	40	47
Carrot	35	33	41	37	39	42	37	44	44	46
Cucumber	55	56	58	59	56	63	61	62	61	63
Pepper	46	48	49	55	47	49	53	46	49	54
Knoh-khol	53	53	55	58	56	61	56	58	58	60
Long beans	44	48	45	48	48	54	49	51	52	55
Leeks	35	37	40	38	42	44	42	44	44	49
Luffa	48	49	51	52	50	58	52	53	53	59
Pumpkin	47	53	51	52	54	51	55	57	58	65
Radish	60	60	59	63	61	68	63	63	66	69
Snake gourd	53	54	56	57	50	58	55	53	55	65
Tomatoes	44	43	50	51	51	52	46	46	47	49

Source: Estimated from the wholesale and retail prices provided by the Agrarian Research and Training Institute (various issues[b]) as the difference of these prices divided by the wholesale prices and multiplied by 100.

Marketing margins also vary according to the time of year, depending upon the prices of vegetables. Usually when prices are high, marketing margins are low, and vice versa (Table 13). This suggests that retailers help to reduce the extent of seasonality in vegetable prices.

Table 13. Marketing margin (%) during the high- and low-price months of selected vegetables in Colombo market and its suburbs, (average of 1986-92).

Vegetable	Low-price months	High-price months
Ash plantain	41	38
Beetroot	46	43
Bitter gourd	50	44
Butter beans	36	30
Cabbage	57	54
Carrot	35	40
Chili	35	41
Eggplant	56	50
Okra	53	49
Carrot	54	85
Capsicum	53	76
Eggplant	98	149
Lady's finger	90	117

Source: Estimated from the wholesale and retail prices provided by the Agrarian Research and Training Institute (various issues[b]) by first isolating the three highest price and three lowest price months in every year for every crop, estimating the margin separately for each of these months, and then averaging these margins for the low- and high-price months throughout the period.

Review From the Micro-level Studies

The micro-level studies conducted on marketing margins also suggest that they vary for different vegetables and for different marketing channels. The available estimates of the gross marketing margins are quite high given the fact that vegetables are marketed in an unprocessed form. A study in 1978 (Gunawardena and Chandrasiri 1980) estimated that the gross marketing margins for 16 out of 17 individual vegetables were above 50%, and can be as high 84%. The net price received by the producers was thus below 50% for most vegetables. The latest study of Perera et al. (1991) has shown that marketing margin varies from market to market for the same commodity as well. The retail level consumes a major portion of the marketing margin in all commodities (Table 14). This is because of the small quantities of vegetables sold by each individual retailer, and probably because of the high physical losses at this level.

Table 14. Marketing margin (% of consumers' price) from selected studies

Study place	Market	Bean	Beet	Cabbage	Carrot	Leek	Tomato
Kandy	Wholesale	10.4	10.4	11.7	12.9	9.8	9.9
	Retail	49.6	46.6	60.3	33.1	50.2	34.1
	Total	60.0	57.0	72.0	46.0	60.0	44.0
Colombo	Wholesale	10.5	9.4	11.0	9.6	10.6	8.5
	Retail	33.2	50.7	55.4	49.8	47.1	54.6
	Total	43.7	60.1	66.4	59.4	57.7	63.1

Source: Perera et al. (1991)

International Trade

Total quantity and value of exports and imports and balance of trade during 1981-93 are reported in Table 15. The exports level is small and never exceeded 6000 t. Wide variation exists in the import quantity and value, resulting no trend in international trade.

Table 15. Vegetable import and export quantities (including onion and chili) (000 t) and values (million LKR)

Year	Exports		Imports		Balance of trade	
	Quantity	Value	Quantity	Value	Quantity	Value
1981	1.2	17.5	6.4	30.9	-5.1	-13.5
1982	1.2	10.9	16.6	138.1	-15.4	-127.2
1983	1.7	36.1	26.2	269.5	-24.5	-233.4
1984	2.3	39.0	103.9	833.5	-101.5	-794.5
1985	0.3	4.0	128.9	838.2	-128.6	-834.2
1986	0.6	16.2	99.0	757.4	-98.5	-741.2
1987	1.6	60.3	71.1	691.6	-69.4	-631.3
1988	3.0	71.7	32.4	484.3	-29.4	-412.6
1989	-	-	5.6	119.2	-5.6	-119.2
1990	-	-	78.4	752.2	-78.4	-752.2
1991	2.9	181.6	101.8	1778.5	-98.9	-1596.9
1992	5.5	116.7	74.2	1227.7	-68.7	-1111.0
1993	4.0	147.1	72.9	940.2	-69.0	-793.2

- implies that data are not available.
Source: Office files of Department of Customs.

Sri Lanka has a deficit in vegetable trade, and the country loses up to 1.6 billion LKR in vegetable trade annually. Onion and chili, mainly from India, account for the major share of imports. There is a need to study the domestic resource costs of vegetables in order to pinpoint the technological and institutional constraints that limit vegetable exports from Sri Lanka.

Supply and Demand

Availability

About 800 g of total food are available for an average Sri Lankan, out of which 13% comes from vegetables. Rice accounts for about 45% of the total available food (Table 16).

Table 16. Food availability in Sri Lanka, 1993

Food item	Availability (g/day)	Share (%)
Cereals	359.72	45.0
Fruits	8.41	1.1
Meat, fish, eggs	50.73	6.4
Milk	41.35	5.2
Oils & fats	93.45	11.8

Contd. Table 16.

Food item	Availability (g/day)	Share (%)
Pulses & nuts	15.83	2.0
Roots & tubers	50.35	6.3
Sugar	70.33	8.0
Vegetables	116.00	13.4
Total food	797.45	100.0

Source: Department of Census and Statistics (1994a).

Per capita availability of vegetables in the country is about 116 g/day, or about 42 kg/year. However, these estimates might underestimate actual availability, as vegetable consumption from home gardens, especially in rural areas, is not accounted for in these calculations. Vegetable availability remained almost stagnant during 1981-93. Following the production trend, the annual per-capita availability first increased, reached its highest level in 1986, and then declined until 1992 (Table 17).

Table 17. Trend in per capita availability of vegetables, 1981-93

Year	Total prod (000t)	Population (million)	Trade surplus (000t)	Net availability (000 t)	Annual per capita (kg)	Per capita per day (g)
1981	535.5	15.10	-5.1	540.6	40.8	111.7
1982	448.8	15.28	-15.4	464.2	35.8	98.1
1983	742.1	15.47	-24.5	766.6	30.4	83.2
1984	773.0	15.65	-101.5	874.5	49.6	135.8
1985	793.8	15.84	-128.6	922.4	55.9	153.1
1986	782.3	16.03	-98.5	880.8	58.2	159.5
1987	767.4	16.22	-69.4	836.8	55.0	150.6
1988	829.8	16.41	-29.4	859.2	51.6	141.4
1989	714.6	16.61	-5.6	720.2	52.3	143.4
1990	711.5	16.81	-78.4	789.9	43.4	118.8
1991	646.4	17.01	-98.9	745.3	47.0	128.8
1992	656.3	17.21	-68.7	725.0	42.1	115.4
1993	630.5	17.41	-69.0	699.5	42.3	115.9

Source: Estimated from production data, excluding potato, but including chili and onion.

Consumption

The latest detailed vegetable consumption survey was conducted in 1986-87 (Table 18). The survey, although somewhat outdated, provides important information about vegetable consumption across income groups in Sri Lanka. Average monthly vegetable consumption by all income groups was 2666 g (89 g/day), which is consistent with the availability estimates.

Table 18. Per capita monthly vegetable consumption (g) by income group, 1986-87

Vegetable	Income group												Mean value
	0-100	101-200	201-400	401-600	601-800	801-1000	1001-1500	1501-2000	2001-3000	3001-5000	5001-10000	>10000	
Fruit and root vegetables													
Ash plantain	_	42	88	84	82	95	99	102	122	112	110	120	106
Ash pumpkin	_	_	1	2	4	7	5	6	9	4	5	10	6
Beans	273	245	209	205	235	234	262	314	335	398	419	450	320
Beetroot	89	256	52	60	63	67	75	99	117	129	152	156	103
Bitter gourd	9	62	65	67	56	55	52	60	66	78	89	68	65
Capsicum	27	8	16	31	30	32	42	56	49	62	73	78	51
Carrot	28	63	38	23	32	28	38	49	67	101	154	157	66
Cucumber	_	16	13	21	17	18	21	25	31	32	85	64	31
Drumstick	17	131	74	115	94	95	99	101	95	95	73	102	96
Eggplant	61	164	291	237	246	256	280	266	274	238	252	181	260
Eggplant (small)	61	39	39	43	33	17	23	27	28	31	30	18	27
Golden melon	_	6	75	32	36	49	39	45	48	30	40	22	41
Knol-khol	_	17	17	27	35	36	37	48	45	49	44	46	43
Kohilala (Spinyelephantsear)	_	72	7	6	15	14	16	21	23	27	29	26	21
Kohila yams	_	_	7	9	8	9	14	12	14	26	27	20	16
Lady's finger	94	65	32	62	74	64	70	76	94	111	112	101	86
Long beans	180	82	99	106	139	128	130	136	140	134	124	74	132
Luffa	56	94	81	87	68	75	57	67	73	63	59	76	66
Pumpkin	173	46	118	168	150	185	193	189	211	213	182	177	194
Radish	99	113	54	35	61	57	46	54	49	47	47	43	50
Snake gourd	0	128	34	70	78	67	71	65	75	72	63	78	70
Tomato	33	44	63	48	48	38	42	49	49	51	54	87	49
Winged bean	_	_	9	24	23	23	20	22	22	27	27	26	23
Other	65	218	58	104	81	89	80	69	61	57	79	51	71
Leafy vegetables													
Amaranths	_	_	1	8	9	8	14	18	13	11	8	11	12
Cabbage	56	125	102	123	137	135	163	184	197	186	162	176	173
Cabbage leaves	_	_	10	17	14	18	18	18	23	14	11	16	18
Gotukola (Asiatic penny wort)	71	58	56	53	50	65	63	66	74	90	101	85	73
Kangkong	_	_	18	21	21	15	19	25	32	42	43	46	29
Kathurumurunga (Sesbania)	32	33	12	16	15	10	14	18	28	35	54	37	25
Leek	121	135	25	24	30	37	44	53	67	90	107	129	63
Mukunuwenna (Alternanthera)	280	222	110	85	108	112	125	139	162	194	229	248	155
Other leafy vegetables	11	69	174	139	126	102	125	114	124	129	165	119	125
Total	1836	2553	2049	2150	2218	2240	2395	2592	2817	2977	3209	3098	2666

Source: Central Bank of Sri Lanka (1991).
– implies less than one or zero.

No significant trend in monthly consumption was observed until income reached beyond LKR 1500. However, consumption is seen to progressively increase after that level.

The vegetable mix varies by income group. For example, the lowest income group consumes more radish, mukunuwenna, long beans, and small eggplant than the highest income group. The spread of the consumption is more diversified for the higher income groups. Thus, with development, consumers not only demand more vegetables, but also more diversity.

On average, households use 6.6% of their income to purchase vegetables. For the lower income groups, as much as 21% of the household income goes for vegetables (Table 19).

Table 19. Percentage of monthly household income spent on vegetables, 1991

Income group (LKR/month)	Percentage of income spent on vegetables
Overall	6.6
0-961	20.6
962-1353	14.6
1354-1724	12.5
1725-2076	10.7
2077-2448	9.5
2449-2879	8.4
2880-3500	7.7
3501-4474	7.0
4475-6440	5.8
6441 and above	3.0

Source: Department of Census and Statistics (1993).

The rural population and the estate sector workers (predominately laborers in tea and rubber plantations) spend more on vegetables out of their total expenditure on food and drinks, than do members of the urban sector; however, the differences are relatively small. The expenditure on vegetables as a percentage of expenditure on food and drinks increased in all sectors during 1986 to 1991 (Department of Census and Statistics 1993). This might have been due to the increase in vegetable prices as discussed earlier.

Demand and Income Elasticities

Demand elasticities are not available for vegetables, except for one study on cowpea and mungbean (Table 20). The own-price elasticities are very high compared to income elasticities, suggesting that reduction in vegetable prices through improved production technology, rather than increase in income, can substantially improve vegetable consumption.

Table 20. Own- and cross-price, and income elasticities for cowpea and mungbean

Commodity	Own price	Cross price	Income
Cowpea	-2.816	0.238	0.435
Mungbean	-0.913	0.437	0.271

Cross Price = Red lentic for cowpea and cowpea for mungbean.
Source: Balasuriya (1992).

Supply Elasticities

Only a few studies are available on the supply elasticities of vegetables. Gunawardena (1977) estimated supply elasticities of three vegetables (Table 21). The supply elasticities are quite low in the short-term, indicating production and institutional constraints blocking additional supply in the short-term.

Table 21. Supply elasticity for selected vegetables

Vegetable	Short-term		Long-term	
	Linear model	Log linear model	Linear model	Log linear model
Cucumber	0.46	0.51	0.84	1.13
Red pumpkin	0.30	0.30	0.61	0.69
Snake gourd	0.53	0.54	1.02	1.06

Source: Gunawardena (1977).

Research Achievements

The Department of Agriculture is the principal organization conducting research on vegetables. In 1994, a separate institute called the Horticultural Research and Development Institute was established under the Department of Agriculture to promote vegetable research. The institute has regional research centers located in various agroecological zones. The main disciplines of research include varietal development and evaluation, crop management, soil science, crop protection, and food technology.

The varietal development program is essentially a breeding program for low-country vegetables and evaluation and selection of introduced germplasm for up-country vegetables. The overall goal is to identify high yielding varieties with desired traits. Regular hybridization programs are restricted to tropical vegetables.

Research is also carried out for suitable agronomic practices, fertilizer levels, seed rates, nursery management practices, and crop protection measures. To address rising concerns on the overuse of hazardous insecticides, which damage the environment, research is carried out on integrated pest management.

Despite a serious shortage of technical personnel, and the fact that most social scientists in the country are mainly engaged in major field crops, such as rice, modest success has been achieved in socioeconomic research. Table 22 shows a number of studies conducted in the discipline on various issues. Eighteen studies were reviewed relating to production and consumption, six on cost of

production, eleven on marketing, one on credit, seven on prices, three on extension, four on vegetable research, and five on policy.

Table 22. Main research fields in bibliography

Name of author	Production & consumption	Cost of production	Market-ing	Credit	Prices	Exten-sion	Research	Policy
Abeytunge and Arulnandhy, 1990	*						*	
Abeysekera and Senanayake, 1974		*	*		*			
Agrarian Research and Training Institute, various issues[a]					*			
Agrarian Research and Training Institute, various issues[b]					*			
Arasasingham and Schmidt, 1964	*							
Central Bank of Sri Lanka, various issues	*							
Charles et al., 1984						*		
Dasanayake, 1996			*					
De Silva and Sathasivampillai, 1976	*	*						
Department of Agriculture, 1990						*		
Department of Census and Statistics, 1990			*					
Department of Census and Statistics, various issues (1981-93)	*							
Evans, 1986	*							
Gunasekara, 1991	*							
Gunawardena, 1977	*				*			
Gunawardena, 1992			*					
Gunawardena and Chandrasiri, 1980	*		*					
Herath, 1983	*							
Herath, 1985	*	*						
Hettige and Senanayake, 1992	*	*	*	*				
Klaus, 1976							*	*
Nutrition and Janasaviya Division, 1992	*				*			
Padmasiri, 1987								*
Perera, 1989	*		*					
Peris and De Silva, 1966	*							
Senanayake, 1977	*		*					*
Socioeconomics and Planning Centre, 1994		*			*			
Suraweera and Agalawatte, 1980			*		*			
Vaz De, 1991	*	*					*	
Weerasinghe and Arulnandhy, 1990	*		*				*	
Weragoda, 1983						*		*
Wijayapala, 1991			*					*

The Socioeconomic and Planning Center has completed cost of production studies on different vegetables. Although only a few vegetables are covered, the information generated is very useful in understanding the input regime. These studies should be expanded to include other vegetables. Moreover, in order to understand farmers' practices under different environments, production studies should be conducted at the ecoregional level. Very little is known about the extent of losses due to different biophysical constraints in vegetable production. Marketing is the most important research area, but the least researched. It has been established by this study that input use in vegetables in Sri Lanka is high. However, the socioeconomic reasons for overuse of material inputs are little understood. Moreover, the effect of the overuse on resources, on consumers' and producers' health, and the environment has not been quantified. A few studies are available on marketing margins, but the interplay of policy environment and marketing efficiency has been completely ignored by researchers. The household consumption survey conducted in the mid-1980s provides complete information on vegetable consumption by income group, and rural versus urban sector of the economy. These surveys need to be continued to discern the dynamics of vegetable consumption across income groups. Moreover, seasonal variation in vegetable availability affects consumption, and ultimately micronutrient intake. This needs to be taken into consideration when planning these surveys, as it has been ignored in the past.

Summary and Discussion of Policy Implications

Vegetables in Sri Lanka are grown in various cropping systems, ranging from the year-round intensive commercial cultivation in the cool highlands to the rice-based cropping system, mainly in the Yala season after rice harvest. Home gardens are an important source of vegetables for families, but their contribution to the total vegetable supply is unknown. Cultivation is almost equally distributed between the two rainy seasons of Maha and Yala.

Vegetable production in the country increased during the early- to mid-1980s, but has stagnated since then. Per capita availability has declined as the population has continued to increase. On the other hand, there is strong pressure on vegetable prices at the retail level to rise while wholesale prices fluctuate around a stagnant trend. Thus, while no price incentive is generated for farmers to increase vegetable supplies, their availability to the poor is threatened.

During 1993, annual per capita vegetable availability stands at about 42 kg, about half of the recommended level. However, strong seasonality in vegetable supply, indicated by seasonal price swings, suggests that the problem of low availability is more serious in some months than in others. The seasonality in individual vegetable prices, based on a monthly price estimate, can be as high as 120% of the price in the peak supply season.

Individual vegetables are more risky to produce, indicated by a high coefficient of variation in production. Most of the variability in vegetable production comes from vegetable yield, rather than from area, implying that stable technologies can help to reduce vegetable production risk in the country.

Vegetable cultivation generates more jobs, although it requires high investment to purchase inputs, such as fertilizer, lime, chemicals, etc. Despite high investment, vegetable cultivation produces a high benefit-cost ratio.

Marketing margins between wholesale and retail levels in vegetable trade are as high as 70%. These margins have increased since the mid-1980s, which explains the increase in retail prices without any change in the wholesale prices. The margins are high during the peak supply period, and low during the lean vegetable supply period. The highest margin is added at the retail level because of the small scale of operations.

Sri Lanka has an international trade deficit in vegetables, mainly because of high imports of onion and chili from India. The country could save much foreign exchange by encouraging domestic production of vegetables. For this, however, a systematic effort would be required to identify the vegetables most suited for production in Sri Lanka, and to identify constraints limiting their cultivation.

Future Research Agenda for Socioeconomists

1. Cost of production and input use studies in different ecoregions to define the optimum input use by ecoregions.

2. Quantification of the extent of losses due to different biophysical constraints in vegetable production will help to prioritize vegetable research in the country.

3. Identification of constraints on the diversification of the rice-based cropping system with vegetables will help to improve and diversify farmers' incomes, and enhance vegetable supply in the country.

4. Estimating the domestic resource costs for vegetables will help to define international trade regimes for different vegetables.

5. Estimation of residual impact of high output use – in terms of resources productivity, consumers' and producers' health, and environmental pollution – will increase awareness among producers, consumers, and policy makers regarding the consequences of high input use in vegetable production.

6. The market inefficiency in vegetable trade is an open secret; there is a need to study the interface of policy regimes and market inefficiency to suggest practical ways and means to reduce this inefficiency. The market margins due to transportation cost, physical losses, profit of various agents, etc., need to be quantified.

7. Quantification of the effect of seasonality on micronutrient intake and health would highlight the importance of vegetable production and consumption in the country.

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TAIWAN

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Introduction

Taiwan is a leaf-shaped island crossing the Tropic of Cancer about 200 km off the eastern shore of the Chinese mainland, strategically located in the East China Sea, about midway between Japan and Korea to the north and Hong Kong and the Philippines to the south. Taiwan stretches about 386 km from north to south and 137 km at its widest point from east to west with a land area of 36,000 km^2.

The climate of Taiwan is subtropical with an average annual temperature of 24°C and an annual rainfall exceeding 1500 mm. Summers (May - July) are hot and humid, while winters (November - January) are cool. Typhoons occur from time to time in the summer. Taiwan's agriculture ranks as one of the most productive in Asia.

About two-thirds of the island is covered with forested mountains. The central mountains vertically divide the island into eastern and western parts. Eastern Taiwan is a region of mountains and highlands, while the west consists mostly of basins, hills, and plains. The largest plain is the Chianan plain, in the southwest, which is also the primary agricultural zone producing much of the rice, fruit, vegetables, and tea, among other crops.

Taiwan Province includes the main island and three offshore islands: Penghu on the west and Orchid and Green to the southeast. The administrative district system of Taiwan includes sixteen prefectures as shown in Figure 1, with the provincial government located in the Chung Hsing Village of Nan-tou Prefecture. With a total population of 22 million and a density of more than 600 people per km^2, Taiwan is one of the most densely populated pieces of land on earth. The per capita GNP of Taiwan in 1996 was US$12,872 (Council for Economic Planning and Development 1997). The cities of Taipei (2.7 million), Tai-chung (0.8 million), and Kaohsiung (1.4 million), are the three largest consumption centers.

In Taiwan, vegetables have traditionally been an important group of farm products, ranking fourth in farm value after fruits, hogs, and rice. The annual value of all vegetable production in 1997 was TWD35.6 billion, which is 12.7% of the value of farm products, 20.5% of the value of all crop production, and 81.8% of the cereal production value. Vegetables were cultivated on 176,123 ha, which is 17.7% of the total cropped area, compared to the 36.6% and 22.8% contributions of rice and fruit areas, respectively. Total vegetable production reached 3.0 million t in 1997 for an average yield of about 17.1 t/ha (PDAF 1997).

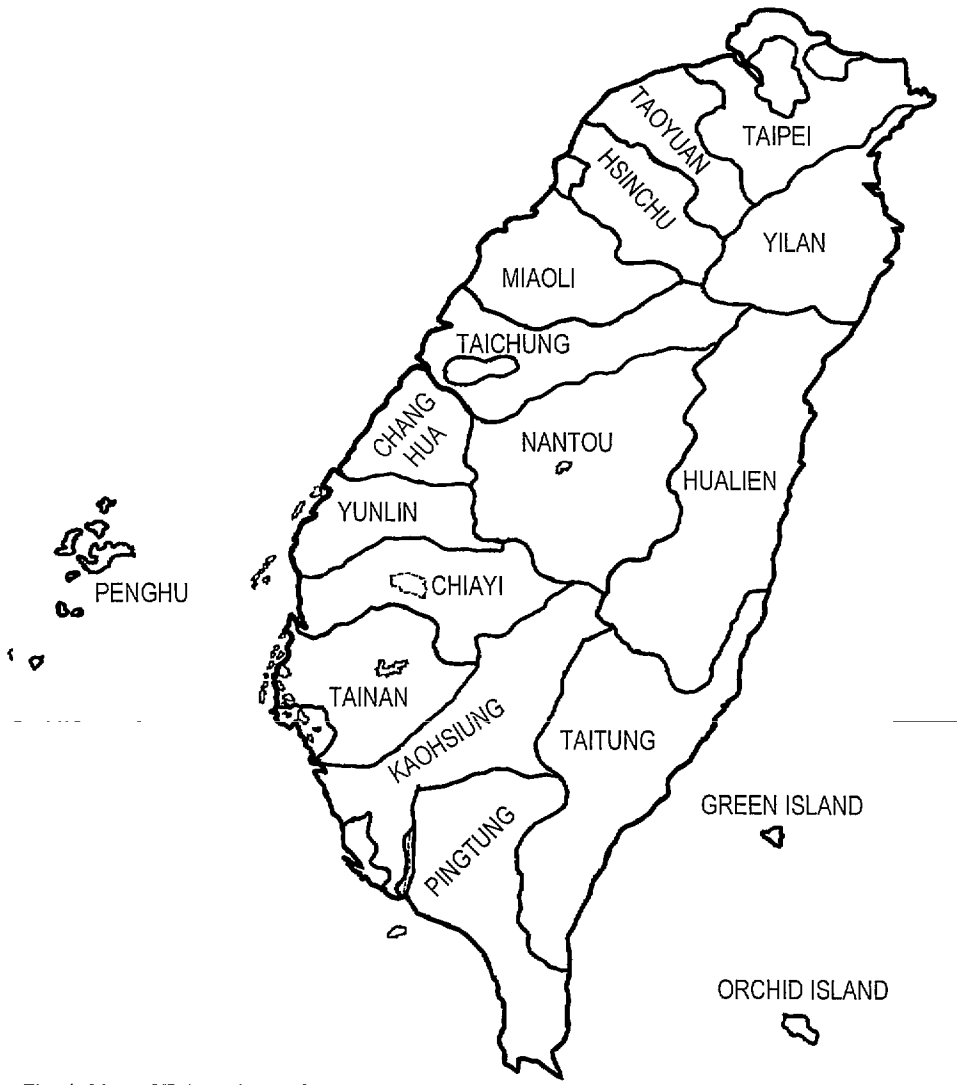


Fig. 1. Map of Taiwan by prefecture

In 1992, the average per capita food availability at the consumers' table was slightly higher than 1.5 kg/day, of which grains (including pulses and starches), livestock products, vegetables, fruit, and other food items constituted, respectively, 29%, 25%, 20%, 18%, and 8% (COA 1994). Twenty-two percent of the total food expenditure goes to vegetables, which is about equally distributed among leafy, fruit, and root vegetables.

Important Vegetables

Currently, hundreds of vegetable species are grown in Taiwan. These can be classified into four categories based on the edible part of the plants, i.e., leaf, stem, root, and fruit (Table 1). Among the four groups of vegetables, fruit vegetables lead in both production and value, followed by stem, leaf, and root vegetables. During the period 1972-97, production and value of root vegetables

were most stable. The importance of leafy vegetables in total vegetable production and stem vegetables in total vegetable value declined, while the share of fruit vegetable production and value increased during this period. Most of this structural change occurred during the early 1970s.

Table 1. Production and value share (%) of vegetables by group, 1972-97

Year	Leafy		Stem		Root		Fruit		Total (incl. melon)	
	Production	Value	Production	Value	Production	Value	Production	Value	Production ('000 t)	Value (million TWD)
1972	30	21	27	45	11	6	32	28	1,704	4,527
1977	26	20	24	36	11	7	39	37	2,587	12,261
1982	25	20	24	37	9	6	42	37	3,044	22,096
1983	23	20	24	31	9	6	44	43	3,019	26,555
1984	22	16	24	35	9	5	45	44	3,416	26,494
1985	22	17	25	32	9	5	44	46	3,243	26,507
1986	23	19	24	30	9	5	44	46	3,128	26,610
1987	23	19	26	30	9	6	42	45	3,284	28,204
1988	23	19	27	31	8	5	42	45	3,095	28,128
1989	22	19	29	34	8	6	41	41	2,955	27,788
1990	22	19	30	34	9	6	39	41	2,713	26,854
1991	22	17	28	35	9	5	41	43	2,864	29,273
1992	23	17	28	32	10	6	39	45	2,825	30,417
1993	22	17	29	30	9	6	40	47	2,840	30,817
1994	25	19	27	32	11	7	37	42	2,594	28,972
1995	24	17	28	36	11	6	37	40	2,853	33,866
1996	26	19	26	34	12	7	36	40	3,059	36,079
1997	26	19	27	34	10	6	37	41	3,004	35,637

Source: PDAF, various issues[b] (1973-98).
Primary species in each vegetable group include the following:
(1) Root vegetables: radishes, carrots, other root vegetables.
(2) Stem vegetables: ginger, taros, scallion, scallion bulbs, onions, leek, garlic, garlic bulbs, water chestnuts, water bamboo, bamboo shoot, asparagus, other stem vegetables.
(3) Leafy vegetables: cabbage, leaf-mustard, Chinese cabbage, celery cabbage, kankong, celery, other leaf vegetables.
(4) Fruit vegetables: cauliflower, lily flower, oriental pickling melons, cucumbers, white gourds, bitter gourds, eggplant, tomatoes, peppers, kidney beans, peas, vegetable soybeans, watermelons, seed watermelons, muskmelons, cantaloupe, strawberries, other fruit vegetables.
Note: To save space, some early years (1973-76, 1978-81) are not reported.

Among the primary vegetable species, bamboo shoot, watermelon, cabbage, vegetable soybean, radish, carrot, Chinese cabbage, and tomato are the leading commodities, accounting for more than half of the total area of vegetables in the country (Table 2).

Regional Distribution and Growing Seasons

Vegetable production in Taiwan is concentrated in certain locations because of comparative advantage of these locations (Table 2). This might be due to a number of factors affecting costs, including climate, availability of varieties, labor cost and availability, and proximity to a major consumption areas. Major vegetable growing areas include Yunlin, Chiayi, Changhwa, Tainan, and Pingtung Prefectures. The combined tonnage of these five prefectures represents almost two-thirds of the national total production. Among the top four vegetable producing prefectures, Changhwa specializes in stem vegetables, Yunlin and Changhwa specialize in leafy vegetables, and Pingtung specializes in fruit vegetables.

Many species can be grown in Taiwan all year round. Generally, leafy vegetables need less time to grow. For instance, Chinese mustard takes only 25-30 days to mature. In some specialized vegetable production areas, there can be eight to ten harvests of short-duration crops. On the other hand, bamboo and asparagus are annual crops (Table 2).

Table 2. Production area, growing and harvesting seasons, and new varieties of major vegetables

Vegetables (% of production of all vegetables)	Growing season	Harvesting season	New/currently grown varieties	Production county (% of total production)
Leafy Vegetables				
Cabbage (8.4)	Aug-Apr	Aug-Apr	K-Y Cross, Sha-Phong No.1, Summer Summit, Summer Autumn	Yunlin (25), Changhwa (23), Taichung (14), Yilan (8)
Chinese cabbage (4.2)	Year round	Aug-Apr	Jewel, Hamamidori, Changpuh, Taoyuan-AVRDC No.2	Yunlin (49), Changhwa (18), Chiayi (13), Yilan (5)
Chinese mustard (2.8)	Year round	Year round	Fengshan Pai-tsai, San-Fang No.2, Golden Pai-tsai, Tokyo Pai-tsai, Shandong round leaf Pai-tsai	Yunlin (53), Taipei (9), Taoyuan (7), Changhwa (5)
Kangkong (1.5)	Year round	Year round	–	Yunlin (16), Tainan city (15), Changhwa (13), Taipei (9)
Leaf mustard (1.6)	Nov-Jan	Nov-Jan	–	Yunlin (51), Chiayi (13), Changhwa (9), Miaoli (6)
Stem Vegetables				
Asparagus (0.2)	Apr-Oct	Apr-Oct	–	Changhaw (38), Chiayi (26), Pingtung (13), Tainan (9)
Bamboo shoot (11.7)	Jan-Dec	May-Oct	–	Yunlin (31), Chiayi (21), Tainan (11), Nantou (6)
Garlic* (1.2)	Nov-Apr	Nov-Feb	Northern garlic, Flowering garlic	Yunlin (33), Yilan (25), Taichung (13), Changhwa (7)

Contd. Table 2.

Vegetables (% of production of all vegetables)	Growing season	Harvesting season	New/currently grown varieties	Production county (% of total production)
Garlic bulbs* (1.8)	Mar-May	Mar-May	Hsilo-Black leaf, Homei Pu garlic, Flowering garlic	Yunlin (83), Tainan (8), Changhwa (4), Tainan city (2)
Onion* (1.3)	Dec-Apr	Feb-Apr	Caulifonia 505, Caulifonia 606, Caulifonia 707	Pingtung (89), Changhwa (6), Kaohsiung (5)
Scallion* (3.5)	Year round	May-Jul	Lan Yang No.1, Fragrant	Yunlin (54), Changhaw (11), Yilan (9), Taichung (4)
Root Vegetables				
Carrot (4.5)	Dec-Apr	Dec-Apr	–	Tainan (54), Yunlin (23), Changhwa (19), Tainan city (4)
Radish (5.0)	Jan-Dec	Aug-Apr	–	Changhwa (20), Tainan (19), Yunlin (15), Chiayi (14)
Taro (1.3)	Jan-Dec	Jul-Sep	–	Pingtung (30), Miaoli (22), Taichung (21), Kaohsiung (8)
Fruit Vegetables				
Cauliflower (2.4)	Aug-Apr	Aug-Apr	Fengshan Extra Early, Farmers Early No. 2, Ching–Nong 80 days	Changhwa (58), Kaohsiung (14), Chiayi (13), Miaoli (5)
Cucumber (1.9)	Jan -Dec	March-Nov	–	Pingtung (33), Changhwa (17), Kaohsiung (17), Nantou (9)
Kidney beans (0.9)	May-April	May -Sep	Taichung No.1, Everest, Similo, Thailand	Pingtung (55), Changhwa (14), Kaohsiung (7), Nantou (7)
Tomato (4.0)	Jan -Dec	Jan-May, Oct -Dec	Taichung-AVRDC No. 4 Hwalien-AVRDC No.5, Santa, Farmers 301, Season Red	Tainan (35), Chiayi (21), Yunlin (12), Kaohsiung (9)
Vegetable soybean* (5.7)	Jan-Dec	May-Sep	KS. 5, KS.S. 1	Yulin (27), Pingtung(25), Changhwa (15), Tainan (13)
Watermelon (10.7)	Feb-Apr	May-Jul	Empire No. 2, Empress, Quality, Yellow Super, Supreme Baby, Pink Orchid	Yunlin (28), Tainan (20), Changhwa (14), Chiayi (12)

Source: The growing and harvesting seasons were determined after the discussion of PDAF and AVRDC scientists. The percentage contribution of a crop in production of all vegetables and percentage contribution of a county in total area were estimated from data in PDAF (1998). For new varieties see Ku (1995).

* Variety sources are from personal communications with scientists at AVRDC.

Trends in Vegetable Production

The linear and quadratic trends in area, production, and yield of individual and total vegetables are reported in Table 3. Most of the individual vegetable species experienced an increasing trend in area in the beginning of the period 1970-97, followed by a declining trend in later years. In celery, the area continued to decline throughout the period at a constant rate, while for water chestnuts, leaf mustard, radish, and oriental picking melon, the area declined at an increasing rate. Leek and white gourd area remained almost stagnant during the period.

Table 3. Trends in area, production, and yield during 1970-97

Vegetable	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
Asparagus	0.045	-0.007	-	-0.006	-0.019	-
Bamboo shoot	0.126	-0.003	0.156	-0.004	0.030	-0.001
Cabbage	0.015	-0.002	0.027	-0.002	0.008	-
Carrots	0.103	-0.003	0.170	-0.005	0.067	-0.001
Cauliflower	0.098	-0.005	0.123	-0.006	0.026	-0.001
Celery	-0.029	-	-	-	0.015	-
Chinese cabbage	0.039	-0.002	0.058	-0.003	0.013	-
Cucumber	0.084	-0.004	0.111	-0.005	0.026	-0.001
Eggplant	0.065	-0.004	0.103	-0.005	0.039	-0.001
Garlic	0.065	-0.004	0.087	-0.005	0.018	-
Garlic bulbs	0.135	-0.005	0.114	-0.005	-0.008	-
Ginger	0.083	-0.005	0.117	-0.005	0.024	-
Kangkong	0.038	-0.002	0.041	-0.001	-	0.001
Kidney beans	0.101	-0.006	0.130	-0.007	0.029	-0.001
Leaf mustard	-	-0.001	0.046	-0.002	0.033	-
Leek	-	-	0.028	-	0.037	-
Muskmelon	0.213	-0.010	0.229	-0.010	0.016	-
Onion	0.059	-0.003	-	-	-	-
Oriental pickling melons	-	-0.005	-0.071	-	-	0.001
Peas	0.125	-0.007	-	-	-0.101	0.006
Pepper	0.132	-0.005	0.130	-0.004	-	-
Radish	-	-0.002	0.035	-0.002	0.021	-
Scallion	0.063	-0.002	0.068	-0.002	0.012	-
Scallion bulbs	0.161	-0.007	0.175	-0.007	0.019	-
Taro	0.119	-0.005	0.144	-0.004	0.035	-
Tomato	0.166	-0.008	0.290	-0.012	0.124	-0.004
Water chestnuts	-	-0.004	-	-0.004	-	-
Watermelon	0.055	-0.002	0.018	-	-0.031	0.001
White gourd	-	-	-	-	0.018	-
Other vegetables	0.096	-0.003	0.090	-0.003	-	0.001
Total vegetables	0.067	-0.003	0.082	-0.003	0.013	-

- indicates that the coefficient is not significant at the 5% level.

For most vegetables, similar production trends can be observed, i.e., an increasing trend in the initial years (1970-81), then a slowdown in the rate of increase or even a declining trend in the later years (1982-97). Leek and watermelon increased, while oriental picking melon decreased at a constant linear rate throughout the period. Asparagus and water chestnuts declined at quadratic rates. Celery, onion, peas, and white gourd production exhibited no trends.

Technological innovation increased vegetable yields at a constant linear rate of 1.3% per annum during 1970-97. Most vegetables follow the linear increase in yield with varying rates, except Kangkong, oriental picking melon, and other vegetables which experienced quadratic increase in yields. The yields of carrots, bamboo shoot, cauliflower, cucumber, eggplant, tomato, and kidney beans increased early in the period but their yields stabilized or even declined in the later years, as reflected by a negative and significant quadratic term in these cases. The opposite is true for peas and watermelon. Garlic bulbs and asparagus experienced a constant yield decline throughout this period, while the yield of onion, water chestnut, and pepper was stagnant.

Variability in Production

Detrended coefficients of variation (CV) in area, production, and yield for selected vegetable species and for total vegetables are reported in Table 4. For comparative purposes, corresponding CVs were also estimated for rice. In addition, the table reports the detrended CVs of the farm-gate and retail prices of selected vegetables.

Table 4. Detrended coefficients of variation (%), 1970-1997

Crop	Area	Production	Yield	Price*	
				Farm gate	Retail
Asparagus	16.6	18.9	16.5	-	-
Bamboo shoot	11.3	13.6	11.1	-	-
Cabbage	9.3	10.9	4.2	17.7	12.8
Carrots	18.9	17.5	7.5	38.3	20.9
Cauliflower	23.5	27.2	6.8	10.6	9.9
Celery	26.0	28.1	3.6	-	-
Chinese cabbage	20.0	19.1	4.0	14.3	11.1
Cucumber	21.7	25.0	6.1	-	-
Eggplant	19.5	23.7	6.0	18.0	11.0
Garlic	19.9	23.8	8.3	31.6	23.7
Garlic bulbs	28.3	26.7	13.7	-	-
Ginger	54.7	61.8	8.2	43.5	29.3
Kangkong	12.0	8.5	9.7	-	-
Kidney beans	28.5	32.8	4.4	-	-
Leaf mustard	13.1	14.9	6.0	-	-
Leek	19.0	21.5	18.9	-	-
Muskmelon	44.8	46.5	7.8	-	-
Onion	20.4	21.2	16.4	31.4	15.6

Contd. Table 4.

Crop	Area	Production	Yield	Price*	
				Farm gate	Retail
Oriental pickling melons	19.7	22.2	14.5	-	-
Peas	32.0	23.2	30.3	19.7	16.0
Pepper	19.1	18.0	11.8	22.1**	13.6**
Radish	10.2	14.9	5.6	20.4	14.5
Scallion	10.9	9.5	4.7	-	-
Scallion bulbs	38.2	39.8	18.6	-	-
Taro	28.2	24.5	9.2	-	-
Tomato	37.8	57.7	22.2	18.4	12.2
Water chestnuts	50.9	52.7	12.0	-	-
Watermelon	12.2	15.2	12.5	17.4	7.9
White gourd	20.8	26.5	14.0	-	-
Other vegetables	14.9	10.4	7.4	-	-
Total vegetable	14.0	14.5	2.8	10.0	-
Rice	6.8	7.7	3.8	9.0	8.3

* Price data is for 1977-97.
** For green pepper only.
- means data were not available.
Source: Estimated from data reported in PDAF, various issues[b] (1971-1998).

With only a few exceptions, the CVs for area, production, and yield of individual vegetable species are higher than the corresponding rice CVs, indicative of the higher risks involved in vegetable production. Even the CVs of area and production for total vegetables, where high variation in one vegetable species is expected to be balanced by lower variation in other species, are almost twice the CVs of area and production of rice. On the other hand, yield variation of individual vegetable crops seems to be negatively related, resulting in a relatively low CV for the yield of all vegetables.

Generally, the CVs in vegetable area are much higher than the CVs in yield of individual vegetable species, as well as of total vegetables as a group, indicating that variation in area was the main contributing factor to the high variation in vegetable production. Factors like limited market size for individual vegetable species, geographical dispersion of small vegetable-growing farmers, and lack of knowledge about other farmers' actions regarding each individual vegetable species result in high instability in prices, which in turn is an important determinant of high year-to-year fluctuations in vegetable area.

A high variation in production creates high variation in prices (Table 4). The price variations in individual as well as total vegetables are generally higher than in rice. The variation in farm-gate prices generally exceeds that of retail prices, indicating that marketing agents helped to stabilize prices by adjusting their profits. The stabilizing effect of marketing agents is often overlooked in the literature.

Seasonality

Seasonality in Supplies and Prices

A major problem facing farmers who grow vegetables during the summer is the regular occurrence of typhoons and floods that can cause severe damage to their crops. After each natural disaster, fields have to be replanted, yields of crops are reduced, and market supplies are interrupted. On the other hand, vegetable area and production increases during winter (Table 5), when many farmers tend to grow short-duration vegetables. This can actually cause economic problems to them because of market gluts, which force prices lower than production costs (Huang 1992b). Ke (1982) also observed significant seasonality in the production of major vegetable crops.

Wind and flood resistant varieties, protected cultivation, and the use of canned vegetables can reduce vegetable shortage during the summer season (Yang 1992). On the other hand, Liao (1975 and 1976) suggested encouraging highland production especially by setting specialized production zones to increase supplies of summer vegetables. This would extend the economic use of highland areas, and benefit highland farmers.

Table 5. Seasonal area and production share (%) of selected vegetables, 1996

Vegetable	Area			Production		
	1st crop	2nd crop	Winter crop	1st crop	2nd crop	Winter crop
Cabbage	35.6	27.6	36.8	29.6	30.6	39.8
Cantaloupe	39.3	19.6	41.1	39.9	20.7	39.4
Carrots	1.0	17.0	82.0	0.7	11.9	87.4
Chinese cabbage	24.5	30.2	45.3	20.6	28.9	50.5
Chinese mustard	36.8	34.9	28.3	36.7	34.5	28.8
Muskmelon	44.1	36.1	19.8	45.8	33.3	20.9
Radish	15.8	22.4	61.8	12.1	19.2	68.7
Tomato	28.1	18.2	53.7	21.5	15.0	63.5
Watermelon	69.5	18.9	11.6	76.0	13.4	10.6

Note: 1st crop refers to crops planted between Jan 1 and April 30, and harvested in the same year.
2rd crop refers to crops planted between May 1 and Sep 30, and harvested in the same year.
Winter crop refers to crops planted between Oct 1 and Dec 31, and harvested the following year.
Source: PDAF (1997).

Seasonality in vegetable production can also be investigated based on the monthly wholesale trade volumes and wholesale prices. High transactions in vegetables occur in December-January with a seasonal transaction index of around 100, compared to a low transaction index of around 73 in August-September. Almost a mirror image of transaction can be observed in the wholesale prices (Figure 2).

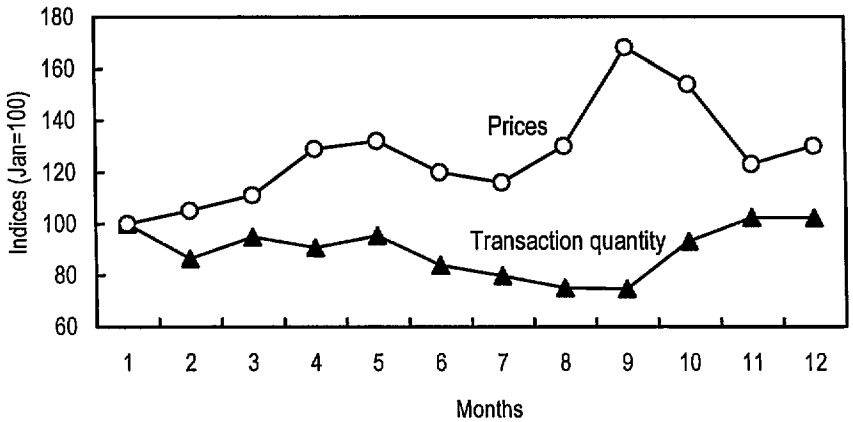


Fig. 2. Seasonality in the wholesale vegetable transaction and wholesale prices (average 1990-97)

Wide variation in monthly wholesale price indices of individual vegetables is also observed, indicative of the seasonal pattern in these prices; prices of most vegetables tend to be high during June-September, while they normally start declining from October, and remain low during January-March. For bamboo shoot, prices are high during January-April, which reflects an opposite pattern compared to that in other vegetables (Table 6).

Table 6. Seasonal indices for wholesale vegetable prices (average of 1990-97)

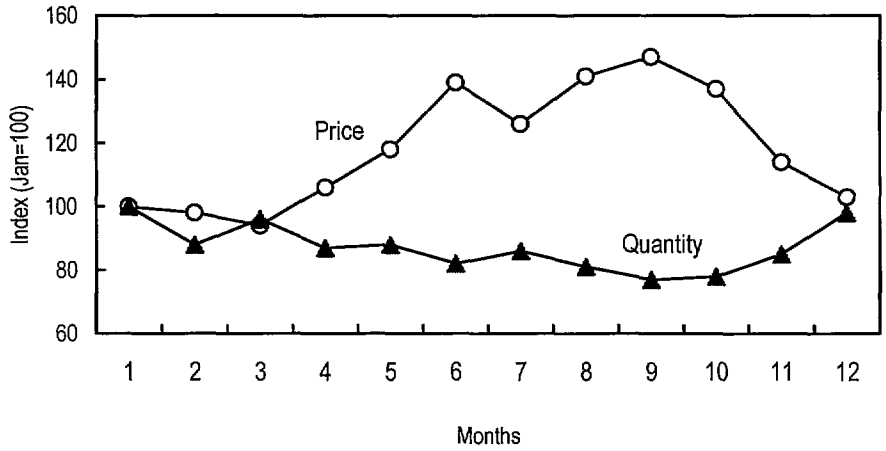
Vegetable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Seasonality
Leafy vegetables													
Cabbage	100	95	91	87	131	209	244	365	335	245	136	146	320
Chinese cabbage	100	97	117	165	167	246	249	318	307	201	152	159	228
Kangkong	100	93	106	101	81	90	86	124	107	85	90	110	53
Stem vegetables													
Bamboo shoot	100	116	110	99	84	64	60	81	79	72	74	88	93
Garlic	100	111	102	106	136	175	194	235	273	245	193	134	173
Celery	100	100	108	121	136	176	227	251	256	193	167	132	156
Onion	100	96	85	81	89	97	104	114	123	116	109	104	52
Root vegetables													
Carrot	100	98	97	104	114	120	122	132	145	147	138	121	52
Potato	100	103	100	99	101	108	109	114	118	121	116	100	22
Radish	100	95	97	118	173	245	288	338	361	176	113	114	280
Fruit and flower vegetables													
Cauliflower	100	98	127	142	177	248	307	362	421	242	162	166	330
Sweet pepper	100	112	100	107	103	136	197	215	286	241	142	113	186
Tomato	100	88	100	108	123	131	171	217	227	220	160	120	159
All vegetables[1]	100	98	99	105	111	128	131	162	161	128	111	112	68

Source: PDAF, various issues[c] (1991-1998).

[1]Monthly all vegetable prices were estimated as total vegetable transaction volume divided by the value of the transaction.

Seasonality in Consumption

The monthly consumption survey in Taipei City gives indication of the seasonal consumption and retail prices of vegetables in the country (Figure 3). Vegetable consumption peaks during the winter and spring seasons, then sharply declines during the summer months. The consumption of vegetables drops as much as 23% in the summer, and retail prices increase by 50%. However, a recent survey by the socioeconomics unit of the Asian Vegetable Research and Development Center (AVRDC) suggests much less seasonality (only 14%) in vegetable consumption in Taiwan.



Source: Official data from Taipei Municipal Government

Fig. 3. Seasonality in vegetable prices and consumption in Taipei City (average 1974-92).

Characteristics of Vegetable Cultivation

Size of Farms

The average size of a Taiwan vegetable farm was 0.86 ha in 1992, similar to the average fruit farm but smaller than the average rice farm (Table 7). The limited size of farms means they are intensively utilized but difficult to mechanize. However, harvesting machinery and automatic seeding techniques for vegetables are continuously being developed by various agricultural experiment and research stations.

Table 7. Average farm size (ha) by product group, 1985-92

Year	Rice farm	Tree/fruit farm	Vegetable farm
1985	1.13	0.76	0.48
1986	1.14	0.73	0.60
1987	1.17	0.67	0.61
1988	1.14	0.82	0.69
1989	1.16	0.81	0.76
1990	1.14	0.77	0.63
1991	1.14	0.75	0.88
1992	1.09	0.87	0.86

Data Source: PDAF, various issues[a] (1985-1992).

Type of Labor

Because vegetables require intensive care, from seeding to harvest to marketing, vegetable production is more labor intensive than cereal production. Most vegetable farms are highly dependent upon family labor, although the contribution of hired labor is generally higher in vegetables than in cereal crops. However, family labor has been declining steadily. The farm population is becoming older, which is likely to result in serious labor shortages, especially for vegetable cultivation. In Taiwan, the proportion of female labor in vegetable cultivation is generally higher than male. Moreover, the female proportion of labor is higher in vegetables than in other field crops, such as maize (Table 8).

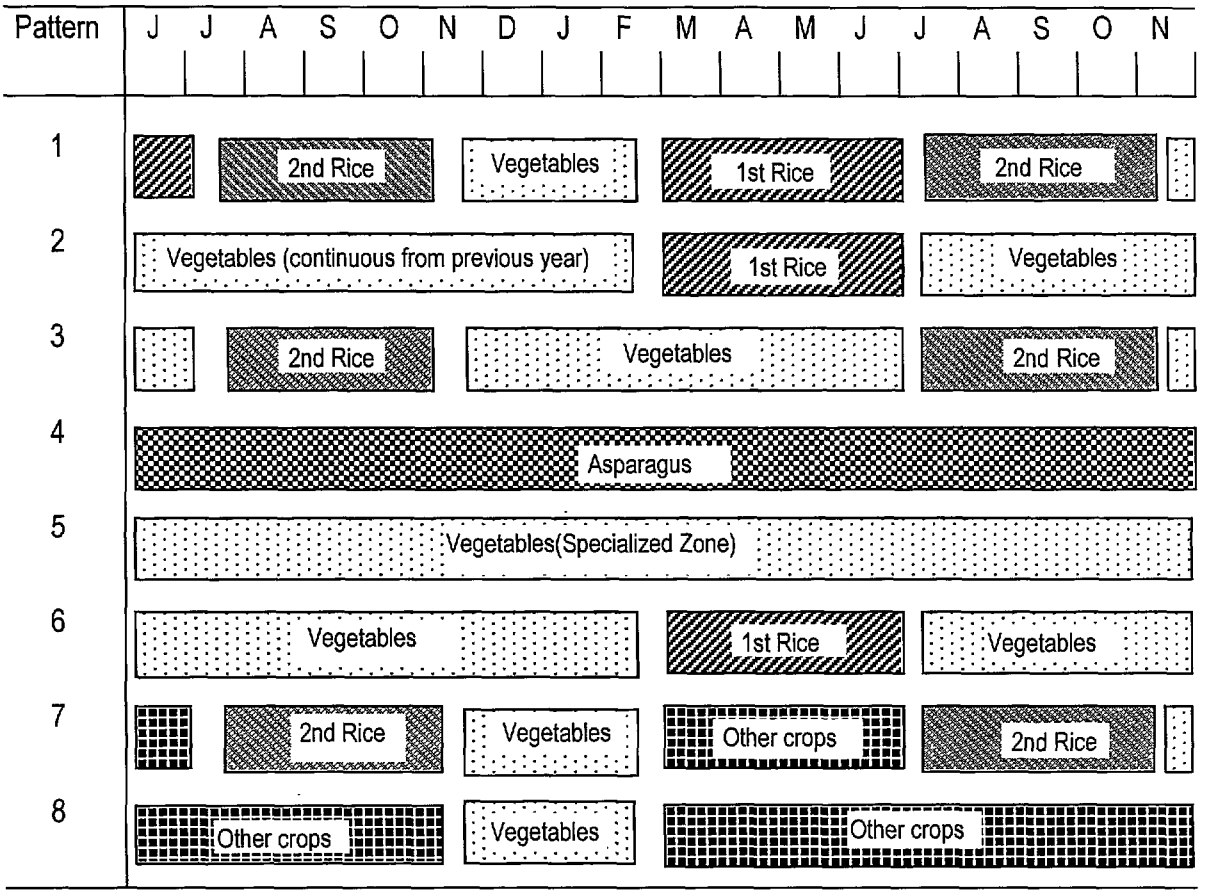
Table 8. Labor requirements and type of labor used in vegetable and field crop cultivation, 1997

	Source of labor (%)[1]		Gender (%)[2]		
Crop	Family	Hired	Female	Male	Total labor (hr/ha)[1]
Bamboo shoot (nakai)	95.7	4.3	19.1	80.9	1267
Bitter gourd (1st crop)	94.4	5.6	54.8	45.2	2040
Cabbage (2nd crop)	95.7	4.3	44.3	55.7	740
Carrot	90.0	10.0	57.0	43.0	293
Cauliflower (2nd crop)	96.7	3.3	59.8	40.2	910
Chinese cabbage (2nd crop)	79.8	20.2	59.5	40.5	603
Chinese mustard (1st crop)	100.0	0.0	56.2	43.8	928
Garlic bulbs (winter crop)	80.8	19.2	67.2	32.8	775
Onion	82.1	17.9	76.5	23.5	1016
Peas (winter crop)	88.8	11.2	74.2	25.8	1606
Radish (winter crop)	90.8	9.2	48.8	51.2	166
Scallion	96.5	3.5	48.3	51.7	921
Sponge gourd	97.1	2.9	39.1	60.9	1899
Tomato	97.2	2.8	64.0	36.0	4723
Tomato (small)	93.1	6.9	64.1	35.9	5503
Vegetable soybean (1st crop)	95.2	4.8	25.6	74.4	156
Maize (2nd crop)	98.6	1.4	42.1	57.9	121
Rice (Japonica, 2nd crop)	-	-	-	-	163*

Source: [1] The estimates are based on relative expenditures on each type of labor; [2]PDAF (1998).
*To estimate this, the total labor cost was divided by the average farm wage rate for men and women.

Vegetable-based Cropping Patterns

Alternative cropping patterns for vegetables are presented in Figure 4. Because rice is the principal staple food of the Chinese people, most of Taiwan's crop land has been engaged in growing paddy rice. There are two crops of rice per year; the first rice crop covers the April-July period, while the second crop is grown between August and November. This leaves mid-December to mid-March as the spare period, which is normally used to grow vegetables. Hence, the most popular cropping pattern in Taiwan is rice-rice-vegetables. For the specialized vegetable farms, multiple cropping and harvesting six to seven times in one year is very common for most short-duration vegetable crops. A detailed discussion on vegetable copping patterns in Taiwan can be seen in Hwang (1980).



Source: Hwang (1980)

Fig. 4. Cropping pattern of vegetable farms in Taiwan.

Developments in Vegetable Production

Cultivation Under Structures

To ensure production of summer vegetables, especially leafy vegetables, protected cultivation was introduced to farmers in 1971 and has been widely adopted. Protected cultivation methods include high-stand net houses, plastic tunnels, pipe houses, etc. High-stand net houses, which have been exclusively applied in the cultivation of leafy vegetables during the summer, protect crops from wind, rain, direct sunlight, and diseases; they speed crop growth and reduce the requirement for chemicals. Nevertheless, production in net houses can be negatively affected because: i) temperatures in the house usually exceed those outside, and ii) as a result of high temperatures and humid summer weather, ventilation can become problematic (Kuo 1993; Yang 1993b). Most vegetable cultivation in net houses takes place in the Yunlin and Changhwa Prefectures, and mostly in specialized production zones, with a total of about 400 ha in 1992 (PDAF 1993).

The plastic tunnel is designed to protect crops from cold waves of air and low winter temperatures. In 1993, plastic tunnels were used on about 600 ha of vegetable land.

The purpose for adopting pipe house cultivation differs according to the season. In the summer, a pipe house covered with plastic protects crops from heavy rains, without worsening ventilation. Closed pipe houses, which can keep plants warm when outside temperatures are low, are effective in growing off-season, high-return crops during the winter.

The investment costs of protected horticulture depend on the type of structure used. High plastic net houses cost more than TWD300,000 per 0.1 ha, less than TWD50,000 for a low stand net structure of the same rounded configuration, and TWD50,000-100,000 for a concrete stand net house (Yang 1993b). Adoption of protected production techniques is still low in Taiwan, mainly because of high investment costs. For hot pepper, current open field production practices are considerably more profitable than growing the crop in shelters, and the environmental conservation benefits obtained through protected management are not economical given the prevailing hot pepper prices (Jansen and Green 1994). Other constraints on protected vegetable cultivation are presented in Kuo (1993).

Institutional Reforms

Taiwan has experienced rapid agricultural development since the 1960s, with significant changes and improvements in both production and market structures. The first four years of the government-sponsored agricultural marketing improvement program, begun in 1970, changed the emphasis in agricultural development from production to marketing. Reconstruction of wholesale markets was undertaken and cooperative marketing of fruits and vegetables was initiated in 1973 and aggressively promoted. During the 1970s, fruit and vegetable wholesale markets were reconstructed in five large consumption centers: Taipei, Keelung, Taichung, Tainan, and Kaohsiung. Meanwhile, more than 30 fruit and vegetable wholesale markets were set up. As wholesale markets are crucial to agricultural price formation, modernization of market management and improved efficiency in transaction systems were encouraged under the Agricultural Products Markets Transaction Law (Wu 1993).

Since 1973, the government has encouraged farmers in vegetable growing regions to form so-called specialized vegetable production zones under the Accelerating Rural Development Program (ARDP). The aims of the ARDP included improving yield and quality of vegetables, enhancing farm income, and reducing the gap between supply and demand for vegetables. Specialized zones were first set up near urban metropolitan areas such as Taipei and Kaohsiung. To qualify as a specialized production zone, a vegetable growing region must meet the following requirements:

(1) grow vegetables year round;
(2) have adjoining fields of at least 20 ha;
(3) have a local farmers' association which stimulates and facilitates cooperative marketing.

In turn, the government provides farmers with a revolving fund to jointly purchase seeds, pesticides, fertilizers, and machinery to reduce the cost of production. The local farmers' association is responsible for helping vegetable growers in each specialized zone to set up production teams, teach members improved cultural and management practices, as well as induce cooperation in practice (Hsieh and Chen 1991).

Specialized zones are particularly concentrated near and around urban areas. Taipei City and Taipei Prefecture each have 14 specialized vegetable production zones, which grow mostly short-duration, high-value vegetable species with limited storage life (Chang 1993).

According to a survey conducted by Chang (1993), the total area of specialized vegetable production zones amounted to 2260 ha in 1992, operated by 116 production teams, with an average index of multiple cropping of 5.4. Although specialized zones account for less than 2% of the total vegetable area, their production is almost 7% of the total annual vegetable production. It is obvious that yields in specialized zones are considerably higher, and more stable, than in other vegetable production areas.

Economics of Production

Input Costs and Factor Shares

Total vegetable production costs are generally 2-10 times higher than for rice, except in the case of radish and vegetable soybean where they are almost equal (Table 9). This is true despite the fact that some vegetables (e.g., cabbage, celery, cauliflower, etc.) have significantly shorter crop duration than rice. The considerable cash outlays in vegetable cultivation, which usually small farmers can ill afford, are likely to act as major constraints to expanding vegetable production.

Table 9. Factor share and total costs for major vegetable and cereal crops, 1997

Crop/ vegetable	Factor share (%)						Total cost (000 TWD/ha)
	Seed/ seedling	Labor	Animals/ machines	Fertilizer	Chemicals	Miscellaneous[1]	
Bamboo shoot (Nakai)	3.2	80.6	0.0	12.0	0.9	3.3	276.7
Bitter gourd (1st crop)	4.6	67.1	2.4	11.9	5.7	8.3	420.4
Cabbage (2nd crop)	10.7	53.4	5.1	12.8	10.4	7.6	207.9
Carrot	2.6	25.2	51.8	12.0	6.3	2.1	165.6
Cauliflower (2nd crop)	8.6	57.3	4.9	9.7	8.9	10.6	224.3
Chinese cabbage (2nd crop)	11.6	43.9	11.6	13.8	8.7	10.4	192.6
Chinese mustard (1st crop)	1.6	77.4	4.8	8.3	2.8	5.1	175.7
Garlic bulbs (winter crop)	20.5	44.7	7.7	11.9	10.1	5.1	224.3
Onion	6.2	59.2	12.0	8.3	7.2	7.1	207.4
Peas (winter crop)	1.9	82.1	1.9	6.1	3.3	4.7	212.5
Radish (winter crop)	3.4	29.1	39.8	12.1	10.0	5.6	91.5
Scallion	16.1	37.0	32.3	6.6	5.8	2.2	355.1
Sponge gourd	7.3	67.6	2.0	7.3	3.0	12.8	397.6
Tomato	3.2	78.0	1.5	5.2	4.2	7.9	773.6
Tomato (small)	1.4	74.8	1.2	4.8	2.9	14.9	941.5
Vegetable soybean (1st crop)	11.6	30.0	40.6	9.7	6.0	2.1	97.6
Rice (Japonica, 1st crop)	8.3	32.5	43.8	7.0	6.6	1.8	83.5
Rice (Japonica, 2nd crop)	7.3	28.8	39.9	6.6	5.7	11.7	93.0
Maize (2nd crop)	4.4	29.5	45.0	12.7	4.2	4.2	58.8

Source: PDAF (1998).

[1]Miscellaneous costs include energy, materials and equipment, irrigation charges, building expenditures (depreciation), farming tools (depreciation), and taxes and fees.

Labor is the major cost in vegetable cultivation. Its share of total cost varies from 25% in the case of carrot to more than 80% in peas. Seeds or seedlings are an important cost item in garlic bulb, scallion, Chinese cabbage, vegetable soybean, cabbage, and cauliflower. Mechanical power, mainly used for harvesting, is an important cost item in carrots, radish, scallion, and vegetable soybean. The cost share of chemicals hardly exceeds 10% in any crop.

Absolute fertilizer and pesticide costs in vegetable cultivation generally exceed many times those in field crops; the only exception is field pea because of its natural soil nutrient (N) fixing capacity, and bamboo shoots, perhaps because of their natural resistance to insects and pests. However, with few exceptions, the relative share of these costs in the total cost is similar or even lower than rice (Table 9).

Profitability

Many factors, such as farm size, yield, number of multiple crops, cost of inputs, and degree of specialization, determine the profitability of vegetable production. Profitability also varies across different species, regions, and type of operation. For instance, average net earnings in lowland cabbage were significantly lower than in highland cabbage (Shuai and Chang 1992). The returns earned in the specialized zones for a typical vegetable were normally higher than on ordinary farms, except for cabbage and celery (Shuai and Chang 1992). Shuai (1988) found similar results for bamboo shoot.

Table 10 presents the net return on farmers' management for selected vegetables and alternative crops in 1997. Among the reported vegetable crops, the highest returns were associated with crops produced during the summer-fall period. Garlic bulb has negative return. However, if cost of family labor is excluded, then net returns are positive in all cases.

Generally, net incomes from vegetables considerably exceed those from producing alternative cereal crops, such as rice and maize. However, due to their relatively high input costs, benefit-cost ratios in vegetable cultivation exceed those for other field crops only in a few cases (Table 10).

Table 10. Economics of vegetable and cereal crops cultivation, 1997

Crop/Vegetable	Yield (kg/ha)	Cost and returns (000 TWD/ha)				Benefit-cost ratio (%)[3]	Cost/kg (TWD)
		Variable costs[1]	Total costs[2]	Gross revenues	Net benefit		
Asparagus	4423	337.3	374.1	264.2	-73.1	-19.5	84.6
Bamboo shoot (nakai)	9221	274.1	306.9	495.1	221.0	72.0	33.3
Bitter gourd (1st crop)	19072	419.1	441.4	531.0	111.9	25.4	23.1
Cabbage (2nd crop)	35484	206.4	222.7	313.4	107.0	48.0	6.3
Carrot	50992	163.7	179.2	185.6	21.9	12.2	3.5
Cauliflower (2nd crop)	24497	223.2	234.1	359.0	135.8	58.0	9.6
Chinese cabbage (2nd crop)	33618	191.2	200.9	280.3	89.1	44.4	6.0
Chinese mustard (1st crop)	16639	174.4	182.0	377.5	203.1	111.6	10.9
Garlic bulbs (winter crop)	7252	221.6	235.5	227.5	5.9	2.5	32.5
Onion	46103	206.1	231.9	259.2	53.1	22.9	5.0

Contd. Table 10.

Crop/Vegetable	Yield (kg/ha)	Cost and returns (000 TWD/ha) Variable costs[1]	Total costs[2]	Gross revenues	Net benefit	Benefit-cost ratio (%)[3]	Cost/kg (TWD)
Peas (winter crop)	7868	211.1	227.2	357.9	146.8	64.6	28.9
Radish (winter crop)	45464	90.4	98.1	155.9	65.5	66.8	2.2
Scallion	38448	326.3	367.3	387.4	61.1	16.6	9.6
Sponge gourd	26887	362.9	423.2	447.4	84.5	20.0	15.7
Tomato	55215	772.8	791.9	960.2	187.4	23.7	14.3
Tomato (small)	37330	923.1	974.4	980.1	57.0	5.8	26.1
Vegetable soybean (1st crop)	8393	96.5	108.1	122.1	25.6	23.7	12.9
Rice (Japonica, 1st crop)	6094	83.0	101.7	123.6	40.6	39.9	16.7
Rice (Japonica, 2nd crop)	7094	92.7	107.3	164.8	72.1	67.2	15.1
Maize (2nd crop)	5132	57.3	68.1	74.2	16.9	24.8	13.3

[1]Variable costs include costs for seed and seedling, fertilizer, human and animal labor (hired and family sources), mechanization, chemicals, energy, equipment, and irrigation.
[2]Total costs include variable costs plus land rent, interest, and expenditure on buildings and farming tools.
[3]The benefit-cost ratio is defined as net benefit/total cost.
Source: PDAF (1998), except for asparagus which is from PDAF (1994).

Total cost per kg of output varies from TWD2.2/kg for radish to TWD84.6/kg for asparagus. The relatively high production cost of asparagus in Taiwan, mainly due to the high cost of labor, has rendered Taiwan's asparagus production uncompetitive with other countries (Kan 1986). Wu (1986) found that aging of fields had caused the average yield of asparagus to decline, and the guaranteed purchase price for asparagus was too low to cover all the production costs. As a result, asparagus production in Taiwan is being phased out.

Marketing Systems

In Taiwan, agricultural production is market oriented, and production and consumption decisions are separated. Most vegetable farms are small-scale, while most households consume many varieties of vegetables in small quantities daily. Such characteristics of small-scale production and diversified consumption make marketing functions extremely important for an efficient vegetable industry.

Marketing Channels

Vegetables grown in Taiwan move to domestic markets through many different channels with each channel involving a number of marketing stages. Most fresh vegetables are marketed through the following three channels (Wann 1993a):

Shippers' Channel

Farmer → shipper → wholesaler → jobber/retailer → consumer. This channel is also called the traditional channel and is the longest marketing channel for fresh vegetables. Farmers may choose to

sell crops to shippers either before harvesting or at the local wholesale market. After grading and packing, mostly handled by shippers, products are shipped from their production regions to wholesale markets located near consumption centers. Jobbers and retailers purchase vegetables from wholesalers, and after cleaning and additional handling or packing operations, the produce is sold at local, traditional retail markets.

Farmers' co-operative channel

Farmer co-ops → wholesaler → jobber/retailer → consumer. This channel was created in June 1973. Since small-scale growers often lack market information and marketing capital, the terms of trade tend to be dominated by shippers in the traditional marketing channel. To improve the marketing system, the government has assisted and guided local farmer cooperatives to carry out a cooperative fruit and vegetable marketing program to ship fruit and vegetables jointly from production areas to consumption places via the fruit and vegetable wholesale markets.

Direct channel

Farmer co-ops → produce packing/distribution center → supermarket → consumer. This channel was created in 1983. This channel, which has increased in importance in recent years, consists of the selling of produce by grower cooperatives directly to retail stores, restaurants, and institutions. Although it is not strictly farmer-to-consumer direct marketing, the aim is to stabilize farm income and reduce marketing margins.

Market Efficiency

The efficiency of the vegetable marketing system has often been criticized because of increasing marketing margins, poor packing methods, high wastage, and inconsistent grading. In general, pricing efficiency, performance of wholesale markets, progress in cooperative marketing, and marketing margins are the issues most agricultural marketing economists would choose to analyze.

Performance of Wholesale Markets

Presently, there are some 70 fruit and vegetable wholesale markets in Taiwan, established and owned either by the local government, farmers' associations, or as joint ventures between the two. These markets are nonprofit organizations with the primary goal of serving farmers. Among the 70 fruit and vegetable wholesale markets, only two Taipei markets have adopted an auction system, the others are of the price-negotiating type.

The importance of wholesale markets has continuously risen during the last decade (Table 11). Currently, over 40% of total annual vegetable production is traded via wholesale markets. More detailed information about the distribution of vegetables is reported in Chen (1991a, b).

Currently, most fruit and vegetable wholesale markets near consumption centers face serious space problems. Twenty years of experience with the wholesale market operated by Taipei Agricultural Products Marketing Corporation, for example, has demonstrated the shortage of facilities for auction, trading, and parking, obsolete cold storage facilities with limited space, and environmental deterioration due to surrounding traffic congestion. On the other hand, the transaction volumes in the wholesale markets located in production areas have decreased due to structural changes in the

industry and/or the increasing role of cooperative marketing. Some other markets have lost the opportunity for expanding or relocating due to a lack of long-run market development plans (Wu 1993). There are also markets which have, through illegal activities of management authorities, all but lost their original wholesale function.

Table 11. Vegetable production flow ('000 t) through cooperative and wholesale marketing, 1980-1997

Year	Total production[1]	Cooperative marketing[2]	Wholesale marketing[2]
1980	3225	67 (2.1)	948 (29.4)
1981	2902	69 (2.4)	919 (31.7)
1982	3044	89 (2.9)	1075 (35.3)
1983	3019	100 (3.3)	1069 (35.4)
1984	3416	119 (3.5)	1224 (35.8)
1985	3243	126 (3.9)	1249 (38.5)
1986	3128	134 (4.3)	1175 (37.6)
1987	3284	141 (4.3)	1113 (33.9)
1988	3094	166 (5.4)	1161 (37.5)
1989	2955	176 (6.0)	1069 (36.2)
1990	2713	174 (6.4)	1071 (39.5)
1991	2864	197 (6.9)	1171 (40.9)
1992	2825	203 (7.2)	1147 (40.6)
1993	2840	212 (7.5)	1160 (40.8)
1994	2594	217 (8.4)	1172 (45.2)
1995	2853	227 (8.0)	1211 (42.4)
1996	3059	223 (7.3)	1261 (41.2)
1997	3004	235 (7.8)	1306 (43.5)

Source: [1]PDAF, various issues[b] (1981-1998). [2]PDAF, various issues[c] (1981-1998).
Note: Wholesale marketing figures include foreign trade.
Numbers in parentheses represent the percentage of total production.

Performance of Cooperative Marketing

Cooperative marketing in Taiwan has been promoted for more than 20 years. Since the inauguration of the Taiwan Fruit and Vegetable Corporation (renamed in 1984 as the Taipei Agricultural Product Marketing Corporation), volumes handled by vegetable cooperative marketing have increased annually, and the market share in terms of total production has gradually increased from 2% in 1980 to nearly 8% in 1997 (Table 11).

While wholesale markets in consumption areas are the major outlets for products marketed by farmer co-ops, nearly 95% of the vegetables and 80% of the fruit from cooperatives are concentrated in the two Taipei wholesale markets. This situation indicates that the number of outlets for products marketed by farmer cooperatives is limited. Meanwhile, the performance of cooperative marketing has been unsatisfactory, despite implementation of production planning since 1978. Inconsistent grading and packaging of cooperative produce has yet to be corrected (Wu 1993).

In addition, the changing structure of retailing in big cities, particularly the increased number of supermarkets, as well as the increase in the number of vegetable outlets, has made it difficult for the farmer co-ops to survive. However, these co-ops have turned to supplying vegetables to hospitals, the army, and other large institutional buyers.

Marketing Margins

Marketing margins, estimated from secondary price data, range from 39% to over 87% for different vegetables in different years. In general, marketing margins have widened over time, reducing the farmer's share of the consumer price (Table 12).

Table 12. Marketing margins (%) of selected vegetables, 1977-97

Years	Bottle gourd	Cabbage	Carrot	Cauliflower	Chinese cabbage	Eggplant	Garlic	Ginger	Green pepper	Onion	Peas	Radish	Spinach	Tomato	Watermelon
1977	60.2	61.1	56.2	58.6	63.4	57.2	51.8	54.5	49.2	60.3	42.2	63.0	58.6	72.0	64.9
1978	61.9	66.9	60.7	61.9	63.7	57.6	58.0	55.0	55.3	70.7	48.3	68.4	59.0	68.3	62.8
1979	67.7	71.0	60.8	61.0	68.9	60.1	47.9	50.9	48.5	56.0	46.4	67.2	60.0	68.7	57.4
1980	61.0	67.0	58.8	55.8	65.1	59.9	45.0	44.6	43.5	53.2	44.6	68.1	57.2	55.8	57.3
1981	58.1	64.0	53.5	63.6	64.5	58.3	58.8	50.8	46.2	81.3	45.5	70.8	61.2	45.7	60.7
1982	66.2	72.3	64.1	69.9	66.8	61.5	48.1	52.5	56.4	58.7	53.9	76.0	61.4	62.4	58.6
1983	61.8	65.4	64.0	68.0	64.1	61.4	43.1	43.8	53.2	62.1	46.9	76.3	61.4	63.7	59.0
1984	61.8	70.2	62.9	64.5	62.4	61.0	59.8	54.5	53.6	62.8	48.7	76.8	57.1	64.9	58.7
1985	65.5	68.5	70.0	68.3	70.2	62.2	56.7	55.5	60.4	54.2	51.9	73.6	65.4	67.7	58.9
1986	64.6	64.3	69.6	68.4	66.7	64.7	63.3	56.4	65.5	60.7	62.1	71.3	60.3	63.9	64.8
1987	67.6	68.8	66.3	69.0	65.7	63.9	51.1	56.0	61.6	60.4	41.4	74.0	56.0	68.1	60.4
1988	71.1	70.1	63.6	65.7	65.7	62.8	73.4	62.7	59.6	61.7	62.3	72.4	59.0	59.4	57.3
1989	71.0	69.9	69.6	65.0	74.1	64.2	77.5	65.0	61.0	74.6	60.3	74.0	72.7	64.8	64.3
1990	66.9	71.8	70.8	68.3	65.2	56.3	73.9	57.9	55.8	59.5	67.9	68.7	71.9	70.7	62.9
1991	74.2	72.3	72.5	69.0	69.7	63.2	84.6	40.9	63.8	62.7	55.7	77.6	72.8	67.7	66.5
1992	64.3	76.3	84.5	70.8	70.1	60.3	81.7	62.3	62.7	74.1	44.0	71.4	76.2	59.9	61.1
1993	70.5	75.2	83.2	69.8	68.0	65.9	81.7	58.6	66.2	80.6	57.1	73.6	74.4	61.2	62.5
1994	69.7	70.0	83.5	68.8	64.4	61.5	85.8	38.9	62.7	71.0	59.7	75.7	81.8	61.1	68.0
1995	68.5	75.1	46.9	71.0	66.6	65.4	79.0	58.6	58.2	61.1	50.0	78.3	77.6	64.2	57.4
1996	66.5	72.8	78.1	67.2	68.1	59.9	69.2	54.1	61.4	83.4	51.1	78.7	70.1	61.8	69.7
1997	73.0	74.6	84.7	73.7	71.4	70.5	87.0	52.2	79.1	87.2	64.8	73.8	71.0	71.5	76.5

Source: Estimated from the farm-gate and retail prices reported in PDAF, various issues[b] (1980, 1990, 1998).

The farmers' share tends to increase after crop failure caused by natural catastrophe (e.g., typhoons). The same is true during the off-season in October (Table 13). Similar conclusions were reached by earlier studies which focused on the distribution of margins in different marketing stages with particular attention to the farmers' share and the market power exercised by retailers (Yang 1992; Wann 1993a; Yang 1993a).

Table 13. Seasonal marketing margins for selected vegetables (1991-94 average)

Vegetable	January			October		
	Retail price (TWD/kg)	Farm price (TWD/kg)	Margin (%)	Retail price (TWD/kg)	Farm price (TWD/kg)	Margin (%)
Cabbage	27.3	6.8	75.1	52.3	15.0	71.3
Carrot	27.1	7.2	73.4	31.3	12.8	59.1
Cauliflower	44.0	9.2	79.1	68.2	22.2	67.4
Chinese cabbage	28.9	7.0	75.8	42.4	12.1	71.5
Eggplant	44.1	16.1	63.5	51.8	20.3	60.8
Peas	92.9	4.1	95.6	211.4	123.7	41.5
Radish	25.4	5.2	79.5	37.9	8.0	78.9
Spinach	38.4	10.1	73.7	82.0	16.8	79.5
Sweet pepper	56.3	24.5	56.5	86.4	46.8	45.8
Tomato	38.4	12.1	68.5	65.9	27.5	58.3

Source: Retail and farm-gate prices were taken from PDAF, various issues[b] (1992-1995).

The second approach to estimate the marketing margin is based on primary data collected by surveys on prices of raw products, marketing service costs, and wastage rates at each marketing stage. Shuai and Chang (1992) analyzed the farm-retail spread for selected summer vegetables in different marketing channels based on such survey data. They concluded that farm-retail spreads of summer vegetables in direct marketing channel are less than in other channels. Wann (1993a) concluded that: (i) profit absorbed most of the marketing margin; (ii) the highest marketing costs occurred at the retail stage in the form of retailers' profits; (iii) retailers receive the highest gross return and rate of return in comparison with other marketing agents; (iv) in the cooperative marketing channel, the highest rate of wastage occurs at the wholesale stage (Table 14).

Pricing Efficiency

Various empirical studies (Lin 1984; Wann 1993a; Yang 1993a) have concluded that the reason vegetable markets are not competitive is because of incomplete farm-wholesale-retail price transmission and asymmetric distribution of bargaining powers between sellers and buyers. On the other hand, vegetable retailers are often suspected of possessing a certain degree of market power since they usually adopt either a constant or fixed-proportion in the mark-up of prices, with a range of TWD 2-10/kg, amounting to 20-65% of the total margin. To analyze these hypotheses, the traditional approach is to disaggregate marketing margins into costs, transportation losses, and gross returns based on survey data. Subsequently, retailers' average net returns are estimated in order to determine whether they receive normal or excessive returns (Hsu 1984; Huang and Huang 1994). Since selling vegetables is a labor-intensive activity and is mostly a family business, net returns earned by vegetable retailers are hard to estimate. Thus, it can be expected that such accounting-based studies are not able to provide a convincing conclusion regarding pricing efficiency.

Table 14. Itemized marketing margin (% of the total margin) by types of markets in selected commodities, 1992

Item	Cabbage			Cucumber			Radish		
	Middle trader	Coop-erative	Super-market	Middle trader	Coop-erative	Super-market	Middle trader	Coop-erative	Super-market
Auction									
Transportation	4.5	5.0	4.7	3.4	4.5	3.3	4.2	4.2	6.1
Material cost	2.9	2.9	2.7	6.8	4.6	2.7	3.6	3.1	4.1
Output loss	2.3	1.6	4.6	3.9	0.9	1.4	0.8	1.6	2.0
Management	0.5	2.6	0.0	1.2	4.8	1.9	0.8	2.2	1.0
Labor	1.6	1.2	6.3	2.1	2.3	1.4	0.9	1.9	4.4
Profit	2.5	0.0	4.9	13.2	0.0	20.2	8.1	0.0	7.5
Total	14.3	13.3	23.1	30.6	17.1	30.9	18.4	13.0	25.1
Wholesale									
Transportation	1.3	1.7	-	1.6	1.5	-	3.2	1.6	-
Material cost	1.3	1.7	-	1.0	1.5	-	1.4	1.9	-
Output loss	6.8	10.9	-	3.8	5.6	-	5.7	6.3	-
Management	0.9	1.0	-	1.2	1.3	-	1.6	1.1	-
Labor	1.3	0.0	-	0.0	0.0	-	1.2	0.1	-
Profit	15.3	18.0	-	20.8	30.4	-	15.7	21.2	-
Total	26.9	33.3	-	28.4	40.3	-	28.8	32.2	-
Retail									
Transportation	3.4	5.1	10.0	4.8	4.2	4.2	4.2	6.1	10.3
Material cost	4.2	3.7	8.7	5.6	4.5	4.2	4.0	4.2	8.5
Output loss	8.1	7.2	15.9	2.9	3.4	5.5	3.3	3.9	7.1
Management	8.3	7.8	26.2	10.2	8.5	11.7	11.1	9.3	11.4
Labor	0.4	0.4	5.5	1.0	0.7	5.2	1.0	1.3	10.5
Profit	34.4	29.2	10.6	16.5	21.3	38.3	29.2	30.0	27.1
Total	58.8	53.4	76.9	41.0	42.6	69.1	52.8	54.8	74.9
Total margins of all channels									
Transportation	9.2	11.8	14.7	9.8	10.2	7.5	11.6	11.9	16.4
Material cost	8.4	8.3	11.4	13.4	10.6	6.9	9.0	9.2	12.6
Output loss	17.2	19.7	20.4	10.6	9.9	6.9	9.8	11.8	9.1
Management	9.7	11.4	26.2	12.6	14.6	13.6	13.5	12.6	12.4
Labor	3.3	1.6	11.8	3.1	3.0	6.6	3.1	3.3	14.9
Profit	52.2	47.2	15.5	50.5	51.7	58.5	53.0	51.2	34.6
Grand total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total margin (TWD/100kg)	1518.2	1453.7	765.6	2206.4	1643.7	2742.6	1298.6	1319.6	893.6

Source: Wann (1993a).

Yang (1992) and Wu (1992) tested the hypothesis that vegetable retailers make only normal profits. Empirical results indicate that retailers of Chinese cabbage, Chinese mustard, cabbage, cauliflower, and carrot all had opportunities to make abnormal profits, particularly during the main crop season and when typhoons occur.

International Trade

The main market for Taiwan vegetables is domestic. In 1997, a total of 116,000 t (or about 4% of total domestic production) was exported, while 618,000 t (or 20.6% of total domestic production) was imported.

Total volume of vegetable exports increased from 352,700 t in 1973 to a peak of 568,400 t in 1984. Over that period, exports accounted for nearly one-sixth of the total domestic production of vegetables. Since 1984, annual export volumes declined rather rapidly. The decline was initially the result of a decrease in the export of processed mushroom and asparagus, but later in the fresh vegetables as well. The quantity of vegetable exports declined at an average rate of 4.8% per annum between 1993 and 1997 (Table 15).

The picture of vegetable imports is completely the opposite of that of vegetable exports. Just prior to 1981, vegetable imports ranged between 31,000 and 59,000 t. By contrast, volume of vegetable imports increased dramatically from 1980 onwards and reached over 600,000 t in 1997. In addition, the proportion of imports to availability also increased significantly, from 2% in 1973 to about 18% in 1997 (Table 15).

Taiwan is now facing a deficit (volume) in international vegetable trade, after enjoying continuing surpluses during the 1970s and 1980s. Even the balance of payments (value) in vegetable trade has lately converted into deficit. However, the value of vegetable exports did not decline as rapidly as export quantities. In fact, total value of vegetable exports decreased only moderately (the trend was statistically insignificant), despite a steep decline in export quantities. Thus, Taiwan is now concentrating on the export of high value vegetables.

Vegetable exports have been an important source of farm income and have made a significant contribution to economic growth in Taiwan. In terms of individual product items, over 80 different kinds of vegetable products were exported each year. Among the vegetables exported, canned bamboo products, mushrooms, and tomatoes have been the leading processed vegetable products, while cabbage, carrot, onion, and potato have been the leading fresh vegetables. Exported volumes of canned mushrooms, asparagus, and bamboo shoots stood at over 400 million cases per year and ranked first in the world's trade during the 1970s. Since then, canned vegetable exports have been phased out gradually.

Although many different species are imported, onion and potato are the major imported vegetables.

Exports of processed vegetable products mostly go to the Japanese market. Hong Kong, Singapore, and the United States are secondary markets. The principal export markets for fresh vegetables are Japan and Hong Kong (Ke 1982).

Table 15. Trends in international trade in vegetables, 1973-97

Year	Quantity traded ('000 t)			Share of import in availability	Value traded (million US$)		
	Export	Import	Surplus		Export	Import	Surplus
1973	352.7	30.6	322.1	2.0	166.9	5.1	161.8
1974	307.3	59.2	248.1	3.5	198.4	10.3	188.1
1975	334.8	53.6	281.2	2.8	194.0	11.7	182.3
1976	425.5	50.4	375.1	2.4	286.5	14.1	272.4
1977	468.8	49.8	419.0	2.3	373.2	17.9	355.3
1978	553.8	54.6	499.2	2.4	429.2	20.0	409.2
1979	543.2	44.5	498.7	1.8	418.0	17.7	400.3
1980	550.2	47.2	503.0	1.7	477.7	22.6	455.1
1981	479.6	69.7	409.9	2.8	448.3	35.2	413.1
1982	495.2	70.9	424.3	2.7	465.4	34.2	431.2
1983	440.5	60.0	380.5	2.3	383.9	25.2	358.7
1984	568.4	108.4	460.0	3.7	435.3	28.1	407.2
1985	476.0	338.8	137.2	10.9	360.4	39.6	320.8
1986	496.8	139.9	356.9	5.0	440.2	31.8	408.4
1987	438.2	99.0	339.2	3.4	452.0	35.7	416.3
1988	341.4	249.6	91.8	8.3	414.6	60.3	354.3
1989	353.4	478.0	-124.6	15.5	437.7	96.8	340.9
1990	289.7	516.4	-226.7	17.6	391.1	139.1	252.0
1991	267.8	615.0	-347.2	19.2	367.4	160.3	207.1
1992	204.6	578.5	-373.9	18.1	299.4	169.4	130.0
1993	169.7	503.7	-334.0	15.9	263.3	153.8	109.5
1994	152.8	518.5	-365.7	17.5	234.9	178.1	56.8
1995	162.0	414.0	-252.0	13.3	212.3	179.7	32.6
1996	152.7	562.3	-409.6	16.2	184.5	230.7	-46.2
1997	115.5	617.8	-502.3	17.6	151.6	235.2	-83.6
Growth rate (%)[1]	-4.8	13.7	-14.0	11.0	-	14.7	-9.5

Source: PDAF, various issues[b] (1974-1998).

[1]The growth rate in the trade surplus (both in quantity and value) was estimated after adding the highest negative figure in each year's surplus.

- implies that the growth rate is not significant.

Supply and Demand

Availability

In 1997, availability of vegetables in Taiwan at the farm-level, after accounting for international trade, was 3.5 million t, or an average of 162 kg/person. The trend in per capita availability during 1962-97 remained generally upward, although the increase was at a much faster rate during 1967-80 (Fig. 5). The availability from domestic sources has varied, and has depended upon weather conditions. For example, a rather sharp drop in per capita vegetable availability in 1990 and 1994 was the result of severe crop damage caused by typhoons. Lately, however, availability has also

depended upon international trade, especially imports. The drop in per capita availability in 1995 can be attributed to a substantial decrease in imports.

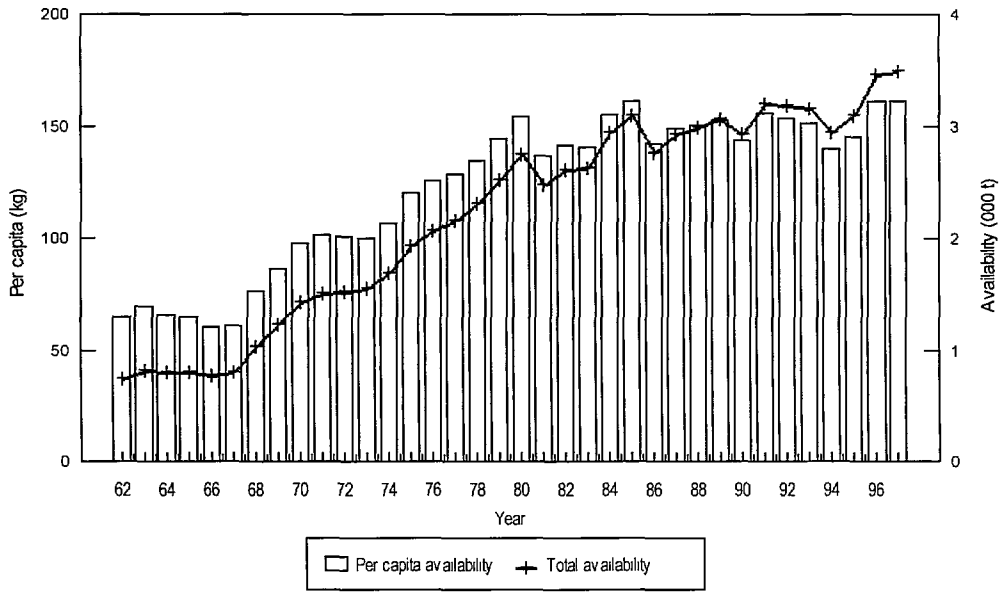


Fig. 5. Annual per capita and total availability of vegetables in Taiwan (1962-97)

Food availability patterns in Taiwan have changed dramatically during the last three decades. Daily per capita availability of all foods, after deducting the post-harvest losses, increased from about 1 kg in 1962 to more than 1.5 kg in 1992. The main increase came in the availability of fruits, vegetables, and livestock products, while daily per capita availability of food grains dropped during this period. Per capita annual vegetable availability increased at the rate of 2.34% per annum during 1962-82, while it remained almost stagnant afterwards. Cereal consumption declined at 1.08% per annum during the 1960s and 1970s, and at 0.8% per annum during the 1980s. However, availability of fruit, livestock products, and other foods continued to increase during the 1980s and early 1990s (Table 16).

Table 16. Trends in per capita availability (g/day) of different food items, 1962-92

Year	Cereals, starches & pulses	Vegetables	Fruit	Livestock products	Other food items	Total
1962*	639	154	59	124	38	1014
1972*	622	250	114	192	60	1238
1982	498	324	196	250	96	1364
1983	482	319	187	259	102	1349
1984	467	354	205	288	104	1418
1985	472	348	225	306	105	1456
1986	477	324	219	314	115	1449
1987	469	343	256	342	119	1529
1988	471	335	286	350	120	1562

Contd. Table 16.

Year	Cereals, starches & pulses	Vegetables	Fruit	Livestock products	Other food items	Total
1989	451	322	296	365	121	1555
1990	452	290	298	372	124	1536
1991	453	314	294	365	123	1549
1992	456	316	273	381	125	1551
Growth (62-82) (%)*	-1.08	2.34	5.07	3.69	3.92	1.38
Growth (82-92) (%)	-0.80	-0.002	3.06	3.90	2.43	1.17

The availability figures for vegetables in this table are lower than reported in Fig. 5 as these do not include the post-harvest losses.

* To save space, all figures for the 1960s and 1970s were not reported here. However, all data were used to compute growth rates.

Source: COA, various issues (1981, 1983 - 1994).

Consumption

The types of vegetables consumed also changed during 1981-92 as both the absolute quantity and relative share of leafy vegetables decreased (Table 17). Per capita annual availability of root and stem vegetables, at the consumers' table, increased at an annual rate of 1.5% during 1981-92. On the other hand, per capita availability of leafy vegetables declined at the rate of 2.5% per annum during the same period. However, it is worth mentioning that this decline was mainly due to a decrease in the availability of cabbage and Chinese cabbage.

Table 17. Annual vegetable availability at the consumers table (kg/capita) by product group in Taiwan, 1981-92

Year	Leafy	Root & stem	Fruit	Others	Total
1981	34.70	36.13	26.05	18.72	115.60
1982	35.23	36.53	24.95	21.50	118.21
1983	32.66	31.55	22.36	27.46	114.03
1984	33.30	40.93	22.97	31.88	129.08
1985	32.59	41.11	25.57	27.80	127.07
1986	31.64	34.58	27.50	24.57	118.29
1987	32.89	39.76	28.46	24.24	125.35
1988	31.47	40.02	29.08	21.53	122.10
1989	28.20	41.67	25.06	22.60	117.53
1990	26.81	40.80	20.78	17.52	105.91
1991	26.46	39.76	27.69	19.53	113.44
1992	28.92	41.37	26.96	17.90	115.15
Growth rate (%)	-2.5*	1.5*	0.45^{ns}	-1.9^{ns}	-0.047

Data source: PDAF, various issues[b] (1982-1992).

* Significantly different from zero at the 5% level; ^{ns} not significant at the 5% level.

These figures also do not include post-harvest losses, hence lower than reported in Fig. 5.

During the 1980s, nearly 70% of all vegetables consumed by households was purchased fresh. For Taiwan as a whole, vegetables account for about 30% of monthly household expenditures on supplemental food, over two-thirds of this amount being for fresh vegetables (Huang 1992b).

A country-wide consumption survey in 1998 by the socioeconomics unit of AVRDC suggests that daily per capita expenditure made on food is NT$139. Twenty-two percent of the daily food expenditure goes to vegetables, 18% to each fish, meat, and fruits, 4% to rice, 5% to other cereals, 6% to milk, eggs, and processed beans, and 8% to other foods. The share of leaf, fruit, and root vegetables in total vegetable expenditure is almost equal.

Demand Elasticities

Huang (1992a) estimated own-price demand elasticities and income elasticities for a number of vegetable species from single regression models where the quantity of annual consumption was specified as a function of retail price and per capita income, both in real terms. Generally, vegetable demand is price inelastic as elasticities are between zero and minus one. With the exception of asparagus, all of the examined species are normal goods, because their income elasticities are positive and less than one. Asparagus is a luxury good, because its income elasticity is more than one (Table 18).

Table 18. Demand and income elasticities for selected vegetables, 1980-89

Item	Demand elasticities		Income elasticities	
	Elasticity	t-statistic	Elasticity	t-statistic
Leafy vegetables				
Cabbage	-0.44	-2.13*	0.30	2.11*
Celery cabbage	-0.56	-3.48*	0.47	2.67*
Chinese cabbage	-0.11	-2.93*	0.07	1.25
Leaf mustard	-0.34	-1.44	0.02	2.05*
Stem vegetables				
Asparagus	-	-	1.56	2.05*
Bamboo shoot	-	-	0.68	1.75
Garlic	-0.15	-2.98*	0.32	3.42*
Garlic bulb	-	-	0.62	2.66*
Onion	-0.55	-3.27*	0.64	2.62*
Scallion	-0.002	-1.01	0.27	2.14*
Root vegetables				
Carrot	-0.06	-1.05	0.25	2.56*
Radish	-0.57	-3.60*	0.45	3.20*
Taro	-	-	0.84	3.14*

Contd. Table 18.

Item	Demand elasticities		Income elasticities	
	Elasticity	t-statistic	Elasticity	t-statistic
Fruit vegetables				
Cauliflower	-0.35	-2.51*	0.18	3.57*
Cucumber	-0.56	-3.48*	0.04	2.48*
Kidney bean	-0.52	-1.76	0.39	3.48*
Tomato	-0.32	-2.08*	0.19	3.10*
Vegetable soybean	-	-	0.74	1.22

* Significant at the 5% level.
- implies that data are not available.
Source: Huang (1992a).

Chen (1990) estimated demand elasticity of processed tomato with respect to guaranteed price and export price as –3.65 and 1.28, respectively. Price elasticities are higher than income elasticities in most cases. Ke (1982) observed income and price as major determinants in vegetable demand.

Consumer Preferences

There exists hardly any literature that has documented the characteristics of consumers' preferences for different types of vegetables, possibly reflecting the fact that individual preferences regarding vegetables are hard to identify and explain. Moreover, there has not been any study to investigate and compare consumers' preferences for vegetables in different regions or at different levels of income. However, it can be stated with confidence that Taiwanese consumers commonly prefer fresh leafy vegetables to other types of vegetables. Significant consumption of canned or frozen vegetables is observed only in post-disaster periods, particularly during the summer months. Wu (1989) noted that Taiwanese consumers are less interested in frozen vegetables than in fresh vegetables, possibly due to the relatively high prices of frozen vegetables. In his survey, 55% of consumers never used frozen vegetables.

Policy Issues

Guaranteed Prices

Insufficient vegetable supply during the summer is hard to solve through storage because most of the vegetables have a short storage life. Moreover, Taiwanese consumers like fresh vegetables, and thus they might not like imported vegetables. In order to encourage summer production, stabilize summer vegetable prices, and to induce orderly marketing, the Taiwan Provincial Department of Agriculture and Forestry has since 1976 assured guaranteed prices and marketing contracts through farmer cooperatives for various important summer vegetables. Deficiency payments, equal to the difference between the guaranteed price to cooperative marketing producers and the actual market price multiplied by the quantity set by the summer marketing contract, act as an incentive to farmers to increase planted areas of summer vegetables. These measures, together with the adoption of heat-tolerant vegetable varieties, resulted in a reduction of the seasonal variation in vegetable prices of high seasonal crops, such as tomato (Figure 6).

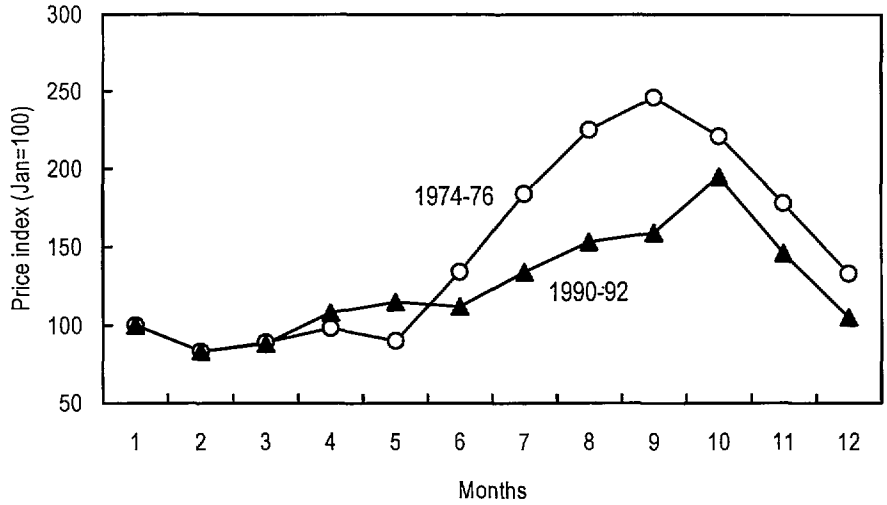


Fig. 6. Seasonality in tomato prices in Taipei city, Taiwan

Compared to a government purchase program, the deficiency payment program is less costly to the treasury, and the government's liability is further limited by restricting payments to products supplied by farmer cooperatives, rather than to total output. And government can avoid engaging itself in storage, handling, and disposal. Consumers benefit from increased supplies of vegetables and lower prices because the total volume produced and marketed is larger than it would be without the program (Wann 1993b). Since the start of the summer vegetable marketing program in 1976, the number of contracting farmer cooperatives increased from 33 to 99, and the volume of contract marketing increased from 10,140 t in 1976 to about 50,000 t in 1992. The deficiency payments are financed equally by the central and local government budgets. Up to 1993, payments to vegetable producers amounted to TWD312.2 million, with an average deficiency payment of TWD0.8/kg.

The performance of the summer vegetable contract marketing program has been criticized because, since the implementation of the program, the Taipei First and Second Fruit and Vegetable Markets have accounted for almost 90% of the total volume under contract marketing. Another consequence of this program is that cooperative marketing has become less popular in most fruit and vegetable wholesale markets, which obviously goes against the policy's original goal (Shuai and Chang 1992; Wann 1993b). Wann (1994) found that a year-round contract marketing program is economical only in Chinese cabbage. Wu (1994) concluded that the summer cooperative contract-marketing program improved the ability of the wholesale markets to manage the source of produce.

Recently, more attention has been devoted to the problem of low vegetable prices in winter. The government is evaluating the feasibility of expanding the summer vegetable contract-marketing program to become a year-round program (Wann 1993b and 1994).

International Trade Policies

In the 1960s and 1970s, the government paid considerable attention to expanding the export of vegetables. Developing and maintaining vegetable exports is challenging because supplies for foreign trade can fluctuate widely from one season to the next. In addition, the performance of vegetable products in foreign countries is greatly affected by the tariff and non-tariff barriers of the importing countries, export management practices, and the general macro-economic environment.

To achieve an orderly export system, the government has established three vegetable export enhancement programs. The first is the planned production and marketing program designed to stabilize export prices. Exporters make purchasing contracts with farmer cooperatives prior to the production season and provide a guaranteed purchasing price. The provincial farmers' association is fully responsible for integrating all the activities, from implementing contractual production to cooperative export. In addition, an export stabilization fund has been set up for onion.

The second program is a contract system introduced for processors to procure raw materials for the export of processed vegetables. The third export system, established in 1986 to replace the previous rules on export adjustments, makes use of export approval certificates. Under this system, exporters procure vegetables based on their actual needs. Exporting vegetables under this system, therefore, is completely free as long as the exporter provides to the vegetable exporters' association information on the quantity and shipping date of exports. This is in order to obtain an approval certificate. A permit for export is then issued based on the certificate. Fresh vegetables, such as ginger, cauliflower, potato, and broccoli, are exported under this system. Since it puts the least restriction on exporters, it not only meets free market principles, but also encourages exporters to expand their business in foreign markets.

During the 1980s, many studies were conducted to evaluate the system of production and marketing for various export vegetables, such as onion (Tai 1983), garlic bulbs (Lee 1985), canned asparagus (Wu 1986), and canned bamboo products (Kan 1986; Lee 1987; Shuai 1988). Even though these studies all concluded that the vegetable export systems of Taiwan have improved, they also point to a need for improving forecasts of domestic and international agricultural supply and demand, and for establishing a complete agricultural production and marketing information system. An intimate knowledge of consumers' preferences as well as trading practices and business customs in Japan and other major export markets would be very valuable. Relative efficiency of the public and private sectors in providing this information should be evaluated.

Vegetable imports are normally regarded as totally open in Taiwan except for the requirement of submitting an approval certificate, issued by the Council of Agriculture, along with each import shipment.

In terms of agricultural protection, the effects of government programs on farmers and consumers can be measured by the producers' subsidy equivalent (PSE) and the consumers' subsidy equivalent. Since the deficiency payments for summer vegetables account for less than 1% of the total annual vegetable production value, the PSE in the vegetable industry is negligible (Wann 1993b). Under international trade treaties administered by the World Trade Organization (WTO), Taiwan agricultural trade policy will, in the near future, increasingly move towards free trade.

Achievements of Economic Research

Most previous economic studies on vegetables have been problem-oriented. The mission of agricultural economists is to define existing or potential economic problems and to provide effective solutions.

Because most agricultural research had focused on rice, the principal staple crop of Taiwan, and cultural techniques for vegetable production continued to improve under the production-oriented policy of the early stage of Taiwan's development, the research on the economics of vegetables did not attract much attention prior to 1970.

During the 1970s the primary mission of agricultural economists conducting vegetable research was to suggest policy reforms to mitigate price fluctuations and to increase supplies of summer vegetables. To ensure farmer income and to adjust marketing flows to meet summer market demand, the guaranteed price marketing program for summer vegetables was initiated and cooperative marketing was stimulated. To gain economies of scale in production, specialized vegetable zones were identified. To protect crops from unfavorable weather conditions, protected horticultural production was introduced to vegetable growers. Meanwhile, exports of processed vegetable products expanded significantly. In addition to the traditional canned products of asparagus, bamboo shoot, and mushrooms, processed tomato was developed for export. The tomato processing industry has drawn significant attention from agricultural economists (Chu 1975; Hsu 1978; Hwang 1994).

Since the late 1980s, agricultural economists have given more attention to domestic vegetable production and marketing. Research is diversified, reflecting the ever-increasing scope and complexity associated with the economics of vegetables. In particular, inefficiencies in marketing systems are being studied, and alternatives for their improvement are being suggested. Recent advances in industrial economic theory and econometric methods have improved the tools for analyzing pricing behavior of agents under imperfect competition (Hwang 1994). In addition, the methods of welfare economics can be utilized to evaluate government vegetable policies (e.g., Wann 1994; Wu 1994).

Summary and Conclusions

Vegetables have traditionally been an important component of the diet and an important part of the agricultural sector. They account for about 22% of daily household expenditures on total food, over two-thirds of which is fresh vegetables. Hundreds of vegetable species are grown in Taiwan, however, bamboo shoot, watermelon, cabbage, vegetable soybean, radish, carrot, Chinese cabbage, and tomato are major vegetables. Major vegetable growing areas include Changhwa, Chiayi, Yilan, Tainan, and Pingtung Prefectures.

An implicit structural change in the production of vegetables has occurred as the total production of vegetables has decreased, but their production values have increased, both in absolute as well as in relative terms compared to other crops. In particular, the importance of leafy vegetables in total vegetable production has declined, while the share of fruit vegetables in both production and value of total vegetables has increased. This is indicative of changing consumer preferences for vegetables. Technological innovation has continued to push vegetable yields upward in most vegetables.

The CVs for area, production, and yield of individual vegetable species are generally higher than the corresponding rice CVs, indicative of higher risks involved in vegetable production. Coefficients of variation in vegetable area are much higher than the CVs in yield of individual vegetable species, as well as of total vegetables as a group, indicating that variation in area is the main contributing factor to the high variation in vegetable production. Thus, policies aimed at stabilizing the area under vegetable cultivation could go a long way to reduce yearly fluctuation in vegetable production.

Strong seasonal patterns in vegetable prices, production, wholesale transactions, and consumption have been observed. Prices have tended to be high during July-October, while they normally remain low during January-March. Summer consumption can be as much as 23% lower and average prices 50% higher than those in the winter or spring months.

Taiwan vegetable market is traditionally domestic in nature, although the share of imported vegetables has been shooting up and the share of exported vegetables has been shrinking. Taiwan is now facing a vegetable deficit, after continued surpluses during the 1970s and 1980s. Taiwan is now concentrating on the export of high value vegetables.

The annual per capita availability of vegetables in Taiwan at the farm level in 1997, after accounting for the net balance from international trade, is about 162 kg. Per capita vegetable availability increased at 2.34% per annum between 1962 and 1982. However, availability remained almost stagnant afterwards.

Vegetable farms have some peculiar characteristics; they are smaller than rice farms and they need more family labor and cash outlays. Labor is the dominant cost item in vegetable cultivation. Absolute fertilizer and pesticide costs in vegetable cultivation are generally higher than in field crops. However, the relative share of these costs in total production cost is similar to rice. Therefore, labor-saving technologies in vegetable cultivation will be in high demand.

Generally, net incomes from vegetables considerably exceed those from the production of alternative field crops, such as maize and rice. However, due to relatively high input costs, benefit-cost ratios in vegetable cultivation exceed those for alternative field crops only in some cases.

The marketing margin ranges from 39% to over 87% of the farmer price for different vegetables in different years, being higher for the more perishable commodities. In most cases, the highest marketing costs occur at the retail stage in the form of retailers' profits.

Farmer share tends to increase after crop failures caused by natural catastrophes (e.g., typhoons). Similarly, the farmer share tends to rise in October, which is off-season for most vegetables. This suggests the usually overlooked role of marketing agents in helping to stabilize market prices during crisis periods. In general, the marketing margin has widened over time, reducing the farmer share of the consumer price. However, it is not clear whether this increase is due to the enhanced exploitative power of middlemen, or to an increase in marketing service costs, such as transportation, packaging, etc.

Demand elasticities of price are higher than income elasticities for most vegetables, implying that price reduction through technology advancement, rather than higher income, can play a bigger role in further enhancing vegetable consumption.

Future Research

Despite the achievements of agricultural economics research in the past, future developments in vegetable economics are not well understood. In the next few years the vegetable industry might undergo more structural changes than during any previous period. Thus, economics research needs to take an in-depth look at realities. The following directions for future research are proposed:

Impact of Agricultural Trade Liberalization

The multinational trade treaty, administered by the WTO, has established rules for reducing or eliminating both tariff and non-tariff trade barriers. Taiwan is preparing to participate in the WTO. Competition in both international and domestic markets for agricultural products can be expected to increase. Since no empirical analysis of the effect of GATT on vegetable trade in Taiwan has been conducted so far, the questions of how rapid growth in vegetable imports would affect the farm sector and what kinds of actions farmers could take to survive will become increasingly relevant for agricultural economists.

Exploring the Decision-making Process of Growers

The decision-making process of vegetable growers under changing economic and market regulations needs to be better understood so that effective policy adjustments can be carried out. Questions such as "how are production decisions influenced by relative prices?" and "how would farmers respond to open trade?" need more attention from agricultural economists.

Improving the Efficiency of Vegetable Marketing

Even though marketing efficiency has caught the attention of researchers in recent years, more comprehensive study in this area is needed to sort out constraints and integrate solutions for improved marketing efficiency.

The Impact of Changing Business Organization and Operation

Direct marketing is a new channel for vegetable growers, and it is believed to be more efficient than other marketing channels. In fact, however, there is not sufficient evidence to support this belief. Moreover, many farmers with relatively small production feel they should concentrate on farming rather than involve themselves in marketing.

Similarly, apart from the traditional family businesses, a growing number of supermarket chains and discount wholesale stores are exerting increasing control over vegetable marketing. The effects of increased market competition on producers, agribusiness, marketers, and consumers need to be investigated.

Preferences of Consumers

Consumption behavior regarding vegetables has been a virtually neglected area of research by agricultural economists. Nevertheless, understanding the characteristics of vegetable consumption is critical to the success of the vegetable industry. More sophisticated packing methods and products with better quality might boost the demand for vegetables. The expanding demand for chemical-free vegetables has opened up vast new areas of research for agricultural economists.

Data Constraints

Numerous economic studies on vegetables have succinctly discussed the need for more and better information on production and management practices, marketing conditions, consumption structure, enterprise-specific costs and returns, etc. Even though data systems exist to monitor conditions in the farm sector, data are aggregated to the county and/or crop group level, making an assessment of

farm-specific and seasonal differences difficult. Furthermore, surveys on individual farmer's costs and returns in vegetable cultivation are conducted only irregularly and do not provide detailed information on adjustments that individual farmers have made (or are expected to make), nor on the constraints faced by growers.

On the other hand, farm-level data on input-output relationships for individual vegetables by production region are important for understanding farm problems, monitoring changes, and studying farm-level behavior and relationships. These objectives require more than an occasional cost of production and marketing survey. Thus, a panel survey design is required in which the same farmers are surveyed at several points in time to create a longitudinal data set. In addition, national household consumption surveys, four or five times a year, would be useful to researchers and policy makers.

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Thailand

Bhantinee Sootsukon, Supote Dechates, and Mei-Huey Wu

Introduction

Thailand is a country on the mainland of Southeast Asia in the middle of the Indo-Chinese Peninsula. To the north and west of the country lies Myanmar, and to the east are Laos and Cambodia. Thailand extends to the south, deep into the Malay Peninsula, where it shares a short border with Malaysia. The total area of Thailand is 513,000 km^2; its greatest length is about 1650 km^2 and greatest breadth is 770 km^2. In the south are the Gulf of Thailand and the China Sea, and to the west of the Malay Peninsula is the Bay of Bengal. The population of Thailand in 1994 was 58.7 million. About 6 million of those people live in the capital city, Bangkok, 2.0 million in Chiang Mai, 1.8 million in Korat, and 1.9 million in Ubonratchathani. The country is divided into 73 administrative units or provinces. The GNP of Thailand in 1996 was US$2943 (Council for Economic Planning and Development 1998).

Vegetables are an important crop group in Thailand. The planted area of all vegetables, including onion, garlic, chili, but excluding potato, was 353 thousand ha in 1994, which accounted for about 2.0% of the total cropped area, or 3.6% of rice area. Total production, including onion and chili, but excluding potato, was 3.4 million t, worth more than 25 billion THB (or US$1 billion), which is about 19% of the value of all cereal production in the country. The average yield was 9.7 t/ha.

During 1994, annul per capita availability of vegetables at the farm level was about 53 kg (or 145 g/day). The latest available consumption survey suggests that Thais consume an average of 742 g/day of all foods, of which vegetables account for about 14%. Cereals, meat and meat products, and fruits account for 45%, 16%, and 12%, respectively.

Topography

The country can be divided into four geographical regions: north, northeast, central, and south (Fig.1). The Central Region is a large alluvial plain called the Menam Basin, which mostly becomes inundated during the rainy season. Winding rivers and numerous canals and streams intersect the Basin. Its main river is the Menam Chao Phya, commonly known as the river Menam, meaning "mother of water." About 40 km from its left bank lies Bangkok.

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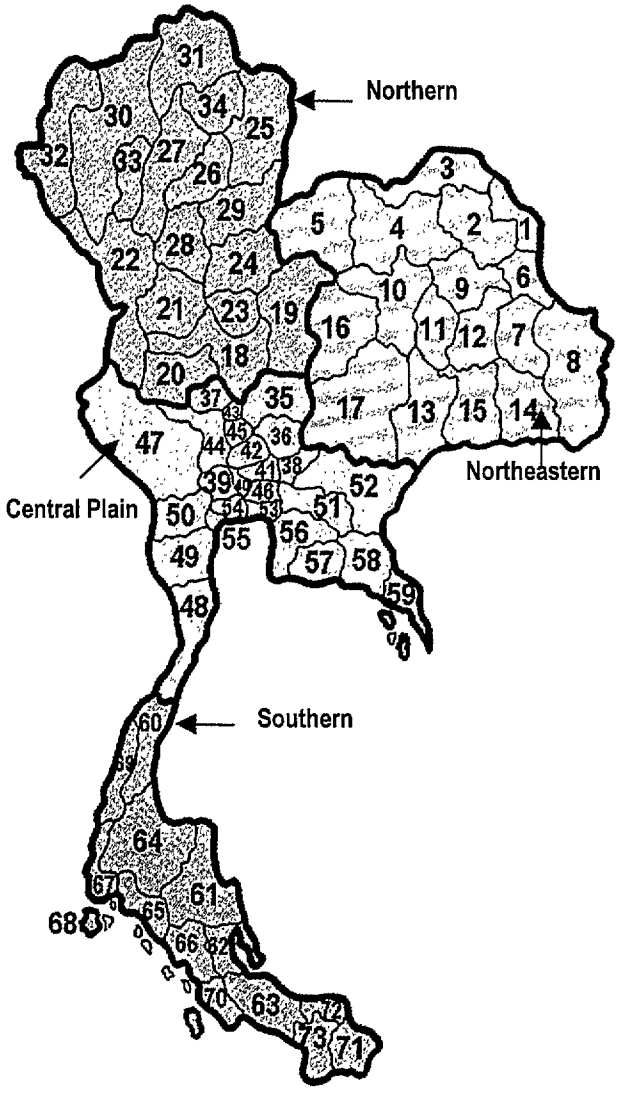


Northeastern Region
1. Nakhon Phanom
2. Sakon Nakhon
3. Nong Khai
4. Udon Thani
5. Loei
6. Mukdahan
7. Yasothon
8. Ubon Ratchathani
9. Kalasin
10. Khon Kaen
11. Maha Sarakham
12. Roi Et
13. Buri Ram
14. Si Sa Ket
15. Surin
16. Chaiyaphum
17. Nakhon Ratchasima

Northern Region
18. Nakhon Sawan
19. Phetchabun
20. Uthai Thani
21. Kamphaeng Phet
22. Tak
23. Phichit
24. Phitsanulok
25. Nan
26. Phrae
27. Lampang
28. Sukhothai
29. Uttaradit
30. Chiang Mai
31. Chiang Rai
32. Mae Hong Son
33. Lamphun
34. Phayao

Central Plain Region
35. Lop Buri
36. Saraburi
37. Chai Nat
38. Nakhon Nayok
39. Nakhon Pathom
40. Nonthaburi
41. Pathum Thani
42. Ayutthaya
43. Sing Buri
44. Suphan Buri
45. Ang Thong
46. Bangkok Metropolis
47. Kanchanaburi
48. Prachuap Khiri Khan
49. Phetchaburi
50. Ratchaburi
51. Chachoengsao
52. Prachin Buri
53. Samut Prakan
54. Samut Sakhon
55. Samut Songkhram
56. Chon Buri
57. Rayong
58. Chanthaburi
59. Trat

Southern Region
60. Chumphon
61. Nakhon Si Thammarat
62. Phatthalung
63. Songkhla
64. Surat Thani
65. Krabi
66. Trang
67. Phangnga
68. Phuket
69. Ranong
70. Satun
71. Narathiwat
72. Pattani
73. Yala

Fig. 1. Regional map of Thailand

The northern region has hilly or mountainous terrain divided by four rivers into relatively large valleys, which run to the south and join the river Menam. Parts of the rivers Salween and Mekong make up the western and northern boundaries. The well-known chief city of this region is Chiang Mai, which is the second city of Thailand in terms of its degree of economic development.

The northeastern region is a saucer-shaped plateau, commonly known as the Korat Plateau, with the Mekong River as its eastern boundary. It is the largest of the four regions and is poorly watered. Its chief cities are Korat (Nakhon Ratchasima) and Ubon Ratchathani.

The southern region, or peninsular Thailand, covers about two-thirds of the Malay Peninsula. Mountains run the length of the peninsula, on either side of which are coastal plains.

Climate

Thailand has three seasons: summer, February–May; 2) rainy season, June–September; and 3) winter, October–January. The climate is tropical, with an average annual temperature of 29°C. Summers are hot and humid, and winters are cool. In the rainy season, depressions occur from time to time until early winter. The central plain region is one of the most agriculturally productive places in all of Asia, and enjoys an annual rainfall of more than 1200 mm.

Important Vegetables, Growing Areas, and Seasons

Thailand grows more than 100 vegetable species. Important vegetables, in order of their contribution to total vegetable area, are peppers, garlic, cucumber, baby corn, chili, yard long bean, tomato, shallot, kale, cabbage, and pumpkin (Table 1).

The cultivation of each vegetable is concentrated in its own specialized area (Table 1). Regional comparative advantage is determined by a number of factors affecting cost, including climate, varieties, labor cost and availability, and others.

Major vegetable growing areas in the north are Chiang Mai and Chiang Rai; in the northeast Nakhon Ratchasima and Khon Kaen; in the central plains Pathum Thani, Bangkok, Chon Buri, Kanchanaburi, and Samut Sakhon; and in the south Chumphon, Nakhon Si Thammarat, and Surat Thani.

Growing season and harvesting season for each of the primary vegetables in Thailand are shown in Table 1. Many vegetable species can be grown year round in multiple cropping and intercropping systems. Leaf vegetables need less time to be grown—Convolvulus, kale, lettuce, and welsh onion, for instance, are ready to harvest in just 20-35 days. In some specialized vegetable production areas, such as Bangkok, Chiang Mai, Ratchaburi, Kanchanaburi, and others, there can be 8 to 10 harvests of these early-maturing crops. On the other hand, bamboo shoot and asparagus take 3-7 years before they are ready for harvest.

The north and the northeast regions not only produce tropical leafy vegetables and root vegetables, but also temperate vegetables, such as spinach, Brussels sprouts, and tomato. In the central plain, and in the east, west, and south, farmers usually grow leafy and fruit vegetables.

Table 1. Growing and harvesting seasons and major growing areas by vegetable species, 1994

Vegetable [% share in all vegetable area]	Growing Season	Harvesting Season	Major growing province (% share in total area of the vegetable)
Angled loofah [1.1]	All seasons	All seasons	Nakhon Pathom (6), Ratchaburi (6), Chumphon (5), Saraburi(4).
Baby corn [7.5]	All seasons	All seasons	Ratchaburi (38), Kanchanaburi (13).
Bitter gourd [1.4]	All seasons	All seasons	Ratchaburi (71).
Cabbage [3.3]	Winter, Summer, Rainy	Winter, Summer, Rainy	Chiang Mai (42).
Cauliflower [1.0]	All seasons	All seasons	Bangkok (13), Chiang Mai (13), Phetchabun (8), Songkhla (7).
Chili [6.4]	Rainy, Winter	Winter, Summer	Chaiyaphum (13), Chiang Mai (13), Loei(11).
Chinese cabbage [1.9]	Winter, Summer, Rainy	Winter, Summer, Rainy	Chiang Mai (25), Pathum Thani (6), Nakhon Ratchasima (5), Bangkok (4).
Chinese radish [1.0]	Jan – Dec	Jan – Dec	Ratchaburi (29), Kanchanaburi (17), Nonthaburi (11), Phetchabun (7).
Cucumber (long) [2.9]	All seasons	All seasons	Udon Thani (13), Chumphon (8), Kalasin (7), Nong Khai (6).
Cucumber (short) [6.1]	All seasons	All seasons	Prachin Buri (10), Ratchaburi (8), Samut Songkhram (5), Buri Ram (5).
Garlic [9.3]	Winter, Rainy	Winter, Rainy	Chiang Mai (29), Lamphun (23), Phayao (8), Chiang Rai (8).
Kale [3.5]	Jan – Dec	Jan – Dec	Bangkok (12), Nonthaburi (9), Nakhon Pathom (8), Pathum Thani (7).
Kangkong [0.9]	Jan – Dec	Jan – Dec	Nonthaburi (36), Samut Prakan (11), Bangkok (7).
Leaf mustard [2.5]	Oct – Feb	Nov – Mar	Lampang (11), Chiang Rai (9), Nonthaburi (9), Phayao (8).
Lettuce [0.9]	Jan – Dec	Jan – Mar	Nonthaburi (26), Bangkok (12), Pathum Thani (11), Chiang Mai (8).
Onion [0.9]	Winter, Rainy	Winter, Rainy	Chiang Mai (82), Kanchanaburi (16).
Pakchoi [2.6]	Jan – Dec	Jan – Dec	Nonthaburi (12), Bangkok (10), Pathum Thani (7).
Peppers [14.0]	Rainy, Winter, Summer	Rainy, Winter, Summer	Nakhon Ratchasima (11), Chiang Mai (10), Prachuap Khiri Khan (9).
Pumpkin [3.1]	Summer, Winter	Summer, Winter	Chumphon (19), Chiang Mai (7), Prachuap Khiri Khan (6).
Shallot [4.3]	Winter, Rainy	Winter, Rainy	Si Sa Ket (32), Chiang Mai (22).
Sweet pea [0.2]	Winter, Summer	Winter, Summer	Chiang Mai (19), Phetchabun (19), Tak (8), Nonthaburi (7).
Tomato [4.9]	Rainy, Winter, Summer	Rainy, Winter, Summer	Nong Khai (24), Sakon Nakhon (20), Chiang Mai (14), Nakhon Phanom (13).
Yard long bean [6.4]	All seasons	All seasons	Ratchaburi (27).

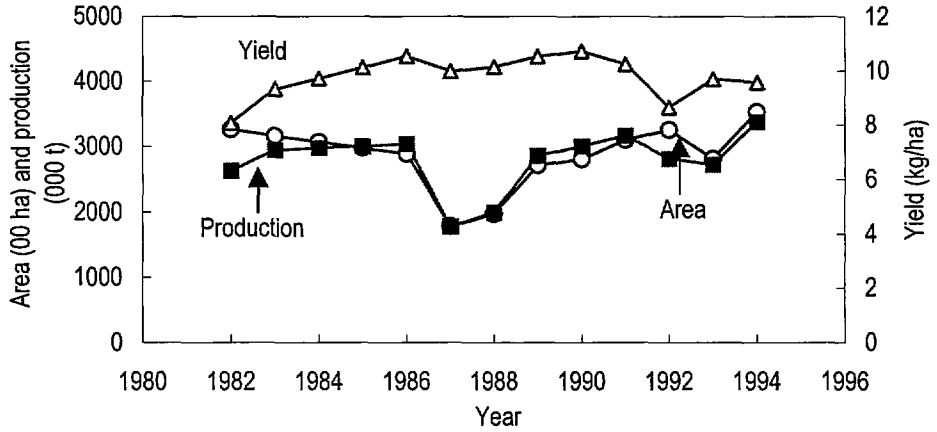
Figures in brackets represent percentage share of total area of all vegetables, and figures in parentheses represent the percentage contribution of a province to the total area of the vegetable.

Source: The data on vegetable area and production across regions are reported in Division of Planning (1995). The data on growing and harvesting seasons is from official files of the Department of Agricultural Extension, Ministry of Agriculture and Co-operatives.

Trend Analysis

Production

The area under vegetables remained in the range of 300 thousand ha during 1982-94, except during 1987-88 when it plummeted. Similarly, vegetable production remained stagnant at around 3 million t, except for 1987-88 when there was a setback due to reduction in area. Per hectare yield showed a slightly declining trend during the last couple of years of the study period (Fig. 2).



Source: Division of Planning (various issues 1983-1995).

Fig. 2. Trend in overall area, production, and yield of vegetables, 1982-94.

The results of trend analyses for area, production, and yield of individual and total vegetables as a group for the period 1982-94 suggest that total vegetable area decreased during the initial study period (because of the dip during 1987-88), and then began to recover. Yield ran opposite to this. This resulted in stagnant production during 1982-94 (as both linear and quadratic terms were insignificant) (Table 2).

Among the individual vegetables, only baby corn and onion area increased linearly; chili, and garlic area decreased linearly; and tomato, pepper, and cucumber area did not show a significant trend. Area of all other individual vegetables decreased in the initial years of the study, suggested by the negative linear terms, while every vegetable recovered its area in the later years, as suggested by the positive quadratic terms. This pattern was shaped by the setback in area during the middle of the study period. Per-hectare yield for most individual vegetables showed the opposite. The trend in production was mixed (Table 2).

Table 2. Trend in area, production, and yield of major vegetables in Thailand, 1982-94

Vegetable	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
Baby corn	0.1149	-	0.1325	-	0.1907	-0.0124
Cabbage	-0.1442	0.0092	0.0410	-	0.1437	-0.0062
Chili	-0.0369	-	-0.0524	-	-	-

Contd. Table 2.

Vegetable	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
Chinese cabbage	-0.3575	-0.0257	-0.1642	0.0155	0.1933	-0.0102
Chinese kale	-0.1241	0.0085	0.0313	-	0.1106	-0.0053
Chinese leaf mustard	-0.2126	0.0131	-	0.0043	0.0851	-
Chinese radish	-0.2725	0.0136	-0.1756	0.0089	0.0321	-
Cucumber	-	-	-	-	0.0222	-
Garlic	-0.0369	-	-0.0524	-	-	-
Onion	0.0712	-	0.2298	-0.0090	0.1387	-0.0076
Pepper	-	-	0.4112	-0.0173	0.4767	- 0.0229
Pumpkin	-0.2023	0.0128	-	-	0.0402	-0.0026
Shallot shoot	-0.1618	0.0090	-	-	-	-
Taro	-0.3541	0.0218	-0.2592	0.0174	0.0948	-0.0044
Tomato	-	-	0.0949	-	0.0768	-
Water convolvulus	-0.7497	0.0478	-0.7704	0.0482	-	-
Yard long bean	-0.1434	0.0094	0.0676	-	0.1742	-0.0068
Other vegetables	-	0.0030	-0.3139	0.0185	-0.0928	-
Total vegetables	-0.1395	0.0102	-	-	0.0703	-0.0047

- implies that the coefficient is not significant at least at the 10% level.
Source: Division of Planning (various issues 1983-1995).

Prices

With few exceptions, all individual vegetable nominal prices are increasing at the wholesale and farm gate levels. However, increases in most cases are higher at the wholesale level. In real terms, the prices of many individual and total vegetables, as a group, increased at the wholesale and farm gate levels (Table 3).

Table 3. Growth rate (%) in vegetable prices in Thailand, 1984-1996

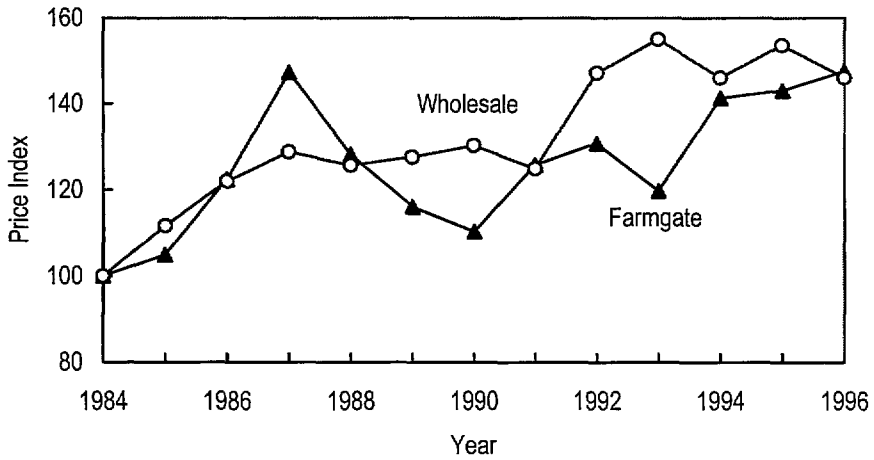
Vegetable	Nominal		Real[1]	
	Wholesale	Farm gate	Wholesale	Farm gate
Asparagus	-	-	-4.24	-4.57
Baby corn	14.46	-	10.57	-
Cabbage	-	-	-	-2.99
Chili	4.11	-	-	-3.51
Chinese cabbage	10.20	6.78	6.31	2.89
Chinese kale	4.78	1.72	-	-2.17
Cucumber	9.19	7.31	5.30	3.42
Garlic	4.55	-	-	-
Ginger	7.78	-	3.89	-
Mushroom	-	6.01	-	2.11

Contd. Table 3.

Vegetable	Nominal		Real[1]	
	Wholesale	Farm gate	Wholesale	Farm gate
Kangkong	6.57	6.65	2.68	2.76
Onion	7.49	5.47	3.60	-
Pakchoi	4.40	2.41	-	-
Pumpkin	4.54	3.65	-	-
Shallot	11.09	7.06	7.19	3.17
Tomato	5.10	-1.40	-	-5.29
Yard long bean	6.68	3.53	2.79	-
Overall vegetables	6.88	6.65	2.99	2.17

[1] The real prices were estimated by deflating the nominal prices with the consumer price index for the respective year.
- implies that the coefficient is not significant at the 15% level.
Source: Individual farm and wholesale vegetable prices were obtained from OAE (various issues[a], 1985-97) and OAE (various issues[c]). Overall farm vegetable price indices were obtained from OAE (1995), and overall wholesale prices were estimated from the individual prices using the Laysper price index.

During the 1990s, increase in overall real vegetable prices has been quite sharp, both at the wholesale and farm levels (Fig. 3). Demand pressure generated by the economically influential group (unaccompanied by breakthroughs in vegetable production) was a factor in pushing the real farm and wholesale vegetable prices up. A shift in vegetable cultivation to distant, more competitive places, raised transportation costs, and resulted in a sharper increase in wholesale prices. These trends will have serious negative implications for the consumption of vegetables by the low-income group.



Source: See footnote to Table 3.

Fig. 3. Trend in overall vegetable prices at the wholesale and farm gate levels.

Production Instability

Shortfalls in supply, and subsequent higher prices, motivate farmers to produce more. As a result, supply rises to excess, causing reduction in prices, which discourages farmers from producing, which in turn causes supply shortfalls and higher prices. This cycle, along with government's lack of interest and support to minimize such fluctuation, and the shortage of production technologies to mitigate the effects of environmental stress, cause great instability in vegetable area and production. The detrended coefficients of variation in vegetable area, production, and yield are a reflection of this (Table 4). Overall, vegetable area, production, and yield have higher CVs than rice, suggesting that vegetables are more risky to produce than rice.

Table 4. Detrended coefficients of variation (CV %) for major vegetables and rice area, production, yield, and prices[1]

Crop	Area	Production	Yield	Prices	
				Wholesale	Farm
Baby corn	33.3	37.0	32.4	25.0	12.3
Cabbage	19.6	16.1	8.0	19.8	9.5
Chili	30.1	24.2	40.4	8.9	14.5
Chinese cabbage	34.5	24.0	18.4	28.0	9.3
Chinese kale	16.5	13.3	8.2	-	-
Chinese leaf mustard	22.7	25.3	12.0	-	-
Chinese radish	26.4	21.0	12.4	-	-
Cucumber	11.4	20.0	16.0	11.9	12.1
Garlic	8.1	24.4	28.0	29.2	27.2
Kangkong	90.3	94.7	15.4	13.7	8.5
Onion	18.0	21.2	16.1	21.0	23.7
Pepper	19.9	36.9	34.5	-	-
Pumpkin	23.9	23.3	5.2	11.6	10.1
Taro	36.4	35.1	9.5	-	-
Tomato	30.5	30.3	16.9	14.0	7.3
Shallot shoot	24.2	24.0	21.9	7.5	18.9
Yard long bean	16.9	17.0	10.1	11.8	8.2
Other vegetables	32.4	38.5	24.7	-	-
Total vegetables	17.3	15.7	7.6	15.0	16.4
Rice	4.3	6.9	3.8	13.2	13.5

[1] The CVs for area, production, and yield for the period 1982-94; CVs for prices for the period 1984-96.
Source: See footnote Table 2 for area, production, and yield data on vegetables. See footnote in Table 3 for the individual and overall farm and wholesale vegetable prices.

The highest variability in individual vegetable production is in kangkong, perhaps because its cultivation mainly depends upon rain. With few exceptions, variability in area is greater than variability in yield in all individual and total vegetables, indicating that variability in production has more to do with area than yield. This suggests that policies, such as assured prices, could contribute

relatively more to stabilizing production. That said, technologies that make crops tolerant to biotic and abiotic stresses could also contribute significantly to stabilizing production.

Variation in vegetable production makes prices unstable. Vegetable prices, as a group, are less stable than rice prices, especially at the farm level. Interestingly, with few exceptions, farm gate vegetable prices are more stable than wholesale prices.

Seasonality in Prices

Low temperatures spur plant growth, and curb vegetable pests and diseases. This leads to higher yield and lower per unit production cost in winter than in summer. As a consequence, farmers favor growing vegetables in winter just after rice. The resulting increase in vegetable area in winter leads to lower prices for farmers, compared to prices paid in the rainy season and summer. This creates seasonality in vegetable production and prices.

Monthly price data show that vegetable prices are usually highest in the middle of the year (May–June), and lowest during September–December or January–March. The only exceptions are garlic, asparagus, and convolvulus. Seasonality in monthly vegetable prices ranges from 22% in asparagus (a perennial crop), to 175% in celery. Despite it being a fruit vegetable, the seasonality in chili prices is relatively high (Table 5).

Table 5. Seasonality in vegetable prices (average of 1989-93)

Vegetable	Month												Seasonality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	
Angled loofah	100	105	93	90	127	115	96	103	109	103	97	98	41
Asparagus	100	101	96	93	89	95	94	99	98	97	105	109	22
Baby corn	100	92	97	101	96	93	58	86	91	91	95	102	76
Cauliflower	100	103	112	147	149	176	188	195	210	212	159	110	112
Celery	100	71	69	105	158	190	175	148	122	120	110	101	175
Chili	100	102	85	105	154	126	120	119	102	78	87	95	97
Chinese cabbage	100	84	85	108	136	149	137	123	111	131	115	99	77
Chinese radish	100	123	124	141	158	158	122	135	153	159	132	116	59
Cucumber	100	90	81	96	114	108	85	96	96	102	92	102	41
Garlic	100	89	69	67	77	76	88	87	85	80	85	87	49
Ginger	100	113	130	156	168	170	143	107	93	84	91	105	102
Hot pepper	100	99	82	87	111	88	74	91	70	68	67	71	66
Kale	100	92	82	116	140	153	92	101	98	139	139	80	91
Kangkong	100	110	83	93	96	83	87	89	99	108	108	98	33
Leaf mustard	100	96	95	120	145	158	148	140	128	141	121	108	66
Lettuce	100	90	77	123	166	189	118	119	119	114	108	94	145
Pakchoi	100	93	98	118	141	143	130	120	126	120	113	82	74

Contd. Table 5.

Vegetable	Month												Seasonality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	
Pumpkin	100	95	100	105	109	117	96	87	91	88	98	90	34
Straw mushroom	100	81	78	93	103	102	108	142	130	134	123	123	82
Yard long bean	100	88	77	82	102	96	74	68	64	74	76	89	59

Source: OAE, various issues[b] (1989-93).

Prices of all vegetables as a group begin drifting up April, and reach their peak in May–June. Prices begin to decline in July, but do not drop below their average level until November–December. Prices remain low during December-March (Fig. 4).

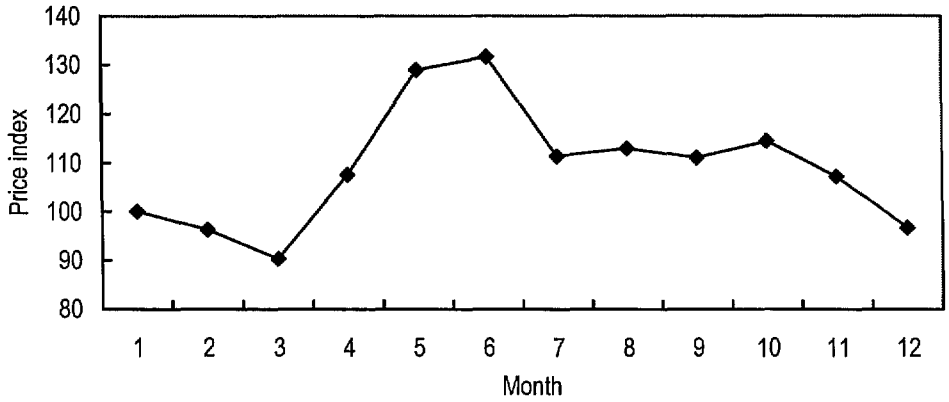


Fig. 4. Seasonality in total vegetable prices at the farm gate (average of 1987-93)

Production Management

Production Systems

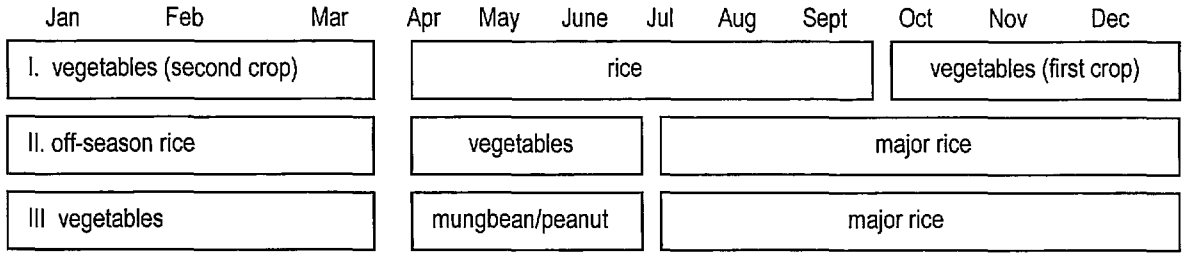
Land-preparation-based Classification

Vegetable production systems in Thailand can be classified based on type of land preparation, as follows:

Sorjon type. A distinctly large raised bed of 5-10 m breadth is commonly prepared throughout the length of the parcel. An irrigation/drainage ditch of about 1-m wide and deep is dug between the raised beds. Irrigation water is drawn from this ditch using either a primitive, manual watering tool or watering equipment similar to modern sprinklers, mounted on a small boat manually navigated.

This system is generally preferred in low-lying areas, suited for 3-5 crops in rotation in a year. Mostly leafy vegetables, cauliflower, chili, cucurbits, and beans are grown. Up to eight crops of early maturing vegetables, such as kangkong and multiplier onion, can be harvested in a year.

Bed type. Flat plots 1–1.5 m wide, elevated 10–15 cm, are used to grow vegetables before or after rice in all regions, but mostly in upland areas. Several cropping patterns are followed:



Farm-business-based Classification

Based on business type, vegetable farms can be classified into four groups:

Backyard Vegetable Gardening. Vegetables are grown primarily for subsistence on idle spaces of the farmstead. Produce in excess of what is needed for subsistence is sold for cash. The vegetables commonly grown are chili, eggplant, and pumpkin.

Vegetables as a Main Occupation. Various crops are cultivated and rotated all year round, depending on agroclimatic conditions, to satisfy market demand. The land is prepared using either furrows or beds. In this system, the vegetables (including green soybean, sweet corn, baby corn, processing tomato, asparagus, leafy vegetables, and others) are grown primarily for processing and for export. The system is quite intensive with respect to input use, and different farm operations, such as harvesting, grading, and packaging, are adjusted to meet the needs of either the processing or export market.

Seasonal Vegetable Cultivation. This is the main farm business where vegetables, including garlic, multiplier onion, onion, fresh tomato, and others, are normally grown, in the uplands and lowlands, after rice.

Use of Machinery

Small landholders usually rely on manual labor and draught power or small machinery. Larger vegetable farms, on the other hand, make use of modern, large farm machines to prepare the land (plow furrows), plant, and, wherever possible, harvest.

Machines are used to plant baby corn, but cobs are picked by hand. Shortage of labor is a serious problem in certain cropping seasons, especially when vegetable harvesting overlaps with the planting of field crops. This problem requires the urgent attention of researchers.

Most vegetables are transplanted, which saves seed, reduces crop length in the field, and facilitates other crop operations. Transplanting requires, however, much more labor than direct seeding, although under-employed family members supply most of this labor. Some large holders hire labor for transplanting.

Economics of Production

Cost of production is generally divided into fixed cost and variable cost. Fixed cost, in our case, includes land tax, rent, and depreciation of farm equipment, while variable cost includes labor and power, and farm supplies, including seeds, compost, chemical fertilizers, pesticides, and miscellaneous items.

Based on a cost survey conducted on 16 vegetables, asparagus has the highest per hectare cost of cultivation. Although roselle is not costly to produce, its low yield makes its unit output cost very high. Other high value crops in terms of per unit output cost are asparagus, chili, garlic, and green soybean (Table 6).

Table 6. Economics of vegetable cultivation (THB/ha) in Thailand, 1992

Crop	Fixed Cost (THB)		Variable Cost (THB)			Total cost (THB)	Yield (kg/ha)	Gross income (THB)	Net benefit (THB)	Cost/kg (THB)	Benefit /cost ratio
	Tax & land rent	Deprecia-tion	Labor & power	Farm supplies	Miscella-neous						
Asparagus	709	1793	61575	53890	10238	128205	8658	223215	95010	14.8	74.1
Baby corn	1031	300	7193	6963	1104	16591	12602	30497	13906	1.3	83.8
Bamboo shoot	20	2965	1908	3153	552	8598	6176	18652	10054	1.4	116.9
Chili	1208	2152	38312	23296	3097	68065	6695	140649	72584	10.2	106.6
Garlic	1564	1846	19485	33370	3038	59303	4101	79963	20660	14.5	34.8
Ginger	1338	226	12402	22532	1807	38305	6823	48275	9970	5.6	26.0
Green soybean	2458	214	35719	16511	1636	56538	5607	67286	10748	10.1	19.0
Lady's finger	2505	2072	40024	31120	9596	85317	12421	99366	14049	6.9	16.5
Onion	1287	1923	21957	24366	2313	51846	16396	132155	80309	3.2	154.9
Roselle (dry)	1789	547	8839	296	302	11773	384	13433	1660	30.7	14.1
Shallot	2190	2406	22179	55017	3555	85347	11271	93996	8649	7.6	10.1
Taro	3084	806	38357	36073	5011	83331	21166	110523	27192	3.9	32.6
Tomato	1970	87	16798	10990	1077	30922	25242	42911	11989	1.2	38.8
Watermelon	307	502	6761	13328	441	21339	16328	32819	11480	1.3	53.8
Yard long bean	535	1274	16428	13646	3120	35003	8580	67695	32692	4.1	93.4
Yam bean	1258	422	7498	1890	428	11496	27543	24902	13406	0.4	116.6
Rice	-	-	-	-	-	6235	2350	8704	2469	2.7	39.6

Source: Office of Agricultural Economics (1993b).

In most vegetables, the largest cost items are labor and farm supplies. However, the relative importance of these two varies across vegetables (Table 7).

Thai farmers choose to grow a cash crop, such as vegetables, if it gives more net return under the given resources available to the household (Benchaphun 1985). As seen in the previous section, when grown under optimal conditions vegetables produce higher net returns than cereals. Low vegetable production in the country, therefore, is believed to be due to lack of farming experience, unsuitable land, and unavailability of capital and labor required for vegetable cultivation. Very little is known about the extent and nature of these constraints in Thailand.

Table 7. Factor share (%) in vegetable production, 1992

Crop	Tax and land rent	Depreciation	Labor	Farm supplies	Miscellaneous
Asparagus	0.6	1.4	48.0	42.0	8.0
Baby corn	6.2	1.8	43.3	42.0	6.7
Bamboo shoot	0.2	34.5	22.2	36.7	6.4
Chili	1.8	3.2	56.2	34.2	4.6
Garlic	2.6	3.1	32.9	56.3	5.1
Ginger	3.5	0.6	32.4	58.8	4.7
Green soybean	4.3	0.4	63.2	29.2	2.9
Lady's finger	2.9	2.4	47.0	36.5	11.2
Onion	2.5	3.7	42.3	47.0	4.5
Roselle (dry)	15.2	4.6	75.1	2.5	2.6
Shallot	2.6	2.8	26.0	64.4	4.2
Taro	3.7	1.0	46.0	43.3	6.0
Tomato	6.4	0.3	54.3	35.5	3.5
Yard long bean	1.5	3.6	47.0	39.0	8.9
Yam bean	10.9	3.7	65.3	16.4	3.7
Watermelon	1.4	2.4	31.6	62.5	2.1

Source: Estimated from data reported in Table 6.

Although farmers are quick to make adjustments in cropping pattern according to the market situation, shifts from lower to higher value crops are not always accompanied by a parallel change from traditional to more modern cultivation techniques, especially if such technologies are difficult to afford. In such cases, expansion in the output of new crops is attempted using low-cost inputs and fairly traditional techniques. This indicates that the low yields recorded for most vegetables in Thailand are not necessarily the result of a lack of innovation or dynamism on the part of Thai farmers. On the contrary, they probably reflect farmers' response to the relatively high prices of modern technologies, and lack of resources to adopt these technologies.

Marketing

Wholesale Markets in Bangkok

In terms of significance and volume of transactions, Bangkok is the central market for major vegetables. Supplies of important and high-value vegetables are collected in the Bangkok central market before being redistributed to the provincial markets and sent for export.

Five wholesale markets located in metropolitan Bangkok are:

Ongarntalard Market

Ongarntalard Market is 8800 m^2. It is a semi-government institution directed by a governing board, including a number of prominent government officials attached to the Interior Ministry.

Yodbhimarn Market

Yodbhimarn Market is 14,400 m^2. It is a private-run business located adjacent to the aforementioned Ongarntalard Market.

Songsermkaset-Thai Market

Songsermkaset-Thai Market adjoins the Yodbhimarn Market. It is a private enterprise focused on creating opportunities for farm producers and upcountry assemblers to sell their own vegetables.

Warehouse Organization Market

As the name suggests, this market belongs to the Internal Trade Department's Warehouse Organization. The market is 2800 m^2, and employs a manager who is in charge of supervising activities and providing facilities for both sellers and buyers. The market provides a place for farmers to conduct their own trade and bargain a good price for their produce.

Northern Simummeung Market

Northern Simummeung Market is a central market established recently near northern Bangkok's major transport routes. This is a main receiving and distributing depot for vegetables and fruits from the north, northeast, and central regions. It is the biggest (2 km^2) semi-government wholesale market in the country. Like Ongarntalard, it is a marketplace for farmers and provincial brokers.

Wholesale Business Characteristics

Most vegetable trade is conducted by sole proprietorships, and the rest by partnerships and corporations. About one-third of traders own a means of transport, such as a pickup truck or six-wheel truck. The manual two-wheelers, owned by one out of two traders, are used for hauling, loading, and unloading vegetables. Materials commonly used for packing vegetables include bamboo baskets of different sizes, plastic bags, and plastic ropes. An average vegetable trader requires 25 bamboo baskets and 2.5 kg of plastic bags daily (OAE 1993a).

Marketing Channels

The three main marketing channels for vegetables are as follows:

Marketing Channel Involving a Central Market

Most vegetables are delivered through this channel. Neighboring farmers combine their produce and sell it in a central market, or sell it to a village assembler, who takes it to a central market. From the central market, the Bangkok or provincial wholesalers purchase the produce and then sell it to retailers. Some output goes for export, by way of a processor or a Bangkok wholesaler (Fig. 5).

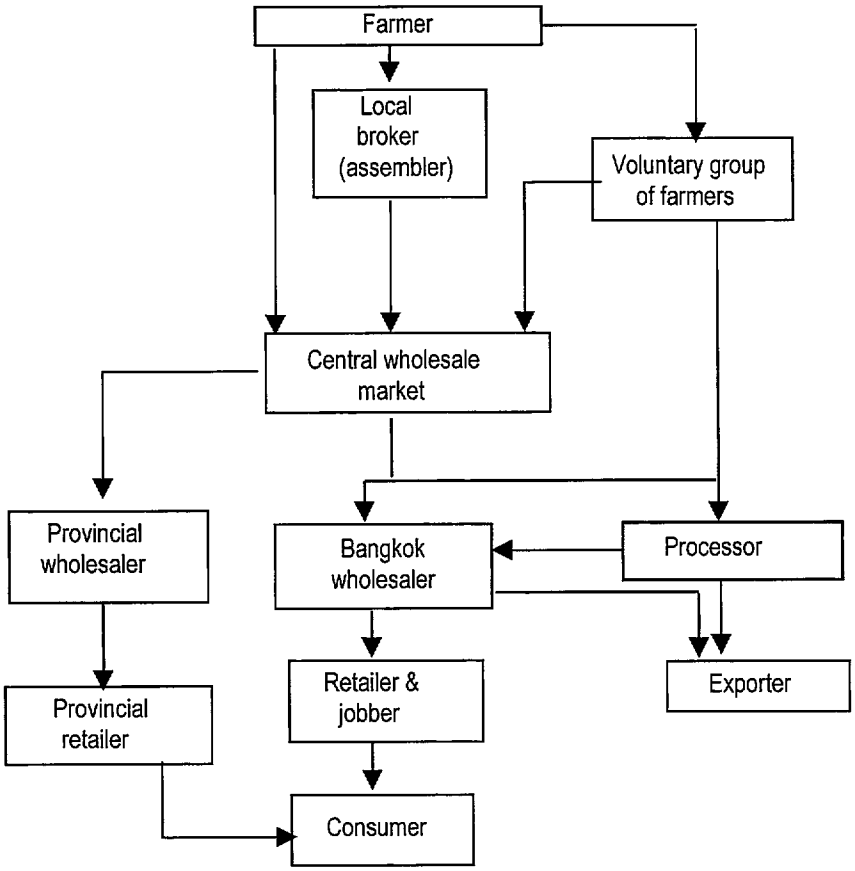


Fig. 5. Marketing channel involving a central market for fresh vegetables.

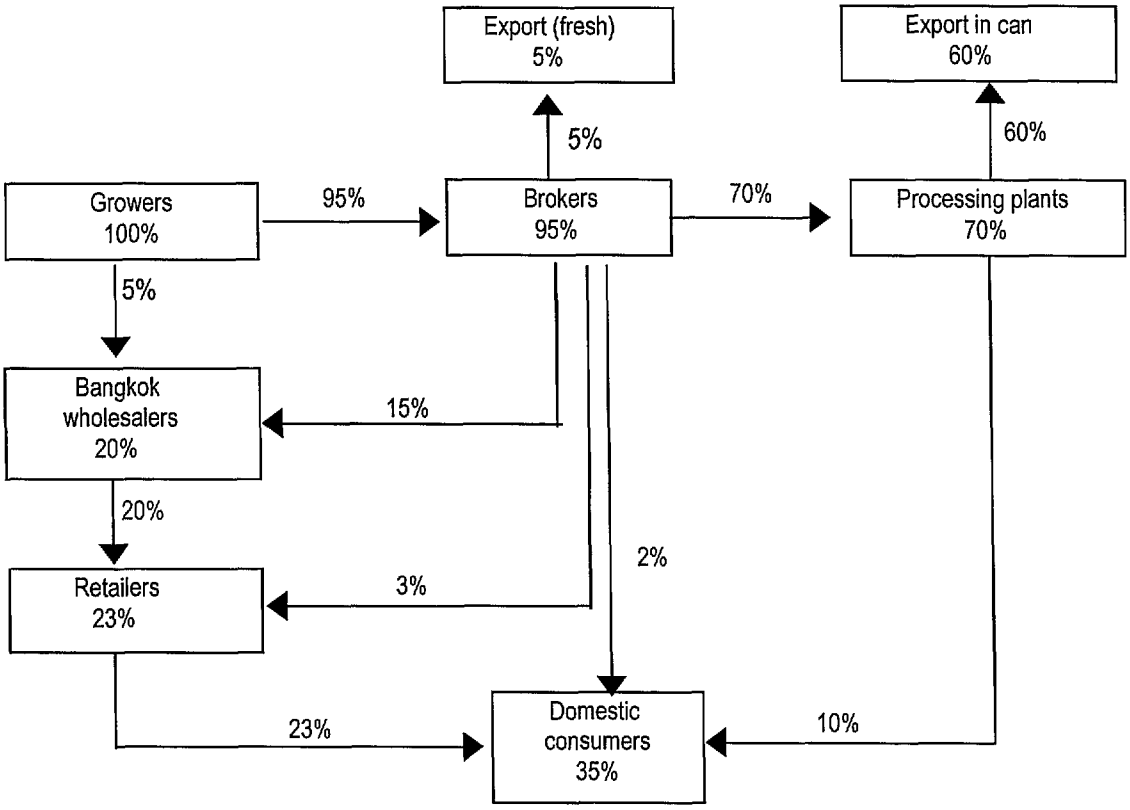
Marketing Channel Not Involving a Central Market

In this channel, farmers sell their vegetables at their farms, either to village assemblers, provincial wholesalers, processors, or directly to exporters. Some farmers haul their produce to a vegetable trader or processor. Some farmers enter into contracts to supply their vegetables exclusively to a particular processor or exporter.

The village broker or assembler might sell his produce to a wholesaler or processor. The wholesaler in turn sells the produce to retailers, or processors and exporters.

This marketing channel handles vegetables (tomato, sweet corn, baby corn, bamboo shoot, white asparagus for canning, green asparagus, lady's finger, potato, and others) mostly destined for processing and export. An example of this type of marketing channel is shown in Figure 6 for baby corn.

In the case of onion and potato, members of growers' cooperatives sell their produce through their cooperative's managers who negotiate with assemblers and processors. Other farmers sell to assemblers and processors directly.



Source: APO (1989).

Fig. 6. Marketing Channel for fresh baby corn, 1986.

Direct Channel

In this channel, growers sell their vegetables directly to consumers in their locality or in the provincial market. Most of the produce is consumed within the province. This channel handles sweet potato, taro, and other root and tuber vegetables.

Marketing Margins

Estimates of marketing margins are not available for many vegetables passing through the different marketing channels. Thus, the causes of the large differences in producer and consumer prices, and degree of monopoly power in vegetable marketing, if any, cannot be determined. Estimates for onion and bamboo shoot suggest that cooperative marketing increases farmers' share of the consumer price. In the case of onion exported through farmers' cooperatives, the farm production cost and farmers' profit account for 41% of the consumer price, freight charges account for 36%, while the growers' cooperative retains 14% of the margin. Internal transportation, port charges, taxes, labor, and other charges account for the remaining 9%. Similarly, cost of production of bamboo shoot contributes 35% of the consumer price, and farmers retain 22% as profit margin. In turn, traders account for a marketing cost of 24%, with a profit margin of 19% (OAE 1993b).

Estimates suggest high losses during transportation of vegetables from one marketing stage—as high as 20% or more in the case of Chinese cabbage, Chinese kale, and coriander. Post-harvest losses are usually higher when vegetables are transported from the wholesale to the retail level, as compared to when they are transported from the farm to the wholesale level (Table 8).

Table 8. Post-harvest losses (%) in selected vegetables

Vegetable	Farm to wholesale	Wholesale to retail	Total
Cabbage	4.20	11.09	15.29
Chinese cabbage	15.40	4.89	20.29
Chinese kale	8.84	12.42	21.26
Chive	5.83	10.24	16.07
Coriander	16.20	7.62	23.82
Cucumber	6.40	7.21	13.61
Fresh chili	7.40	8.46	15.86
Green onion	9.80	9.82	19.62
Lettuce	5.50	6.80	12.30
Luffa	4.70	8.09	12.79
Tomato (small fruit)	10.22	9.49	19.71
Yard long bean	7.80	4.09	11.89

Source: APO (1989).

International Trade

Thailand enjoys a surplus in vegetable trade, both in quantity and value, and the surplus increased at an annual rate of 13.9% and 23.3%, respectively, during 1983-94. This is because the quantity and value of exports increased at a much higher rate, 13.6% and 22.9%, respectively, compared to the quantity and value of imports, which grew at 8.3% and 18.9%, respectively, during this period (Table 9).

Table 9. International trade in vegetables, 1983-94

Year	Imports					Exports					Surplus
	Fresh	Frozen	Preserved	Dried	Total	Fresh	Frozen	Preserved	Dried	Total	
						Quantity (t)					
1983	64	19	66	3678	3827	24477	65	29869	3653	58064	54237
1984	90	31	140	5188	5449	27297	194	34701	2892	65084	59635
1985	61	24	152	3802	4039	24578	127	46608	5898	77211	73172
1986	68	46	161	3811	4086	22332	48	58007	9701	90088	86002
1987	62	27	1376	6878	8343	23930	333	106675	7104	138042	129699
1988	95	52	548	4699	5394	39374	2665	115189	5326	162554	157160
1989	38	43	759	4861	5701	37468	8767	131306	4098	181639	175938

Contd. Table 9.

Year	Imports					Exports					Surplus
	Fresh	Frozen	Preserved	Dried	Total	Fresh	Frozen	Preserved	Dried	Total	
1990	700	76	2523	5085	8384	35562	14870	140721	2870	194023	185639
1991	219	68	2819	4140	7246	35573	18955	201292	2612	258432	251186
1992	958	66	5168	3689	9881	38548	23600	167838	3628	233614	223733
1993	1430	118	4782	4424	10754	22747	14484	65480	1750	104461	93707
1994	949	122	6655	5023	12749	46432	34737	214055	2308	297532	284783
Growth (%)	35.1	17.0	54.1	0.5	8.3	4.3	92.3	16.4	-7.6	13.6	13.9
						Value (million THB)					
1983	1.9	0.7	1.5	94.9	99.0	145.4	2.1	396.5	33.6	577.6	478.6
1984	2.9	1.3	5.1	119.2	128.5	168.1	3.6	424.8	43.7	640.2	511.7
1985	2.3	0.9	6.7	98.7	108.6	168.7	4.3	624.3	81.3	878.6	770.0
1986	3.5	1.7	6.1	74.6	85.9	134.9	2.0	943.0	123.3	1203.2	1117.3
1987	3.9	0.9	26.7	66.6	98.1	173.3	15.1	1892.0	105.2	2185.6	2087.5
1988	4.3	2.0	16.1	64.9	87.3	300.1	70.5	1954.0	64.4	2389.0	2301.7
1989	2.9	1.6	30.1	95.5	130.1	465.4	169.6	2317.5	66.1	3018.6	2888.5
1990	15.5	3.0	77.0	109.8	205.3	630.6	268.8	2680.1	67.8	3647.3	3442.0
1991	43.7	2.5	105.1	111.5	262.8	607.3	476.3	4072.8	90.7	5247.1	4984.3
1992	218.6	3.4	192.8	107.5	522.3	751.7	741.6	3570.4	108.7	5172.4	4650.1
1993	302.9	4.5	156.9	110.9	575.2	437.0	373.6	1375.8	92.9	2279.3	1704.1
1994	218.5	5.0	191.6	154.3	569.4	1016.9	924.7	4021.8	124.5	6087.9	5518.5
Growth (%)	64.4	18.3	55.1	3.3	18.9	20.1	88.9	22.0	7.4	22.9	23.3

Sources: Estimated from data reported in Department of Customs (various issues, 1984-95).

The vegetables traded in the international market can be classified into four groups: fresh, frozen, preserved (in vinegar or other than vinegar in different types of containers), and dried. During 1983-94, the highest increase in exports came from frozen vegetables, while the quantity of dried vegetables exported decreased, although their value increased. The highest increase in imports was in preserved vegetables (Table 9).

The share of dried vegetables in import value declined steadily, while the share of fresh vegetables increased steadily during 1983–1993. The share of preserved vegetables increased during the period. Frozen vegetable imports remained small (Table 10).

Preserved vegetables have accounted for 60-87% of the value of total vegetable exports in different years. The value shares of fresh and dried vegetable exports declined during 1983-94, while the value share of frozen vegetables increased steadily (Table 10).

Table 10. Share of various categories of vegetables in total import and export values, 1983–1994

Year	Imports				Exports			
	Fresh	Frozen	Preserved	Dried	Fresh	Frozen	Preserved	Dried
1983	1.9	0.7	1.6	95.8	25.2	0.4	68.6	5.8
1984	2.3	1.0	3.9	92.8	26.3	0.6	66.3	6.8
1985	2.1	0.8	6.1	91.0	19.2	0.5	71.0	9.3
1986	4.0	2.0	7.1	86.9	11.2	0.2	78.3	10.3
1987	3.9	0.9	27.2	68.0	7.9	0.7	86.6	4.8
1988	5.0	2.3	18.4	74.3	12.6	3.0	81.7	2.7
1989	2.2	1.2	23.2	73.4	15.4	5.6	76.8	2.2
1990	7.6	1.5	37.5	53.4	17.3	7.4	73.4	1.9
1991	16.6	1.0	40.0	42.4	11.6	9.1	77.6	1.7
1992	41.9	0.7	36.9	20.5	14.5	14.3	69.1	2.1
1993	52.7	0.8	27.3	19.2	19.2	16.4	60.3	4.1
1994	38.4	0.9	33.6	27.1	16.7	15.2	66.1	2.0

Source: Estimated from data reported in Table 9.

More than 40 vegetable products are being traded internationally each year. Among the fresh vegetables, onion and shallot, lady's finger, chicory, asparagus, and salad beet root are the leading vegetable exports, while bamboo products and sweet and baby corn are the major preserved vegetable exports. Frozen beans are a major export, as well as a major import, which suggests that they are being imported mainly for re-export. The same is true for salad beet root. Peas and mushrooms and turfs are the major dried vegetable import (Table 11).

Table 11. Contribution of important vegetables in the international trade of vegetables, 1994

Item	Export	Import
Fresh and chilled	100.0	100.0
Onion and shallot	21.5	-
Lady's finger	16.5	-
Chicory	14.4	-
Asparagus	14.2	-
Salad beet root	13.1	93.6
Frozen	100.0	100.0
Mixture	36.9	14.3
Beans	29.1	61.1
Other leguminous vegetables	5.6	15.7
Sweet corn	5.2	-

Contd. Table 11.

Item	Export	Import
Preserved	100.0	100.0
Bamboo shoot	30.0	-
Sweet and baby corn	24.2	-
Tomato	6.9	15.0
Mushrooms and truffles	6.6	15.2
Other vegetables in airtight containers	14.7	-
Dried	100.0	100.0
Peas	-	33.3
Shallots	10.0	6.0
Bamboo shoots	3.9	9.9
Mushrooms and turfs	3.7	22.3

Source: Estimated from data reported by Department of Customs (1995).

Thailand's exports are narrowly focused on the Japanese market. Imports come from more diverse sources, although individual import categories have narrow origins (Table 12).

Table 12. Direction of vegetable trade during 1994

Fresh		Dried		Frozen		Preserved	
Country	Share (%)	Country	Share (%)	Country	Share (%)	Country	Share (%)
				Export			
Japan	75.1	Japan	44.4	Japan	64.1	Japan	37.5
Malaysia	9.9	S. Korea	17.6	United Kingdom	8.7	USA	26.1
United Kingdom	3.4	USA	9.7	Hong Kong	5.1	Australia	5.2
Taiwan	2.1	Australia	8.6	USA	3.0	Germany	4.6
Netherlands	2.0	Germany	4.5	Taiwan	2.6	United Kingdom	3.8
Others	7.5	Others	15.2	Others	16.5	Others	22.8
				Import			
Taiwan	95.2	China	68.2	New Zealand	60.3	China	55.7
Others	4.8	Canada	8.8	Japan	14.1	Vietnam	22.0
		New Zealand	5.4	USA	9.5	Others	22.3
		Others	17.6	Others	16.1		

Source: Department of Customs (1995).

A wide variety of temperate vegetables are being produced in Thailand. But so far, little of their export potential has been exploited. The major constraints to exploiting export markets are: i) high production cost, ii) lack of a consistent supply of good quality produce, iii) insufficient quality control, and iv) stringent quality restrictions by importers.

High cost of production makes certain vegetables noncompetitive in the international market. For example, an analysis of onion production indicated that cost per unit of output is higher in Thailand than in mainland China and New Zealand. Thus, onions from these two countries are available in

Thailand during the off season when prices of the imported onions make them more attractive than local onions, despite a 158% import tariff.

An important characteristic of Thailand's vegetable production is that most is grown for the local market, and the export and processing markets often take what is left. The local vegetable market has been protected by a tariff as high as 46% (World Bank 1987), which has restricted healthy competition. Primitive post-harvest technologies prevent the industry from meeting export quality requirements.

Supply and Demand

Per Capita Availability

Per capita annual vegetable availability in Thailand ranged from 31 to 58 kg (or 84-159 g/day) during 1983-94. The worst years with respect to availability were 1987 and 1988, due to setbacks in production. Unlike cereals, the wide variation in vegetable availability suggests government and consumer insensitivity to the consumption level of vegetables. Excluding the worst years, availability ranged from 45 to 58 kg, without significant gains throughout the decade (Table 13).

Table 13. Per capita availability of vegetables in Thailand, 1983-94

Year	Production (million t)	Trade surplus (million t)	Net availability (million t)	Population (million)	Per capita availability (kg)
1983	2.946	0.053	2.893	49.680	58.2
1984	2.977	0.059	2.918	50.637	57.6
1985	3.008	0.073	2.935	51.189	57.3
1986	3.040	0.085	2.955	52.382	56.4
1987	1.777	0.129	1.648	53.421	30.8
1988	1.994	0.157	1.837	54.417	33.8
1989	2.855	0.176	2.679	55.425	48.3
1990	3.005	0.186	2.819	56.096	50.3
1991	3.167	0.251	2.916	56.532	51.6
1992	2.815	0.224	2.591	57.375	45.2
1993	2.720	0.094	2.626	58.083	45.2
1994	3.382	0.285	3.097	58.716	52.7
Growth rate (%)	0.832^{ns}	12.997	0.873^{ns}	1.544	-1.236^{ns}

Source: For the source of production data see Table 2; vegetable surplus is taken from Table 9, while population of Thailand is taken from OAE (1995).

ns implies that the growth rates are not significant at the 10% level.

Consumption

Since 1962, only three consumption surveys have been conducted in Thailand. The latest was in 1986, which found that Thais consume an average of 742 g of all foods every day. Average daily consumption of vegetables is 106 g, which accounts for 14% of the total food consumed. The fruit consumption is lower than vegetable consumption. Typical of Southeast Asia, food in Thailand is dominated by cereals followed by meat and meat products (Table 14).

Table 14. Consumption of major food items in Thailand (g/day), 1986

Food Item	Urban		Rural		Overall	
Rice and other starch	297.6	(37.1)	360.4	(49.9)	336.5	(45.4)
Meat and meat products	149.9	(18.7)	103.3	(14.3)	121.2	(16.3)
Vegetables	107.5	(13.4)	105.5	(14.6)	106.3	(14.3)
Fruits	108.0	(13.5)	71.1	(9.8)	85.3	(11.5)
Fat	29.6	(3.7)	19.1	(2.6)	23.2	(3.1)
Sugar	12.9	(1.6)	9.1	(1.3)	10.5	(1.4)
Milk	12.3	(1.5)	3.0	(0.4)	6.6	(0.9)
Others	84.0	(10.5)	51.5	(7.1)	52.8	(7.1)
Total	801.8	(100.0)	723.0	(100.0)	742.4	(100.0)

The figures in parentheses represent the percentage share of the total food.
Source: Department of Health, Ministry of Public Health, and School of Public Health, Mahidol University (1995).

Per capita food consumption is significantly higher in urban areas than in rural areas. Rural people consume more cereals, while urban people consume more meat products, fruits, fats, sugar, and miscellaneous other products. The difference in vegetable consumption is not significant (Table 14).

The consumption survey in 1986 suggested that bamboo shoots, Chinese cabbage, cucumber, kangkong, and string beans are major vegetables consumed in Thailand, in both rural and urban areas (Table 15).

Table 15. Consumption of major vegetables (g/day)

Food Item	Urban	Rural	Overall
Angle gourd	4.21	3.31	3.60
Asparagus	1.14	0.00	0.44
Bamboo shoots	8.64	5.35	6.61
Bean sprouts	3.69	3.24	3.41
Cauliflower	3.35	1.69	2.23
Chili	2.29	1.88	2.10
Chinese cabbage	9.67	6.58	7.77
Coriander	0.49	1.26	0.96
Cucumber	9.68	13.67	12.13
Eggplant	5.27	5.73	5.56
Garlic and ginger	0.14	0.51	0.37
Jack fruit (young-raw)	0.24	2.73	1.77
Kale	4.87	2.38	3.34
Kangkong	6.67	7.54	7.21
Mushroom	0.96	3.53	2.53
Mustard	3.52	1.86	2.49
Onion	2.42	1.99	2.16

Contd. Table 15.

Food Item	Urban	Rural	Overall
Papaya (raw)	1.21	5.07	3.58
Peas	1.63	0.00	0.63
Pumpkin	1.44	1.19	1.28
Snake gourd	0.44	0.21	0.30
Spinach	0.29	0.07	0.16
String beans	7.15	7.37	7.29
Tomato	2.43	1.30	1.74
Wax gourd	2.28	2.64	2.50
Others	23.41	24.43	24.15
Total	107.53	105.53	106.31

Source: Department of Health, Ministry of Public Health, and School of Public Health, Mahidol University (1995).

Estimation of the consumer expenditure function for vegetables, both in urban and suburban districts in Bangkok, suggests that the income elasticities of leafy vegetables are higher in urban areas than in suburban areas, and that the opposite is true for fruit and root vegetables (Table 16).

Table 16. Income elasticities of vegetables in Bangkok urban and suburban areas, 1982

	Income elasticities
Urban	
Expenditure for leafy vegetables	0.5312
Expenditure for fruit vegetables	0.1619
Expenditure for root vegetables	0.2200
Suburban	
Expenditure for leafy vegetables	0.4203
Expenditure for fruit vegetables	0.5594
Expenditure for root vegetables	0.5911

Source: Eamkitsumrit (1984).

Thais, especially children and more specifically female children in rural areas, suffer a high incidence of anemia (Table 17). As vegetables are the cheapest source of minerals and vitamins (Ali and Tsou 1997), increased consumption of these can be an economical way to correct deficiency.

Table 17. Prevalence of anemia (% of the total population) in Thais by age and sex

Age group	Male			Female		
	Urban	Rural	Overall	Urban	Rural	Overall
0-1	73	75	74	58	80	73
2-5	29	40	37	30	42	37
6-9	53	73	64	43	54	51
10-14	40	27	31	17	67	44
15-19	25	10	14	42	48	45
20-59	2	6	5	22	20	21
60+	25	30	28	25	65	48
Pregnant women	-	-	-	41	40	40

Source: Department of Health, Ministry of Public Health, and School of Public Health, Mahidol University (1995).

Vegetable Research

Vegetable research in Thailand is conducted by a number of government agencies, and, lately, by a few big private corporations, which concentrate on high-value crops. The Department of Agriculture focuses mainly on variety improvement, crop pest and disease prevention and management, soils, and fertilizer use with the ultimate goal of lowering per-unit cost of production. Aside from the Department of Agriculture, other major research organizations working on vegetables include the research departments of various universities, the Ministry of Science, Technology and Energy, and the National Research Council. The Office of Agricultural Economics is responsible mainly for commodity analysis and development plans.

Since 1974, the Vegetable Research and Development Group has been functioning under the National Research Council. In 1980, the group, which includes research and development officers from the government and universities, became a subcommittee of the National Research Council of Thailand. Now there are five working parties in the subcommittee focused on tomato, brassica, legumes, baby corn, and fruit vegetables. In addition, the Ministry of Agriculture and Co-operatives has two working groups, one focused on alliums and the other on vegetables for export. The working and groups subcommittees promote their respective crops and work to control supply fluctuations. The latter objective involves a bid to enforce zoning in production (Department of Business Economics 1987), and the recommendation of specific crops in the light of price projections. In the case of onion, loans to growers for cold storage and restrictions on seed imports are additional tools of control.

Summary and Conclusion

Vegetables hold an important place in Thai agriculture and are important to the country's dietary well being. Vegetables are grown on 353 thousand ha, producing 3.4 million t , worth 25 billion THB. Per capita annual availability amounts to about 53 kg (14% of all food consumed). In terms of consumption, this figure is far below the 73 kg recommended by AVRDC. This has caused serious health problems, such as anemia, especially among women and children. For example, 37-74% of children and 40% of pregnant women were found to have anemia in Thailand.

Despite the health consequences of low vegetable consumption, no serious attempt has been made to increase vegetable supply. Production has remained stagnant, and per hectare yield has been on a declining trend during the 1990s. This has created a demand pressure on vegetables as incomes and population have continued to grow, and has resulted in higher vegetable prices in real terms, both at the farm gate and wholesale levels. Although the country enjoys a surplus in international trade of vegetables, and exports continue to rise, the share of vegetables going for export is still negligible relative to total production. Revitalization of the vegetable sector will require commercialization of the agriculture sector in general and the vegetable sector in particular, coupled with continuous introduction of low-cost production techniques.

Poor, small landholders with high production costs, lack of suitable varieties and appropriate technology (including good quality seed), and the absence of an auction mechanism in the wholesale markets are the major problems facing Thailand's vegetable industry. To resolve these issues, an extensive vegetable research and development program on all aspects of vegetable production, distribution, and consumption is needed.

Currently, certain types of the vegetable seeds are domestically produced, collected, and distributed. Some quantities of hybrid seeds and seeds of some subtropical and temperate vegetables are also produced. Despite this, imports of vegetable seeds in 1988 amounted to 634 t (OAE 1989). A study on the constraints to vegetable seed production, along with government policies to encourage vegetable seed production, could save foreign exchange and help to boost vegetable productivity.

Vegetable production is shifting from areas close to cities to more distant areas with a comparative advantage, as vegetable dealers are able to transport produce. This, however, has pushed wholesale prices higher, despite a common notion that market arrangements have improved. Constraints and potential of production and marketing of leafy vegetables (from peri-urban production areas) and fruit and bulb vegetables (from provincial locales) need to be evaluated.

The vegetable farm decision-making process needs further investigation to facilitate economic planning. Farm-level production and socioeconomic constraints should be quantified and ranked on a regional basis to help better understand farm resource allocation decisions.

Wide fluctuations in vegetable production were observed. Development of pest and disease resistant varieties and stress tolerant management practices could boost and stabilize vegetable production. This should be combined with policies designed to stabilize vegetable area. More research and development are needed on processing in order to reduce high seasonality in prices and improve quality. This could also generate substantial additional employment and income for rural and urban poor.

Given the changing economy, accentuated by implementation of the GATT, an impact study on vegetable trade is urgently needed. The study should determine the competitiveness of various regions. For this, the economics of vegetable production and distribution, post-harvest activities, and the processing industry need to be quantified for individual vegetables at the regional level. Thailand's competitiveness in the exportation of fresh and chilled vegetables could be improved through quality control and more research into post-harvest technologies, with due emphasis on technology transfer.

Vegetable marketing is a big black box largely untouched by researchers. Studies on alternative marketing systems, with the goal of suggesting marketing reforms, are urgently needed. The studies should quantify marketing margins, itemize losses as vegetables pass through marketing stages, shed light on the power of marketing agents, and explore consumer preference. Research is needed into the factors affecting the supply and demand of vegetables.

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VIETNAM

Nguyen Tri Khiem, To Dung Tien, and Nguyen Thi Thanh Thuy

Introduction

Vietnam covers an area of about 333 thousand km^2 and extends for some 1600 km from 23°08'N to 6°50'N. Three-quarters of the land area comprise hills and mountains. The population of the country in 1994 was 72.5 million with about 80% residing in rural areas. Average population density is 218 persons per km^2. Between 1980 and 1990, the population's annual growth rate was 2.3%. The annual per capita income in 1994 was US$213 (General Statistical Office 1995).

Although the country lies almost entirely within the tropics, the climate varies from humid tropical in the southern lowlands to temperate in the northern highlands. The average annual temperature at sea level is about 27°C in the south, falling steadily northward to about 21°C in the extreme north. Most of the country receives about 2000 mm of rainfall every year, but the mountains of the narrow central region are considerably more humid, with an annual rainfall of up to 3000 mm. The southeast part of central Vietnam is very dry, having an annual rainfall of only 800 mm.

The road system is relatively poor, the whole country has about 87,000 km of all-weather, four-wheel vehicle road. In general, most of these roads are national and provincial roads. District and village roads are in poorer condition. The vegetable marketing institutions are not developed yet as the economy is moving from a centrally controlled economy toward a market oriented economy.

The Vietnamese diet is heavily dominated by rice, which accounts for 56.7% of the total daily per capita food consumption. With a share of 24%, vegetables make up the next important food in the diet, while fruits claim a share of only 0.3%. Other cereals and tubers contribute 5.8%, livestock products and seafood 7.5%, and other food items, such as sugar, beans, sauce, etc., 5.7% (National Institute of Nutrition Research 1992).

Rice is the most important crop in the country, occupying about 66% of the total cropped area. Other important crops are industrial crops (rubber, coffee, sugarcane, and soybean), maize, sweet potato, cassava, and fruits. Vegetables are grown on 325,000 ha, contributing about 3.5% of the total cropped area.

Total production of vegetables in Vietnam in 1996 was recorded at over 4.07 million t valued at about 900 billion Vietnam dong (US$ 200 million). With an estimated population of 73.5 million in

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1996, annual per capita vegetable availability was about 55 kg. The most important vegetables in the southern lowlands are cabbage, tomato, fruit vegetables, such as beans and cucurbits, leafy vegetables, such as lettuce, mustard, amaranth and garland chrysanthemum, and root vegetables, such as radish, yam, and taro. In the central highlands and in the northern regions, the cool winter is suitable for many temperate vegetables, such as cauliflower, kohlrabi, Chinese cabbage, and Irish potato.

Agroecological Regions

With the diversified environmental and socioeconomic conditions, vegetable production and consumption patterns vary across ecoregions of the country. The seven relatively distinct ecoregions in Vietnam include the North Mountain and Midland, Red River Delta, North Central Coast, South Central Coast, Central Highlands, Eastern Mekong Delta, and Mekong Delta.

North Mountain and Midlands

This region occupies arable area of 1.3 million ha, or 17.6% of the total land area of 7.3 million ha (Table 1). About 22% of the area is forest land. Arable land which is of degraded gray soil accounts for 12.4%. This region is influenced both by the tropical monsoon and northeastern winds, giving this region climatic characteristics distinct from the rest of the country. There are four seasons: winter (cold), summer (very warm), and spring and autumn (between the two extremes). Average total annual rainfall is about 2400 mm, concentrating during July-August. The population of this region is composed of many ethic minorities, distributed throughout, with a density of about 120 people/km^2.

Table 1. Basic demographic and agriculture statistics of various regions in Vietnam in 1994

Region	Population density (person per km^2)	Arable land		Vegetable area		Vegetable production	
		000 ha	% share	000 ha	% share	000 t	% share
North Mountain and Midland	120	1293.1	17.6	56.1	19.1	607.0	17.4
Red River Delta	1124	721.3	9.8	70.9	24.2	1056.1	30.3
North Central Coast	190	693.0	9.4	42.6	14.5	326.6	9.4
South Central Coast	167	533.2	7.3	33.6	11.5	206.3	5.9
Central Highlands	53	572.7	7.8	9.8	3.3	149.7	4.3
Eastern Mekong Delta	378	937.3	12.8	28.9	9.9	451.0	12.9
Mekong Delta	400	2597.8	35.3	51.4	17.5	688.2	19.7
Vietnam	218	7348.4	100.0	293.3	100.0	3484.9	100.0

Source: Department of Agricultural Statistics (1995).

About one fifth of the country's vegetable area is in this region. A narrow selection of vegetables is grown. Major species include convolvulaceae (*Ipomoea aquatica*, *Ipomoea reptans*), field cabbage (*Brassica capitata*), cucurbits, and root vegetables (radish, taro, cocoyam, etc.). Kangkong (*Ipomoea aquatica*) is the most widely grown vegetable species, accounting for nearly one-third of the total planted vegetable area in the region.

Red River Delta

The Red River Delta covers 0.7 million ha, mainly lowlands with degraded riparian alluvium soil. The land holdings in the delta are the smallest in the country, and the region has the highest population density (Table 1). The region's Thai Binh province is the nation's most densely populated. Pressure on cultivated land is greatest as there are only 512 m^2 of arable land per person, or 2397 m^2 per agricultural laborer in this region. This region has unique potential, unequaled by other regions: it has excellent conditions for high-value vegetable crop production on a large scale during the cool months, and for high-value fruit production, such as lychee, small-seed longan, and jujube. This region accounts for about one-fourth of the vegetable area in Vietnam.

North Central Coast

This region is characterized by partly denuded and moderately eroded hills and mountains and sand bars along the coast. Population density is 190 people/km^2 (Table 1), concentrated in small deltaic areas along the coast. Some 712 m^2 of arable land is available per person. Ethnic minorities living in small tribes in the mountains practice slash-and-burn farming.

South Central Coast

This region has a climate similar to the rest of southern Vietnam, except for some extremely dry locations during the dry season (e.g., Phan Rang has only 800 mm of rainfall per year). Alluvial deltas are suitable for rice production and many other cash crops. The population density is 167 people/km^2. Prior to 1975, vegetable consumption in this region depended on supply from Da Lat in the adjacent highlands. This supply source declined with the drive for self-sufficiency and the abolition of private marketing. With the return of a market system, however, the reliance is shifting back to Da Lat.

Central Highlands

This vast highland has mild temperatures and humidity, suited to growing high value crops. Soils of the western high plateaus are of reddish brown basalt types rich in nutrients when properly covered. Tens of thousands of hectares of precious forest have been wantonly exploited, the soils are denuded, exposed to severe erosion and are becoming acidic. A large part of the region is still not cultivated. Population density is relatively low (Table 1). The region presents an example of an integration of lowland Vietnamese and ethnic minorities. This region has a high potential for industrial crops, e.g., rubber, tea, coffee, fruit trees, and high value vegetables.

Although the share of area planted to vegetables is not large (Table 1), this region has an important commercial vegetable production center (Da Lat) supplying high value vegetables to Ho Chi Minh City (HCMC), which is 300 km away, and many other urban areas in the southern region. Da Lat also has potential for vegetable production for export.

Eastern Mekong Delta

Soils of this region belong to two major groups: reddish brown basaltic soils adjacent to the highlands, and degraded gray soils (with patches of acid sulfate soils). Both soil groups are being eroded due to exploitation of forests and defoliation during war. This region accounts for 10% and 13% of the country's total vegetable area and production, respectively (Table 1).

Mekong Delta

Soils of the Mekong Delta are young alluvium, about 40% of which are acid sulfate soils and seasonal saline soils. This region is the rice bowl of Vietnam; 1.923 million ha (or 45.3%) of the country's rice land is in this region. The Mekong Delta has the highest per capita arable land, 1639 m^2 per person, or 4627 m^2 per agricultural laborer. Important commercial vegetable areas are in Tien Giang province (with more than 11,000 ha, or 22% of total vegetable area of the Delta). These areas supply vegetables to Ho Chi Minh City.

Major Vegetables

Being situated along several parallels, and influenced by different climate regimes, the geographical conditions and the environment in Vietnam are suitable to many tropical and temperate vegetable crops. In addition, high variation in the distribution of arable land and population pressure on land result in varied vegetable production practices and types of vegetables grown across different ecoregions of the country. More than 70 plant species are used as vegetables or processed into vegetable products, but only 30 species are commonly planted, and data are available on only 19 species that have dominant economic value.

National data on individual vegetable species are rarely reported. Recently, the Research Institute for Fruits and Vegetables (RIFAV) collected vegetable data by species and by province from the official files of the Statistical Department of the Ministry of Agriculture and Rural Development. Most common vegetables grown, and major production provinces are reported in Table 2. Mustard, vegetable beans, cabbage, kangkong, and garlic are important vegetable species.

Table 2. Major vegetables and major production areas, 1997

Crop and planted area [% of area of all vegetables]	Production location (% of total area of the given vegetable)
Baby corn [0.1]	An giang (100)
Cabbage [7.6]	Lam dong (13.9); Nam dinh (8.4); Bac ninh (5.9)
Carrot [0.5]	Lam dong (82.59); Thai binh (10.65); Thanh hoa (2.13)
Cauliflower [0.4]	Lai chau (30.0); Lam dong (21.1); Binh thuan (19.3)
Chayote [0.1]	Lam dong (100)
Chili [1.4]	Quang Nam (21.5); hai duong (15.9); Quang tri (11.1)
Chinese chieve [0.1]	Baclieu (72.6); Vinh long (27.4)
Cucumber [1.9]	An giang (20.3); Soc trang (11.9); Hai duong (10.7)
Cucurbits [3.6]	Ho Chi Minh (16.7); Vinh phuc (6.5); Ba ria-vung tau (6.0)
Garlic + multiplier onion [5.8]	Hai duong (30.09);Soc trang (14.46); Bac ninh (5.14)
Kangkong [5.9]	Ha Tinh (14.57); Nam dinh (12.32); Thanh hoa (10.54)
Kohlrabi [4.6]	Nam dinh (11.5); Thai binh (7.9); Ha tay (7.3)
Mungbean [0.5]	Yen bai (50.8); Cao bang (34.0); TP.Ho Chi Minh (15.2)
Mustard [19.4]	Soc trang (16.99); Dong nai (13.04); Thai binh (12.28)
Onion [0.4]	Lam dong (32.2); Ninh thuan (25.12); Bac ninh (22.63)

Contd. Table 2.

Crop and planted area [% of area of all vegetables]	Production location (% of total area of the given vegetable)
Tomato [3.5]	Lam Dong (21.1); Hai duong (8.0); Hai phong (6.9)
Vegetable bean [9.9]	Ho Chi Minh (19.1); Quang Nam (15.0); Lam dong (9.6)
Water melon [1.1]	Bac lieu (50.93); Soc trang (30.35); Quang nam (12.97)
Others [33.0]	Nghe an (13.9); Ho Chi Minh (8.7); Thanh hoa (8.1)

Source: Official files of Statistical Department, Ministry of Agriculture and Rural Development.
The percentage of total area, in brackets, is based upon those provinces where cropwise data are available. In some provinces the cropwise classification was not available.

Lam dong is the major vegetable growing area in the country, especially famous for cabbage, carrots, chayote, onion, and tomato. The dominant vegetable species grown in Hanoi during the wet season are kangkong, on nearly 27% of the total vegetable area, cucurbits on 25%, and crucifers on 14% of the total vegetable area. Dry season species are more diversified, and include cabbage, kohlrabi, cauliflower, and carrot. Ho Chi Minh City is famous for cucurbits and vegetable soybean.

A recent farm survey conducted in northern Vietnam by the Asian Vegetable Research and Development Center (AVRDC) suggested that most vegetables are grown after summer, so they are abundant during the winter season in November-February. Summers are hotter and wetter in southern Vietnam, so seasonality is expected to be more pronounced there.

National and Regional Trends

National Trends

The total output of vegetables in 1996 was 4.07 million t from a planted area of 325,000 ha. There was a steady linear increase in area and production during 1977-96. Total planted area of vegetables increased at 3.9% and 3.4% per annum during 1977-86 and 1987-96, respectively, while annual production growth rates were 3.3% and 3.7% in the respective periods. Vegetable yield remained stagnant, fluctuating between 11 and 12.5 t/ha over the period (Fig. 1). From the aggregate data, it is not possible to evaluate trends for individual vegetable species.

Regional Trends

Vegetable area increased linearly in four out of seven regions, as well as for the whole country in the period 1984-96 (Table 3). No trend in area was observed in the northern central coast, while the trend was quadratic in the southern central coast. In the eastern Mekong Delta, area first decreased as the linear term was negative, and then the decrease was stopped or even increased in the latter years as the quadratic term became positive.

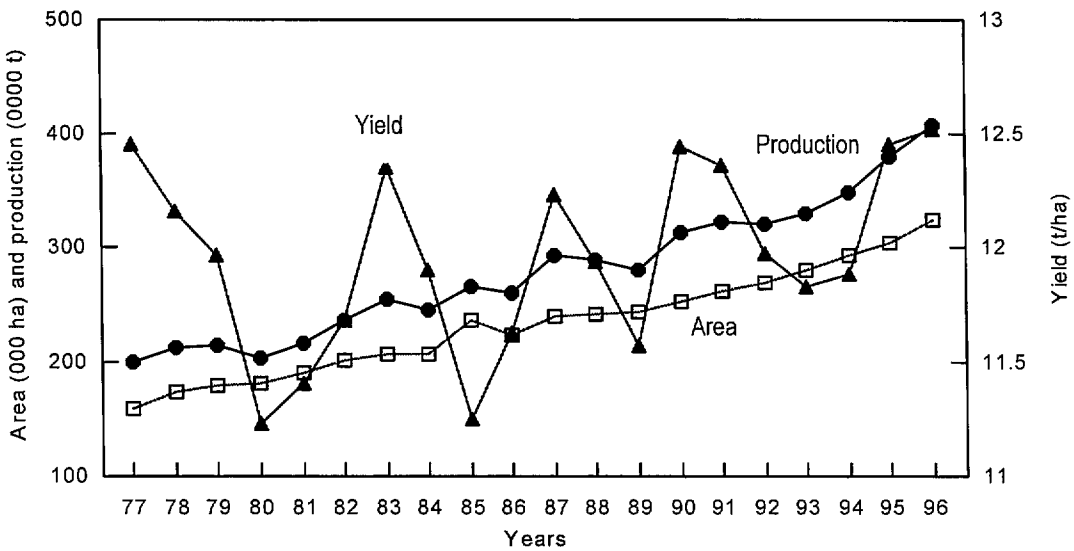


Fig. 1. Trends in vegetable area, production, and yield in Vietnam, 1977-96

Table 3. Trends in area, production, and yield in vegetables by region, 1984-96

Region	Area		Production		Yield	
	t	t^2	t	t^2	t	t^2
North Mountain and Midland	0.040	-	0.037	-	-	-
Red River Delta	0.041	-	0.042	-	-	-
North Central Coast	-	-	0.065	-0.003	0.061	-0.004
South Central Coast	-	0.003	-0.045	0.004	-	-
Central Highlands	0.064	-	-	-	-0.045	0.003
Eastern Mekong Delta	-0.065	0.006	-0.101	0.008	-0.037	0.003
Mekong Delta	0.060	-	0.098	-	0.039	-
Overall Vietnam	0.017	-	0.022	0.001	-	-

- implies that the coefficient was not significant at the 10% level.
Source: Estimated from data reported in Department of Agricultural Statistics, various issues.

No trend in yield was observed in three out of seven regions and for the whole country. The Mekong Delta is the only region where yield increase contributed significantly to the increase in production throughout the period. In other regions, the overall trend is either not significant, or the opposite sign of linear and quadratic terms suggests no overall change in yield.

Thus, increase in vegetable production was linear in the North Mountain and Midlands, Red River Delta, and Mekong Delta, mainly because of the linear increase in area, while in the Central Highlands, no trend in production was observed. In other regions, opposite sign of linear and quadratic terms suggests no overall change in production during the study period.

Supplies from Peri-urban Areas

The most dynamic development in vegetable production was observed in the peri-urban areas of large cities, especially in Ho Chi Minh City and Hanoi, the country's two biggest cities. Before 1975,

most of the vegetable demand for Ho Chi Minh City was met by supplies from uplands, such as Da Lat, 300 km away from Ho Chi Minh City in Lam Dong province. Total peri-urban vegetable area in Ho Chi Minh City was only 5500 ha, producing only 88,000 t of output.

From the mid 1970s to mid 1980s, the government pushed a drive for local self-sufficiency, supported by the introduction of new species of temperate vegetables that can be grown in tropical conditions, and banned vegetable supplies from uplands. This reduced the domestic trade volume of vegetables between specialized regions and cities, and gave a push to vegetable production in the peri-urban areas of the big cities. For example, area around Ho Chi Minh City increased 173%, from 5500 ha in 1976 to more than 15,000 ha in 1984, and production in this period increased threefold, from 88,000 t to 270,000 t. Vegetable area in the highlands of Da Lat plummeted from 4500 ha to 1900 ha, while production dropped from 113,000 t to 44,000 t during this period (Fig. 2). Such a self-sufficiency drive in Hanoi, much earlier than 1976, developed vegetable production around its periphery on more than 5000 ha. Both cities were almost self-sufficient in vegetables in 1984.

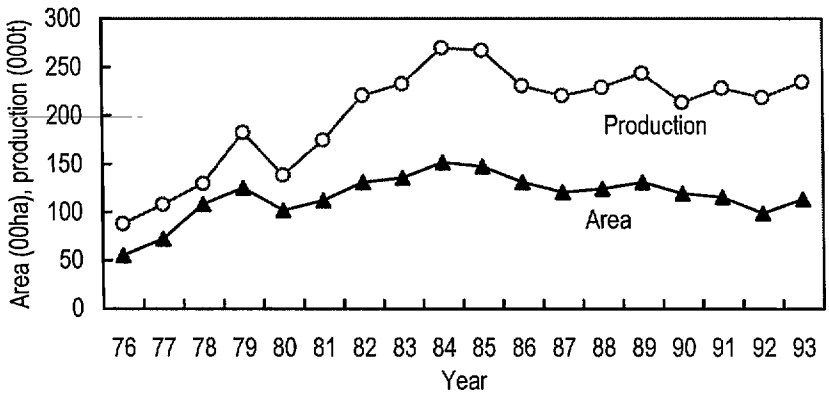
Another swing in vegetable supplies occurred when trade restrictions were relaxed in 1985. Despite the growing demand of Ho Chi Minh City brought about by population growth and income increase, vegetable area in Ho Chi Minh City declined to 11,000 ha in 1993 (Fig. 2). Similarly, vegetable production in Hanoi has not shown a significant increase since 1985, except for a small increase of 1.2% per annum due to an improvement in yield. On the other hand, it started picking up in the adjacent highland provinces where the potential for producing high-value vegetables has attracted investment from state companies and foreign counterparts. For example, vegetable area in Da Lat increased from 1617 ha in 1985 to 3909 ha in 1993, while production increased from 40,000 t to 75,000 t (Fig. 2).

Tien Giang province of the Mekong Delta has 11,000 ha of vegetables and an annual output of 141,000 t, concentrated in the Tan Hiep district, 50 km south-west of Ho Chi Minh City. Major vegetable species grown in this region are Indian mustard, kangkong, cabbage, lettuce and common bean. Vegetable production in Cu Chi district of Tay Ninh province also contributes a significant share of the vegetable supply to Ho Chi Minh City. Currently, vegetable production in the peri-urban areas of Ho Chi Minh City supplies about 68% of demand (State Planning Commission 1989), which is expected to decline as domestic trade restrictions are further relaxed.

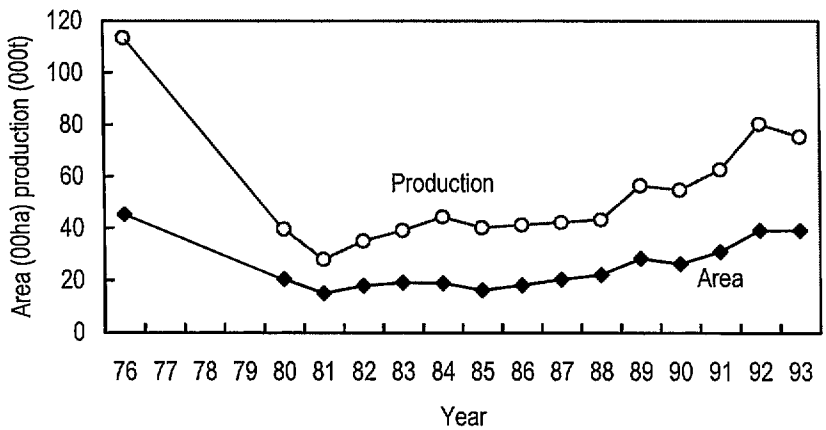
Prices

Under the centralized planned economy, vegetable marketing in urban areas was undertaken by state enterprises, with the prices dictated by them. In general, state-set prices were kept constant, but were readjusted from time to time. Economic reforms in Vietnam, initiated in 1989, have created conditions for market prices to operate freely and reflect the supply and demand conditions, so that they are increasingly becoming signals for producers and consumers.

Ho Chi Minh City



Da Lat



Source: Official files of Department of Agricultural Statistics, General Statistical Office, State Planning Commission, Hanoi.

Fig. 2 Trends in area and production of vegetables in Ho Chi Minh City (1975-93) and Da Lat (1980-93).

A few years after the market liberalization started, vegetable prices in Vietnam began increasing at a higher rate relative to the increases in the prices of other commodities. The rate of increase in the nominal vegetable prices was around 50% per annum during 1986-95. After deflating the nominal prices with the consumer price index (CPI) to account for the increase due to inflation, the average rate of increase was 7.8% per annum (Table 4). The increase was more abrupt during 1988-89 (Fig. 3). The increasing price trend will have serious consequences on the consumption of vegetables, especially for people in the low-income group in the urban centers.

Table 4. Growth rates (percent per annum) in selected vegetable prices, 1986-95

Vegetable	Nominal	Deflated
Tomato	57.5	11.6
Field mustard	53.8	7.9
Cauliflower	52.9	7.0
Cabbage	52.8	6.9
Lettuce	49.3	3.4
Average	53.8	7.8

Source: Estimated from data obtained from official files of Central Price Commission, Hanoi.

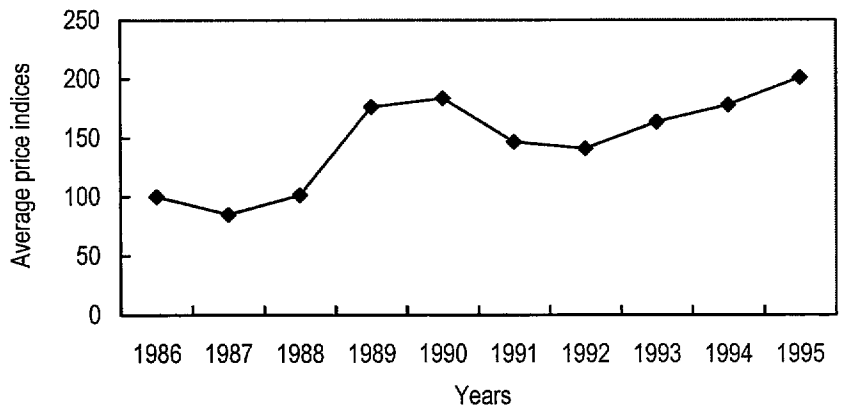


Fig. 3. Trend in real overall vegetable price index (average of selected individual vegetable price indices), 1986-95

International Trade

Since the implementation of the economic reform policy and liberalization of the market system, commercial vegetable production centers have been established in peri-urban areas of Hanoi, Haiphong, Haihung Thai binh, Ninh binh, and Nghe in the northern region, and Dong nai, Song be, Long an, Tien giang, Vinh long, and Can tho in the southern region. Moreover, potential production of high-value vegetable species in the Hanoi area during the winter-spring season and year-round in the Da Lat highlands has attracted foreign investment.

Japanese companies (JAVIDEC International – a consulting firm – and a joint venture between Japan and the National Institute for Agricultural Planning and Projections, NOZAKI) are introducing seeds of Japanese vegetable species in an effort to promote export of Vietnamese vegetables produced in the Red River Delta and in the Central Highlands. These species are cabbage, onion, carrot, taro, snow-peas, lady's finger, asparagus, and Shiitake mushroom.

The export of processed vegetables, such as salted mushrooms, canned baby corn, cucumber pickles, and spices, has grown fast in recent years. The Vegetable and Fruit Export Import Company No. 1 in Hanoi procures and processes vegetables for export. In the Mekong Delta, a joint venture between a Hong Kong-based company and Agroproduct Export Company of Can Tho, MEKO company, is boosting the production of rice straw mushrooms and baby corn by contracting with farmers at assured prices. The company then processes and exports the produce. Although foreign counterparts

receive a major part of the profit, they play an important role in transferring technology and know-how to local entrepreneurs.

Trading of vegetables and fruits, especially for the export market, was consolidated by the establishment of the Vegetable and Fruit Export Corporation (VEGETEXCO) in 1988. This corporation is vested with three main functions (i) production of fruits and vegetables on 28 state farms totaling 30,000 ha (ii) processing of fruits and vegetables from 15 processing plants, mainly for export, and (iii) conducting research on production and processing of fruits and vegetables.

Before 1990, almost all exported produce went to the former Union of Soviet Socialist Republics (USSR) and other communist countries in Eastern Europe. Much of this produce has since been diverted, quite successfully, to markets in other countries in Southeast Asia, as well as to Japan and Europe. Shipments to Association of South East Asian Nations (ASEAN) markets currently account for 45% of agriculture exports (excluding rice and fishery products), to the former USSR and Eastern Europe 25%; and to EC countries 20%.

Good prices in foreign markets for "clean" fresh vegetables grown under conditions of minimum chemical application has prompted the investment in biological pest control and organic farming in Da Lat and Hanoi. Bio-Organic Company in Da Lat, a Dutch commercial vegetable production joint venture, has begun exporting high-value vegetable species, such as broccoli, English cabbage of Iceberg variety, Brussels sprouts, and parsley, all grown using minimum chemical input. Besides renting about 20 ha of land, this company contracts with individual vegetable growers in Da Lat. The company provides technological assistance, seeds or seedlings, and markets the products. Contracted farmers sell the produce to the company at an agreed price, the company then processes the produce and exports it to Hong Kong and Singapore markets.

Export quantity has varied greatly from year to year. The highest level of fresh exported vegetables was recorded in 1986 (Table 5).

Table 5. Vegetable exports (t), 1981-91

Year	Export	Year	Export
1981	2209	1987	9202
1982	5650	1988	9645
1983	8400	1989	9535
1984	13,387	1990	2959
1985	2872	1991	450
1986	18,700		

Source: Official data from Research Institute of Vegetables and Fruits, Hanoi.

Supply and Demand

Per Capita Availability

Average annual per capita availability of vegetables in 1996 was 55 kg (151 g per day). Although production increased from about 3 million t in 1985 to 4.07 million t in 1996, per capita availability increased only marginally (and that increase occurred just during the last two years) because of the high population increase (Table 6).

Table 6. Trends in per capita availability, 1981-96

Year	Population (million people)	Total supply (000 t) (production+imports-exports)	Per capita availability	
			kg per year	g per day
1981	53.7	2218.9	41.3	113
1982	55.9	2418.6	44.0	121
1983	56.3	2621.6	46.7	128
1984	57.4	2522.5	43.9	120
1985	58.7	2970.9	50.6	139
1986	59.9	2686.9	44.9	123
1987	61.1	3033.4	49.6	136
1988	62.5	3000.1	48.0	132
1989	63.7	3004.2	47.1	129
1990	64.4	3237.5	50.3	138
1991	66.2	3319.2	50.1	137
1992	67.8	3308.7	48.8	134
1993	69.3	3397.5	49.0	134
1994	71.0	3590.4	50.5	139
1995	72.5	3915.0	54.0	148
1996	73.7	4069.0	55.2	151

Note: Total production includes pulses.
Source: Population was obtained from General Statistics Office, various issues, total supply from the data used in Table 3, and exports from Table 5.

Consumption

Average consumption of vegetables in 1987-89 was 125 g per day, which about matches the availability figures, although this allows for relatively low losses from farm to household. The average daily intake varies greatly across regions (Table 7 and Table 8).

Table 7. Average vegetable consumption, 1987-89 (g per capita per day)

Ecoregion	Sample size	Pulses	Vegetables	Vegetable tubers
North Mountain and Midland	2134	3.47	170.4	61.3
Red River Delta	5180	0.74	166.3	54.1
North Central Coast	1015	2.54	155.8	35.9
South Central Coast	1015	0.40	72.1	22.2
Central Highlands	199	0.00	144.4	22.8
Eastern Mekong Delta	1032	1.19	121.6	56.0
Mekong Delta	1077	5.40	64.3	50.0
Hanoi & Ho Chi Minh Cities	989	3.59	135.5	48.0
Vietnam (average)	12641	2.79	124.8	46.5

Source: National Institute of Nutrition Research (1992).

Table 8. Average per capita per day vegetable consumption (g) by ecoregion, 1978-89

Ecoregion	Upland	Lowland
Northern region	136	155
Southern region	120	90

Source: Same as Table 7.

Vegetable consumption patterns differ significantly between urban and rural areas. Unlike in other countries, the consumption of fruits and vegetables in Vietnam is lower in urban areas than in rural areas. This might be because of poor transport infrastructure and absence of formal marketing institutions. However, urban people compensate for the low fruit and vegetable consumption with higher consumption of livestock and fish products (Table 9).

Table 9. Food consumption by region (g per capita per day)

Foodstuff	Urban n = 1655	Rural n = 9153	Mountainous n = 1634	Overall Vietnam n=12442
Rice	421.3 (53.5)	457.1 (57.1)	497.8 (57.1)	457.7 (56.7)
Other cereals	14.2 (1.8)	3.7 (0.5)	7.4 (0.9)	5.6 (0.7)
Tubers	11.8 (1.5)	47.4 (5.9)	38.8 (4.5)	41.5 (5.1)
Beans & peas	2.4 (0.3)	1.6 (0.2)	4.0 (0.5)	2.0 (0.3)
Tofu	16.5 (2.1)	4.9 (0.6)	8.7 (1.0)	6.9 (0.9)
Nut & sesame	4.2 (0.5)	3.0 (0.4)	9.4 (1.1)	4.0 (0.5)
Vegetable leaves	108.5 (13.8)	145.2 (18.1)	169.0 (19.4)	143.4 (17.8)
Vegetable tubers	39.4 (5.0)	49.4 (6.2)	68.4 (7.9)	50.6 (6.2)
Fruits	10.2 (1.3)	1.2 (0.2)	0.2 (0.0)	2.3 (0.3)
Sugar	1.8 (0.2)	0.3 (0.0)	0.1 (0.0)	0.5 (0.1)
Sauces	22.3 (2.8)	30.2 (3.8)	23.5 (2.7)	28.3 (3.5)
Oil & fat	6.4 (0.8)	2.6 (0.3)	2.7 (0.3)	3.1 (0.4)
Meats	49.3 (6.3)	13.7 (1.7)	28.5 (3.3)	20.4 (2.5)
Eggs & milk	9.6 (1.2)	1.4 (0.2)	2.0 (0.2)	2.6 (0.3)
Fish	62.2 (7.9)	29.3 (3.7)	8.1 (0.9)	30.9 (3.8)
Other aquatics	7.8 (1.0)	8.8 (1.1)	1.8 (0.2)	7.7 (0.9)
Total	787.9 (100.0)	799.8 (100.0)	870.4 (100.0)	807.5 (100.0)

Source: Same as Table 7.
Numbers in parentheses are the percentage shares of the total food consumed.

Vegetable consumption increases with increase in income. For example, average annual per capita consumption is 53 kg for the lowest income group and 147 kg for the highest income group (Table 10).

Table 10. Vegetable consumption by income group

Monthly income (x1000 dong/month)	Per capita vegetable consumption	
	g/day	kg/year
< 300	144	53
300 - 600	239	87
600 - 900	376	137
900 - 1200	327	119
1200- 1500	367	134
> 1500	402	147

Source: Khiem (1996).

Seasonality in Prices

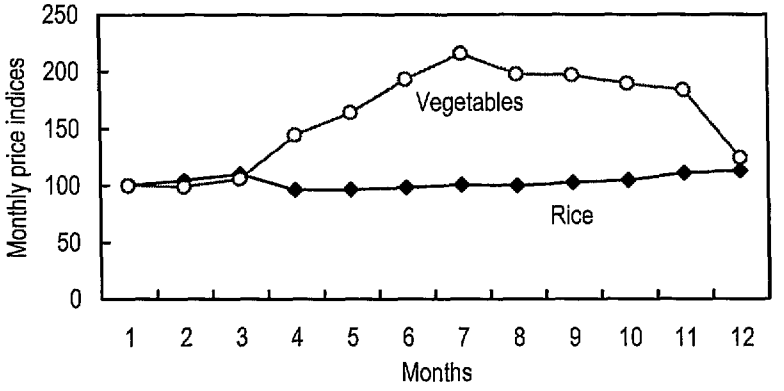
As noted earlier, vegetables are abundant in winter, and are in short supply during summer. The seasonal nature of vegetable production combined with short shelf life leads to seasonal fluctuation in vegetable prices. Vegetable prices in Hanoi are generally low in January-February, except for lettuce, which is cheapest in September. The prices are generally high during the summer months, except for eggplant, which is most expensive in November (Table 11).

Table 11. Seasonality in selected vegetable prices in Hanoi (average of 1990-93)

Vegetables	Months of		Seasonality
	Maximum price	Minimum price	
Cabbage	June	January	111
Cauliflower	July	January	86
Chinese cabbage	September	January	229
Eggplant	November	February	66
Lettuce	May	September	224
Mustard	September	January	111
Tomato	July	January	111
Overall vegetables	July	January	107
Rice	November	January	46

Source: Estimated from data obtained from official file of Central Price Commission, Hanoi.

Prices of vegetables taken as a group, are more seasonal than cereal crops such as rice (Fig. 4). The high seasonality of vegetable prices affects supply, and thus has serious implications for the consumption of vegetables and micro-nutrient supply.

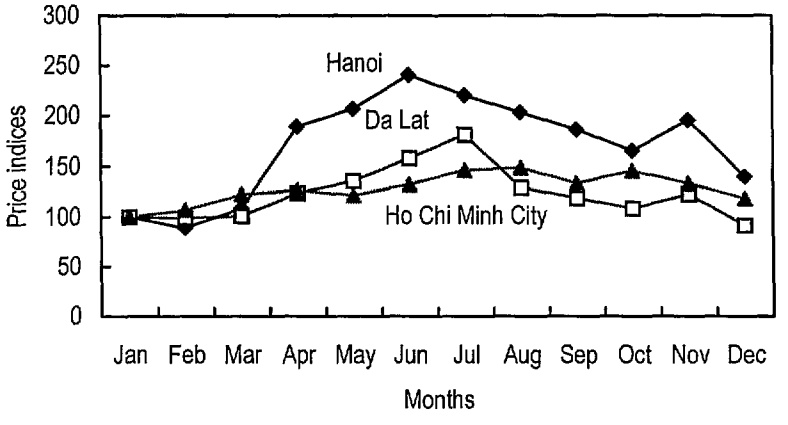


Source: Estimated from data obtained from official files of Central Price Commission, Hanoi.

Fig. 4. Monthly seasonal prices of vegetables (as a group), and rice in Hanoi market (average 1990-93)

The extent and incidence of seasonality varies across regions in Vietnam (Fig. 5). For example, the prices of vegetables in Hanoi show the largest variation, reflecting strong seasonality in production in the region. On the other hand, price seasonality is less pronounced in peri-urban areas of Ho Chi Minh City, because of the more widely spread cropping seasons and availability of vegetables from adjacent upland areas, such as Da Lat.

The highest vegetable prices are in June in Hanoi, in August in Ho Chi Minh City, and in July in Da Lat (Fig. 5). Thus, there is some possibility of reducing seasonality in prices through regional trade. However, careful analysis of the seasonal price trend of individual vegetables in each region would be required.



Source: Estimated from data obtained from official files of Central Price Commission, Hanoi.

Fig. 5. Seasonality in overall vegetable prices by region (average of 1990-93)

Inter-regional Comparison of Vegetable Cultivation

Given the availability of data and importance of commercial vegetable production, the two peri-urban vegetable production systems around Hanoi and Ho Chi Minh City are analyzed in this section. A summary of a rapid survey in Da Lat done by the senior author, intensive surveys conducted in the Mekong Delta by Can Tho University and in Ho Chi Minh City by AVRDC are the basis of this analysis. As these surveys were done almost at the same time, the information generated by these surveys also provides an interesting inter-region comparison.

Farming Practices

Ho Chi Minh City. Characterization of peri-urban vegetable cultivation near Ho Chi Minh City was done by AVRDC in collaboration with the University of Agriculture and Forestry of Ho Chi Minh City (Jansen et al. 1995). The study found that a total of 26 different vegetable species were grown by the sample farmers. A majority of them grew 2-3 varieties. Cabbage, common bean, cauliflower, and tomato were the most commonly grown vegetables in the area. The distinct wet and dry seasons create seasonality in the availability of vegetables.

Mekong Delta. Commercial vegetable areas in Tien Giang province supply vegetables to Ho Chi Minh City. These traditional vegetable areas have high cropping intensity, grow 5-6 crops per year, and have access to good irrigation.

About 2,000 ha of cabbage are planted yearly in the Mekong Delta. KK Cross and Newtop, both hybrids, are the dominant varieties. Cabbage is harvested throughout most of the year (except for August-October because of high rainfall). The main crops of cabbage, however, are planted during November-January and harvested during January-April.

More than half of the tomato-sown area in the Mekong Delta (about 2,000 ha) is concentrated in Tien Giang province. Different local varieties of tomato are used for making salad, sauce, and ketchup.

About 2.78 t of radish seed is imported to the Mekong Delta annually (from Hong Kong and Thailand), for a planted area of 1,500 ha, of which 600 ha is in Tien Giang province. Yield of sample farms averaged 42.7 t/ha. The main season for radish in the Mekong Delta is October-March.

The most popular cucurbit grown in the Mekong Delta is cucumber, which is planted on about 1,500 ha, giving annual output of about 30,000 t. Tien Giang has the largest area share (500 ha).

Input Use

Ho Chi Minh City. Vegetable farmers in Ho Chi Minh City apply 4-82 t/ha of organic material, consisting of animal manure and compost. In addition, the average quantity of chemical fertilizers applied is as high as 1.8 t/ha, or more than 900 kg of soil nutrients (Table 12). Leafy vegetables receive a much lower dose of chemical fertilizer. Pesticide use is largely limited to insecticides; herbicides are not used. Insecticides of the organophosphate group (methamidophos, methylparathion, monocrotophos, phentoate, zolone, diazinon, profenophos), pyrethroids (cypermethrine, decamethrine, fenvelerate, esfenvalerate), and bacterine (*bacillus thuringiensis*) are most commonly used.

Table 12. Input quantities (unit/ha) used in major vegetables and rice in Vietnam, 1992

Crop	Labor[1] (days)	Fertilizer (kg nutrient) N	P	K	Total	Manure (t)	Pesticide (000 dong)	Reference
Angled loofah	242	370	21	88	479	34.8	35	Jansen et al.
Bottle gourd	326	379	18	6	403	54.2	60	(1995)/
Bitter gourd	462	189	80	23	292	31.4	123	Ho Chi Minh
Cabbage	470	212	75	90	377	40.7	240	
Cauliflower	417	235	66	55	356	49.8	186	
Common bean	440	156	48	68	272	29.8	104	
Cucumber	256	120	58	53	231	25.4	69	
Eggplant	231	654	98	178	930	82.1	276	
Garland chrys.	503	76	-	-	76	21.9	51	
Indian cabbage	517	66	-	-	66	13.3	9	
Indian spinach	588	83	42	14	139	18.5	13	
Lady's finger	620	269	64	30	363	15.5	137	
Leafy amaranth	505	140	-	-	140	14.8	9	
Lettuce	519	73	-	-	73	16.6	21	
Mustard	537	61	42	14	117	12.0	13	
Radish	374	96	32	13	141	4.1	59	
Tomato	403	211	56	48	315	39.2	140	
Yard-long bean	575	126	24	36	186	25.9	107	
Cabbage	408	-	-	-	850	2.0	73	Can Tho University
Coriander	484	-	-	-	192	-	3	(1995)/Mekong
Cucumber	333	-	-	-	800	1.0	52	Delta
F. mustard	298	-	-	-	214	1.8	27	
Garland chrys.	549	-	-	-	366	-	61	
Lettuce	304	-	-	-	200	1.0	10	
Pechay	303	-	-	-	350	1.5	65	
Radish	421	-	-	-	582	2.0	29	
Tomato	399	-	-	-	450	2.0	60	
Watermelon	326	-	-	-	644	-	92	
Rice	48	-	-	-	210	2.8	-	IRRI (1995)

- implies that data are not available.
[1]Includes family labor.

Dependence on imported seeds is high for some vegetable species. KK cross (Takii, Japan) and Newtop dominate the cabbage market. Radish and mustard seeds from Choi Hing Lee Seed Co., Wong Yuan Shing, and Chan Man Hop (Hong Kong) are popular among growers.

Most vegetable crops require 200-600 labor days per ha compared to only 48 labor days for rice. Therefore, vegetable cultivation can generate substantial additional employment important for growing economies, such as Vietnam, although the negative environmental and resource sustainability consequences of high chemical use should be carefully watched.

Da Lat. The vegetable production system in Da Lat is the most intensive in the country. Informal diagnostic survey suggests that average labor use per ha is in the range of 300-800 person days. Farmers apply 500-1100 kg/ha of chemical fertilizers, and 2-4 t/ha of animal manure. Besides chemical fertilizer and manure, farmers also use large amounts of fish manure – a byproduct of fish sauce – which has a high salt content. After two or three crops, salt accumulation seriously deteriorates the soil productivity. Thus, the topsoil of vegetable beds must be replaced after about two years, which is a costly proposition.

Mekong Delta. A total of 300-400 person days per ha, made up of family and hired labor, are used on various vegetables, while per hectare fertilizer use ranges from 200 kg for lettuce to 850 kg for cabbage. In addition, farmers apply 1-2 t of farm manure. The use of farm manure is relatively low, while chemical fertilizer use is relatively high in the Mekong Delta compared to Ho Chi Minh City. Pesticide use in the Mekong Delta is also relatively low (Table 12).

Yields

Average yield of vegetables in the peri-urban areas of Ho Chi Minh City ranges from 10 to 21 t/ha, except for cabbage, radish, and eggplant (the average yields of these range from 30 to 65 t/ha) (Table 13). The yields of leafy vegetables are higher in Ho Chi Minh City, while temperate vegetables, such as tomato, cucumber, and radish, produce higher yield in the Mekong Delta.

Costs and Returns

Vegetable cost per hectare range from 4 to 11 million dong, compared to 2 million dong for rice. As noted before, input use in the Mekong Delta is lower than in the Ho Chi Minh City area, leading to lower per hectare cost of vegetable production in the former than in the latter place (Table 13).

Because of their proximity to market, farmers in the Ho Chi Minh City area have better access to price information and therefore are generally able to earn a higher price for a vegetable than are farmers in the Mekong Delta. The price difference can also be due to the difference in time of the year when vegetables are supplied from each area. However, farmers in the Mekong Delta generally can produce vegetables at a lower per unit cost than can farmers in the Ho Chi Minh City area. Except for lettuce, garland chrysanthemum, and radish, the benefit-cost ratios for vegetables are higher in the Mekong Delta than in the Ho Chi Minh City area (Table 13).

The benefit-cost ratios for vegetables are positive (yard-long beans being the only exception). The benefit is less than 25%, normally considered to be low, in many vegetables in Ho Chi Minh City.

Based on per unit cost of production, common beans, bitter gourd, yard-long bean, and coriander have relatively high per unit cost of production.

Table 13. Per hectare economics of vegetable cultivation in Ho Chi Minh City and Mekong Delta, 1992

Vegetable	Y0ield (t)	Price (Dong/kg)	Gross revenue (0000 Dong)	Total cost[1] (0000 Dong)	Net revenue (0000 Dong)	B-C ratio	Cost/kg (Dong)	Reference
Angled loofah	15.0	421	632	604	28	0.05	403	Jansen et al.
Bitter gourd	10.8	1295	1399	1205	194	0.16	1116	(1995)/
Bottle gourd	21.1	583	1230	637	593	0.93	302	Ho Chi Minh City
Cabbage	30.0	736	2208	1111	1097	0.99	370	
Cauliflower	17.5	1354	2370	956	1414	1.48	546	
Common bean	9.3	1239	1152	1024	128	0.13	1101	
Cucumber	13.3	703	935	775	160	0.21	583	
Eggplant	65.1	567	3691	1665	2026	1.22	256	
Garland Chrys.	15.7	1979	3107	966	2141	2.22	615	
Indian cabbage	14.1	729	1028	702	326	0.46	498	
Indian spinach	16.9	753	1273	912	361	0.40	540	
Lady's finger	19.3	692	1336	1102	234	0.21	571	
Leafy amaranth	13.0	796	1035	797	238	0.30	613	
Lettuce	17.6	1012	1781	800	981	1.23	455	
Mustard	13.6	789	1073	717	356	0.50	527	
Radish	36.2	297	1075	662	413	0.62	183	
Tomato	17.1	1013	1732	860	872	1.01	503	
Yard-long bean	10.1	779	787	921	-134	-0.15	912	
Cabbage	23.2	680	1578	530	1048	1.98	228	Can Tho
Coriander	6.3	1940	1222	561	662	1.18	890	University
Cucumber	19.9	646	1286	690	595	0.86	347	Survey (1995)/
Garland Chrys.	11.4	1875	2138	838	1299	1.55	735	Mekong Delta
Lettuce	10.7	434	464	384	80	0.21	359	
Mustard	13.6	600	816	417	399	0.96	307	
Pechay	17.3	380	657	465	192	0.41	269	
Radish	42.7	283	1208	774	435	0.56	181	
Tomato	22.9	1160	2656	810	1846	2.28	354	
Watermelon	22.8	601	1370	554	817	1.47	243	
Rice	3.3	3838	301	214	87	0.41	632	IRRI (1995)

[1] Total cost includes labor and nutrient import cost.

Factor Share

Labor is the most important factor in vegetable production, consuming a share ranging from one-third to three-fourths of the total cost (Table 14).

Table 14. Factor share (%) in total cost

Vegetable	Seed	Fertilizer	Insecticide	Labor[1]	Others[2]	Total cost (Dong/ha)	Reference
Angled loofah	3.8	45.7	5.8	40.0	4.6	604	Jansen et al.
Bitter gourd	7.8	27.5	10.2	38.3	16.2	1205	(1995)/Ho Chi Minh City
Bottle gourd	*	37.2	9.4	51.2	2.2	637	
Cabbage	6.8	25.1	21.6	42.3	4.2	1111	
Cauliflower	5.2	24.8	19.4	43.6	6.9	956	
Common bean	3.5	31.1	10.2	45.8	9.5	1024	
Cucumber	5.3	48.8	8.9	33.0	4.0	775	
Garland chrys.	15.6	27.0	5.3	52.1	0.0	966	
Eggplant	*	33.3	16.6	36.4	13.8	1665	
Indian cabbage	*	25.1	1.3	73.7	0.0	702	
Indian spinach	6.6	27.5	1.4	64.5	0.0	912	
Lady's finger	0.8	23.7	12.4	56.3	6.8	1102	
Leafy amaranth	8.9	26.6	1.1	63.4	0.0	797	
Lettuce	4.1	28.4	2.6	64.9	0.0	800	
Mustard	*	23.3	1.8	74.9	0.0	717	
Radish	10.7	16.6	8.9	56.5	7.2	662	
Tomato	1.9	27.7	16.3	46.9	7.3	860	
Yard-long bean	2.7	19.4	11.6	62.4	3.8	921	
Cabbage	6.4	28.6	9.0	53.9	2.1	8087	Can Tho University
Coriander	10.9	9.5	0.5	77.0	2.1	5605	Survey (1995)/
Cucumber	4.5	31.9	7.6	53.9	2.1	6903	Mekong Delta
Field mustard	3.9	14.1	6.4	72.6	3.0	4171	
Garland chrys.	12.3	12.0	7.3	66.6	1.8	8382	
Lettuce	6.1	12.9	2.1	75.2	3.7	3843	
Tomato	1.1	23.6	11.4	61.0	2.9	5298	
Pechay	5.5	22.1	14.1	55.6	2.8	4644	
Radish	6.7	20.7	3.8	65.7	3.2	7735	
Watermelon	3.0	32.7	16.9	44.6	2.8	5537	

[1] Includes family labor evaluated at the average wage rate in the area at the time of survey on all sample farms.
[2] Others include fuel charges, irrigation cost, and/or tax.
* implies no seed cost because seed was saved from the previous crop in these cases.

Fertilizer is another important input in terms of its share of total cost, ranging from 9 to 49% (more than 20% for most crops).

Insecticide accounts for 1-22% of the total cost of production. About half of the crops in Ho Chi Minh City and one-third in the Mekong Delta have pesticide factor shares measured in double digits. Technological development for prudent use of insecticide would reduce cost, help save the environment, and safeguard the health of consumers and producers.

Marketing Systems

Production and marketing systems of vegetables as well as other important crops in Vietnam during the period 1975-93 were dictated by the policy. Prior to market policy reform, marketing service was done by state companies. To secure the vegetable supply to Hanoi, the Vegetable and Fruit Company went into contract with cooperatives in surrounding areas. In return, the company ensured the supply of staple food and necessary inputs to the cooperative farmers. Vegetable supply was not generally decided by demand but by the plan of the state vegetable marketing company.

De-collectivization policy has given individuals the freedom to make decisions on crop production. The role of cooperatives and the Vegetable and Fruit Company has diminished. Small vegetable growers either directly bring their products to retail markets in Hanoi or sell to small vegetable dealers. Since most of the vegetable growing areas are close to Hanoi, bicycles are the most common means of transport. Very early in the morning, farmers bring their produce to Hanoi markets or sell as street venders and return home in late afternoon.

Marketing systems servicing Ho Chi Minh City are more developed. Before 1975, private vegetable dealers bought fresh vegetables from growers or local dealers in Da Lat and sold them in Ho Chi Minh City. After 1975, state companies took over most of the role of private dealers and monopolized the means of transport. Market reforms in the mid 1980s again permitted the operation of private markets. Local dealers buy produce from individual growers, or vegetable growers bring their produce on three-wheel vehicles or carts to collection sites for sale to wholesalers. The wholesalers then truck the produce to wholesale markets in Ho Chi Minh City. Sorting, cleaning, and packaging are usually done at the collection sites. Da Lat supplies about 150 t of fresh vegetables to Ho Chi Minh City every day.

Besides Da Lat, there are important vegetable collection points in the surrounding provinces of Ho Chi Minh City. Tan Hiep district in Tien Giang province in the southwest, about 50 km away from Ho Chi Minh City, is a traditional vegetable collection point and wholesale market. Among the important wholesale markets in Ho Chi Minh City are Cau Ong Lanh Market for vegetables coming from Da Lat, provinces in the Mekong Delta, and surrounding districts of the city; Hoc Mon Market handles vegetables grown in the district and Cu Chi, Tay Ninh province.

Research and Development

The Fruits and Vegetables Research Institute (RIFAV) located in Hanoi and founded in 1992, coordinates the research work with three experiment stations located in different parts of the country. Vegetable breeding programs at the National Agriculture Science Institute, the Plant Breeding Institute, and the Southern Institute for Agricultural Sciences are the key institutes engaged in crop improvement. These institutes have selected 17 new varieties of which 12 varieties (4 tomato, 2 cabbage, 1 leafy cabbage, 1 cucumber, 2 tuber crops, 1 watermelon, and 1 eggplant) have been developed and released to farmers. However, adoption of these varieties is relatively limited (Chuong 1995).

RIFAV is collaborating on a multilateral vegetable research and development program with AVRDC, which pools the technical know-how and financial resources in the Mekong region. The emphasis is on integrated pest management, disease resistance, socioeconomic studies, and training. RIFAV is also engaging in another collaborative peri-urban vegetable production program with the French

government and AVRDC. Here the emphasis is on understanding the marketing and production constraints in the peri-urban areas of Hanoi, introducing off-season vegetable production technologies, and reducing pesticide use on vegetables. It is expected that these programs will bring enough technical expertise to boost the vegetable sector in the country. However, Vietnam needs to make a big investment to develop a critical mass of researchers and technicians to interact with international scientists, absorb technical know-how, and adapt new vegetable production technologies.

Luckily, Vietnam has a history of cooperative farming. And although communes have been abolished, cooperative sprit remains. With proper support from the government, this spirit could be transformed into formal cooperatives. These cooperatives could be instrumental in reaching farmers and diffusing technological innovations.

Much needs to be done in crop management research. Researchers need to understand the current management practices used by farmers. The major constraints in various ecoregions need to be documented. Only then can new technologies be adapted, consistent with farmers' practices and socioeconomic environments. The comparative advantages of various vegetables in various regions need to be understood. For all this, researchers need to adopt a multidisciplinary approach, and the socioeconomic side of vegetable research needs to be strengthened.

Summary and Conclusions

Vegetable production in Vietnam has grown during the last 20 years, mainly through expansion in area. However, the trend should be carefully interpreted. Under collectivization, a large proportion of vegetables were produced on individual farms, i.e., the land that cooperatives allotted to its members for family production (e.g., about half of the vegetables planted in the northern provinces were in such plots). These farms were free from tax and other obligations to the state, and no records were kept. Therefore, increase in vegetable area seen in the post-reform period might be due to the inclusion of individual plots in the statistics.

The main concern is the stagnation in vegetable yield during the last 20 years. Varietal development of vegetables needs support from research institutions. Vegetable farmers depend on imported seed for most major commercial vegetable crops, or use locally or home produced seeds which are of inferior quality . Breeding efforts have been concentrated on cabbage and tomato, but other vegetable species are neglected. Suitable seed production areas, especially the temperate Central Highlands and the northern region in the cool dry months, need to be exploited.

Problems related to efficiency of farming practices, such as fertilizer application and pest management, especially in intensive production systems, are important technical constraints. Indiscriminate use of pesticides is a major concern of consumers. Investment in production of clean vegetables and in bio-organic farming would promote exports and protect the health of consumers. Research in efficient pest management and selection of resistant varieties, combined with extension programs, should be a priority in vegetable research. Besides the pest-related problems, soil and irrigation management are crucial issues for sustainable vegetable production, especially in commercial and suburban areas. Control of soil erosion and the negative effects of high-salt-content fish manure in the Central Highlands are major researchable issues.

Establishment of commercial production centers in peri-urban areas was principally influenced by

policy that encouraged local self-sufficiency. Liberalization has allowed individual farm households to make decisions on resource allocation, crop choice, and crop management practices. This has facilitated the diversification process (Khiem 1994). The effect of liberalization on vegetable production and diversification of production systems needs to be quantified.

The price index of vegetables increased at almost the same pace as the food crop price index during the first few years after the price system was liberalized in 1986. Afterwards, the vegetable price index increased at a faster rate. Rising real prices will put vegetables out of the reach of poor people in Vietnam.

On the other hand, the low and variable vegetable prices are an important constraint in vegetable production. Price variation was cited as a new phenomenon by farmers used to government-fixed prices. Lack of processing and postharvest facilities, and lack of market information aggravate this problem.

Priority has been given recently to expansion of production during the winter/spring season, especially in the Red River Delta and in the temperate region of the Central Highlands. The economic policy reforms have also induced foreign investment and technology transfer in vegetable production in these areas, especially for export. However, the main issue is the relative economic feasibility of upland versus lowland production systems. In the former case, investment is needed in transport facilities, such as roads, refrigeration, cold storage, etc., while in the latter case, investment in research is required to adapt temperate vegetable production technologies to the tropical environment. The evaluation of these systems should include direct costs, such as fertilizer, manure, labor, water, land, and transportation, as well as indirect costs of vegetable production, such as soil erosion, pollution of the watershed due to high pesticide use in the upland areas, and pollution due to hauling produce long distances.

Lack of processing facilities leads to high spoilage of vegetable produce and low prices to farmers during the peak season. This results in high marketing cost on one hand, and discourages farmers to engage in vegetable production on the other. Marketing institutions and organizations must improve, so must the supply of marketing information. This is particularly important as vegetable production moves toward a free market system. There is a serious lack of new market institutions to replace the old style collective institutions.

Lack of coordination among the institutions involved in vegetable research and lack of investment by the central government in these institutions are among the serious bottlenecks holding back vegetable development in the country.

The procedures for collecting data need to be updated and properly documented. Individual vegetable crop information at the regional level needs to be documented in the national statistics. Regional data on vegetable cost, farm management practices, marketing functions, and losses, etc., are missing. Resource allocation for the development of the vegetable industry, both in the private and public sectors, cannot be planned without such data regularly available.

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