

China and India: A Comparative Perspective on Fertilizer Policy Require- ments for Long-Term Growth and Transitional Needs

Bruce Stone and Gunvant M. Desai

Reprinted from
*China's Rural Development Miracle,
with International Comparisons*
edited by John W. Longworth,
University of Queensland Press, 1989

INTERNATIONAL
FOOD
POLICY
RESEARCH
INSTITUTE

1771 Massachusetts Avenue, N.W.
Washington, D.C. 20036, U.S.A.

**CHINA AND INDIA:
A COMPARATIVE PERSPECTIVE ON FERTILIZER POLICY
REQUIREMENTS FOR LONG-TERM GROWTH AND
TRANSITIONAL NEEDS**

*Bruce Stone and Guntant M. Desai
International Food Policy Research Institute (IFPRI),
Washington DC, USA*

INTRODUCTION

Since the late 1970s, China and India have emerged as dominant forces in the world fertilizer market. Between 1978-79 and 1984-85 they accounted for 50 to 55% of the growth in world consumption and imports, and nearly one-third of the growth in world production. Their contribution to growth of fertilizer consumption, production and imports in the developing world was 70%, 53% and 85%, respectively.

Both India and China are now at a point where some of the policies and institutions which have been reasonably successful in bringing fertilizer use to its current level are no longer appropriate. It is important to distinguish between those elements which can and must continue to be successful and new initiatives which must be developed with much greater vigour if fertilizer use is to continue to play a key role in rural development and technological transformation of agriculture. It is especially important that short-term palliatives, such as price adjustments and subsidies, not be allowed to jeopardize the long-term basis for efficient growth by consuming resources needed to establish that basis.

The next section discusses the limitations of standard techniques for analyzing the growth in fertilizer use in developing countries (especially those characterized by substantial governmental planning) and briefly presents an alternative approach. The succeeding two sections summarize the results of applying this approach to analyzing the long-term growth performance of China and India respectively, and identify some major policy issues facing the two countries. The last section emphasizes lessons from the Chinese and Indian historical experiences and concludes with implied policy orientations.

ANALYSIS OF GROWTH OF FERTILIZER USE IN DEVELOPING COUNTRIES*Limitations of standard techniques*

To understand forces behind growth of fertilizer use in developing countries and the role of public policies, it is necessary to depart from the standard techniques used to examine causes behind short-term changes in fertilizer use in developed market economies. The principal shortcomings of these techniques are implicit assumptions of nationally integrated competitive markets (for fertilizers, farm products, credit etc.) and 'free' play of market forces. Yet a dominant feature of developing countries is the underdevelopment of such markets. Likewise, a defining characteristic of countries like China and India is that such markets are predominantly administered. Hence supply and demand do not equilibrate in the fashion described by standard neo-classical economic theory.

Studies estimating the influence of policy upon fertilizer use (or upon agricultural production through fertilizer use) often focus on prices of fertilizers and farm products via their equilibrating function in well developed markets. Supply equations are frequently ignored and fertilizer prices are wholly exogenous variables appearing in demand equations, since the supply of fertilizer may often be justifiably assumed to be virtually unlimited at a given price from the point of view of micro-economic units. When supply functions are incorporated into macro-economic studies of somewhat longer term, it is often in the context of equilibrium models where supply and demand eventually clear. When information, credit and insurance markets are incorporated, some rather sophisticated processes may be assumed.

These assumptions are generally inappropriate for developing countries, and more so for countries like China and India. Despite recent efforts to allow and encourage the development of markets, the Chinese economy is still one in which governmental planning at the national, provincial and local levels remains a dominating feature. Moreover, the nascent development of 'free' markets is at a far more primitive level in China than in many other (even developing) countries. Although India's private market development is considerably more advanced than China's, it is clearly a developing country in terms of market infrastructure and operation. Moreover, governmental planning and involvement of the state are more pervasive in the Indian economy than in developed market economies.

It is not that prices and equilibrating forces of aggregate supply of and demand for fertilizer are unimportant in developing countries. But a far more complex array of processes governing fertilizer use cannot be ignored. Also, in the evolution of these processes and the environment under which they operate, the state plays a decisive role (Desai 1979, 1988, Desai and Mellor).

An alternative approach

Growth of fertilizer use in developing countries may be viewed as an outcome of the development and interactions among four sets of processes, and changes in the operating environment which influence the progress of the processes and interactions among them. The four sets of processes are those which: (i) influence the agronomic potential for fertilizer use; (ii) convert the potential into farmers' effective demand for fertilizers; (iii) determine the growth of aggregate fertilizer

supply; and (iv) develop the fertilizer distribution system and determine the allocation of fertilizers among farmers. The progress of these processes and interactions among them are largely influenced by three major elements in the operating environment, namely prices, cropping patterns, and national objectives.

These four processes and the interaction with the three major elements of the environment have been discussed elsewhere (Desai 1986a, Desai and Stone). This alternative approach to fertilizer use in developing countries will now be applied to China and India.

CHINA

During the first year of the People's Republic (1949), China produced only six thousand tons of nutrients from manufactured fertilizers and had little foreign exchange to finance imports. By 1952, production had risen to 39 thousand tons with total application of twice that amount, but this averaged only 0.6 kg per sown hectare, all of it nitrogen. During each of the three years to 1986, application rates have averaged 120-130 kg of nutrient per sown hectare for a total of 18 million annually, with more than a dozen different fertilizer mixtures in common use.

Fertilizer use in China complements irrigation facilities which cover 45% of cultivated area and a sophisticated system for breeding, adapting, producing, and disseminating locally suitable high yielding and stress tolerant crop varieties. The growth in fertilizer use has been instrumental in providing increased quantities of staple crops per capita despite the doubling of the Chinese population. Growth in fertilizer use has been of paramount importance during the last decade when staple foodcrops production grew from 285 million metric tons to exceed 400 million tons. The production growth rates for oil crops, sugar crops, cotton and other fibers, vegetables, fruit, tea, tobacco, and other crops were even faster in proportional terms. During this period, use of manufactured fertilizer nutrients more than tripled and there was a shift toward higher quality and more diverse products.

Further intensification of fertilizer use will continue to be important to achieving requisite agricultural growth in the coming decades. Yet the pattern of growth is undergoing a profound transition in China, requiring modified policy, institutional, and public investment orientations. A brief examination of past growth will both help explain how China was able to grow so quickly during the last 38 years (especially the last decade) and provide the basis for understanding China's current position and the nature of the required adjustments.

A perspective on past growth of fertilizer use

China's relatively rapid growth in fertilizer use implies generally better handling of the four fundamental processes than most other developing countries have been able to manage (Stone 1986a, Desai and Stone, Stone and Desai). Yet even Chinese growth could have proceeded more rapidly. Of the four processes, it appears to have been primarily aggregate supply of fertilizers which was most chronically constraining. Had foreign exchange been allocated for fertilizer imports at a more rapidly increasing rate, had domestic capacity construction proceeded more quickly, and particularly, had the decision to invest in large scale

efficient plants for producing high quality fertilizers been undertaken earlier, the other three processes were sufficiently robust to have allowed faster growth in fertilizer use and farm production.

This is partly because the agronomic potential for fertilizer use was already so high in China in the 1950s. With long experience in water control, China in the 1930s had a greater proportion of area irrigated than did most developing countries, and this infrastructure was recovered and complemented during the 1950s. Chinese farmers in the major traditional growing areas were very sophisticated in pre-industrial agronomy and their techniques were transferred to other less developed agricultural areas by the research, extension and administrative establishments. In particular, Chinese farmers used unprecedented quantities of organic manures which often supplied a full complement of nutrient requirements while preserving organic content and other structural properties. The tradition of careful use of manures made the transition to manufactured fertilizers relatively easy in China, and simplified the process of rapid growth through the early to the middle stages: since complementary nutrients were supplied with organic materials, growth in the use of manufactured fertilizer could proceed a long way on the basis of nitrogen alone, since nitrogen evaporated from China's principal manure components.

Not only was China's agronomic potential already high in the 1950s, but it grew rapidly with aggressive investments in water control, meteorology and agricultural research. By the late 1970s, high yielding fertilizer-responsive varieties covered 90-95% of rice area, 60-70% of maize and wheat area, a large proportion of sorghum area, with much of the remaining land sown with fertilizer-responsive root, tuber, and sugar crops.

A broad distribution network was established which provided the possibility of moving fertilizers to most growing areas in China, while concentrating distribution in high and stable yield areas, with the greatest potential for increasing crop production and marketings through fertilizer use. Production and income risks which have chronically inhibiting growth in fertilizer use in many countries, were ameliorated through communal accounting. In addition, as already mentioned, the initiation of fertilizer use required a relatively small leap in understanding for manure-conscious Chinese farmers. Farm product market risks were reduced with aggressive guaranteed purchase plans at prices which remained stable for long periods. Since the government became the monopoly buyer and seller of foodgrains, there was reduced resistance to governmental persuasion in dynamic marketing areas to adopt HYVs. Credit scarcity as an inhibition to fertilizer purchase was obviated with the expedient of allocating fertilizers directly to farmer groups promising increased sales, then deducting the fertilizer costs from the sale value of farm goods after harvest. Meanwhile, restrictions on mobility, asset and product markets, and on non-agricultural economic activities removed much of the opportunity cost of investing in agriculture. And within agriculture, fertilizer purchase was clearly a relatively high return investment, even at a relatively high price and in the face of low prices for farm products during most years since the 1950s.

Thus the system was well set up to absorb exceedingly large volumes of nitrogen at a rapid rate (although some of the components of this system caused considerable hardship and stultified rural economic growth in other ways). But although China's domestic production and imports of nitrogen fertilizer grew

more rapidly than in almost all countries, nitrogen absorbed by crops did not grow quickly enough, bringing about long-term decline in average marketed ratios, income stagnation in major growing regions despite favorable price adjustments, and eventually rural estrangement from government policies. This was partly because a reluctance to spend capital on the agricultural sector led China to emphasize fertilizer development during the 1960s and early 1970s based on small, locally financed factories producing aqueous ammonia and ammonium bicarbonate with low opportunity cost materials. Volatilization was a much greater problem with these products than with more typical nitrogen fertilizers, especially during the first decade of development, and especially within the nation's major growth region (i.e. North China). This meant that the agricultural system remained severely nitrogen-constrained until the large synthetic ammonia/urea complexes purchased in 1973-74 came on line in the late 1970s. This development coincided with a rapid increase in fertilizer imports of all major nutrients as advocated by the new administration, and with continued rapid expansion and some improvement in the quality of the fertilizers produced in small factories.

These developments on the aggregate supply side of the fertilizer market have been primarily responsible for the spectacular growth in staple foodcrop output since 1977 and an important cause of dynamism in the even faster growth for other crops. But if the aggregate supply of fertilizer was the primary constraining process until the last decade, what has enabled China to obviate the pitfalls and lethargy experienced by other countries with the other processes?

Shifting importance of fertilizer development to national objectives

The fact that China was so successful in ensuring that nothing impeded the use of the available aggregate supplies of fertilizer is a testament to the importance attached to rapid growth of fertilizer use and the number of national objectives it was perceived to serve in the Chinese strategy for development and survival, regardless of political vogue and immediate choice of tactics.

As a poor, populous country where arable land per capita was far below that of India, it was inevitable that development of fertilizer use would be the cornerstone of the fundamental strategy for agriculture. National power and prestige were discreet objectives which a dynamic agriculture was seen to serve, but a variety of other factors also contributed to focus national attention on agriculture.

In the 1950s, national security implied food self-sufficiency. The overwhelmingly dominant food exporter, the United States, was regarded as a hostile nation with a powerful navy engaged in active conflict with Chinese forces in Korea. The possibility of an American invasion was not considered remote, and even with peace in Korea, the threat of a trade blockade called for a fundamental strategy of self-sufficiency.

The Chinese Communist Party was far more rurally based in its origins than its Soviet and Eastern European counterparts. Yet urban prosperity was viewed as critical to political stability. A fundamental key to both rural and urban stability was secure provision of basic foodstuffs. There was also humanitarian concern because of the past experiences with frequent famines.

Although China's path was directed toward self-sufficiency, and Mao himself denigrated the value of, and especially dependence on international trade, foreign exchange was already recognized as an important constraint to industrial development. There was clear and consistent administrative resistance to squandering meager foreign exchange resources on food imports.

Contrary to prevailing rhetoric, agriculture has never been the principal focus of developmental attention. But agricultural growth was viewed as important for its fundamental contributions to industrial development. In addition to easing foreign exchange constraints, agricultural development was seen as the key to savings generation both in urban and rural areas via low sustainable prices for food and agricultural raw materials. With growth in agricultural productivity, labour could eventually be released for further development of industry. Power and prestige were first and foremost associated with industrialized societies and the bulk of writing about the socialist utopia was conceived in terms of the new forms of social organization associated with industry. The importance of agricultural growth to industrial development was dramatized in the early 1960s when the agricultural depression sabotaged industrial growth and the entire level of non-agricultural economic activity (Stone 1986b, 1988).

As of the mid 1980s, this impressive confluence of national objectives favoring rapid growth in fertilizer use (which clearly contributed to rapid growth in agriculture, and to farm labour productivity advancements), has begun to disintegrate. Agricultural imports are already being sharply reduced and the prospects for farm export growth, particularly for cheaper bulk commodities, is justifiably viewed with some skepticism. Basic food security for urban areas has been maintained consistently for decades, and food stocks have increased to uneconomic levels even from the Chinese viewpoint, with the handling of farm surpluses becoming a major administrative headache (Stone 1985).

China is already viewed as a powerful agricultural nation and the focus of national interest and pursuit of prestige lies ever more completely in broader economic and technological objectives. Labour is already being withdrawn from crop production in volumes unprecedented in world history, and non-agricultural unemployment and labour absorption are issues of rapidly growing concern. The process of savings generation is now considered in a more sophisticated light, and agricultural savings are not considered of such critical importance for industrial capital formation. Can there be any wonder why pressure to increase agricultural output has waned, especially through fertilizer use which consumes foreign exchange, investment, energy and feedstock resources still in scarce supply? Why indeed should Chinese agriculture and fertilizer use continue to grow rapidly? This, of course, is the essential question for fertilizer intensification in China. Without a satisfactory answer, even institutional inertia will not continue to exert sufficient upward pressure to avoid a prolonged period of very slow growth.

There are several answers, the least important of which is that Chinese agricultural export potential, even in the current climate of trade restrictions, is probably underestimated by planners. China also may stand to gain considerable prestige and influence among developing nations by expanding her food aid programs. But most fundamentally, Chinese domestic demand is not actually satiated.

First, the humanitarian objectives are still relevant. Although the proportions have fallen substantially, China may still be the country with the largest absolute numbers of malnourished people.

Second, even excluding the chronically malnourished, a substantial amount of unsatisfied demand for basic foods still exists. This is because the level of infrastructural development and operation required for efficient functioning of nationally integrated markets is still far beyond China's current situation and because administered markets have been established around a principle of demand suppression rather than demand development. Among other implications, this orientation requires much larger holdings of food stocks at various levels and locations, with associated increase in costs, than would otherwise be necessary.

Why should China bother to develop effective demand? The most important answer, but one which is most difficult for Chinese planners to fully appreciate is that it is through the rapid development of both supply and demand for agricultural goods that the farm sector can make its most dynamic contribution to overall economic growth (Ishikawa, Mellor, Lee).

Finally, with increasing incomes, not only will middle and lower income segments of the population consume more basic foods, but the entire population will shift toward somewhat higher quality, and generally more fertilizer-intensive foods. Notable among these fertilizer-responsive, higher quality food items are sugar crops, vegetables and fruit. Conversely, an income-related shift in diet toward oil crops and pulses, will be more land-consuming, requiring higher yields on remaining land planted with other crops. Eating an increasing proportion of calories in the form of livestock products is also apt to create a more fertilizer-intensive consumption pattern. The net result of the sharp increases in incomes experienced recently will be greater quantities of fertilizer demanded to satisfy the increased demand for more and more fertilizer-intensive foods (Stone 1986a).

Because of the low level of private market development and the current retreat from administered markets, the national and even local equilibration of supply and demand for these products will be more difficult. And thus the conversion of the additional potential of fertilizer use into effective demand for fertilizers will be more constrained without concerted effort to create a favorable policy environment and some substantial public investments in building market-related infrastructure.

Major policy issues

In China's high fertilizer application areas, effective prices for absorbed fertilizer nutrients are not high by international standards, and average purchase prices for farm products are no longer particularly low. Yet there is continued pressure to adjust these prices in favour of farmers, because the marginal response to fertilizer use is low. This is because the intensity of fertilizer use in such areas is already high and approaches the agro-economic potential. Further growth in use without price adjustments must depend on: (1) a shift toward more fertilizer-intensive and higher valued farm products; (2) improved technical and economic efficiency in fertilizer use within existing cropping patterns by reducing waste and promoting more economic use; (3) continued upward shifts in existing crop production functions via technical change in areas other than, but related to fertilizer use (Stone 1986c).

Each of these developments is of course proceeding in China. Suburban farming areas, in particular, are producing a wider variety and larger volume of higher priced vegetables. Meat consumption is growing quickly, requiring a greater quantity of staple crops per unit of human caloric consumption. And fertilizer-intensive crops for production of edible oils and especially sugar are rapidly increasing both area and yield.

Fertilizer use efficiency is promoted through the extension system, via the recently completed national soil survey, the diversification of available fertilizer products, and with the development of fertilizer applicators, rapid incorporation methods and concentration on soil maintenance activities to reduce volatilization and denitrification losses. The rural reforms have encouraged farmers, who are often best able to evaluate their own situation, to choose how to maximize their incomes through individual and economic allocation of fertilizer among their crops. Although investment in basic irrigation structures has sharply declined, emphasis on completion of ancillary facilities for existing structures and water management reform, as well as continued work in seed breeding research, tend to shift upward the production function in high application areas (Stone 1985).

The important questions are whether there is sufficient and appropriate public sector support for these activities and whether the transitional problems to new, more suitable systems have been properly addressed. The answer, unfortunately, may be 'No' to both questions. How is this possible in a country that has grown faster in fertilizer use than almost all developing countries? There are five kinds of answers: (1) inertia suggests that systems which have been successful in the past will continue to be relied upon long after they have ceased to be useful; (2) as indicated above, the importance of public support for a more dynamic agriculture has been historically undervalued even in China, and its perceived importance has decreased with recent agricultural successes; (3) resources which might be devoted to the appropriate categories of public support are being squandered via price subsidies, to artificially support (a) increased fertilizer application among farmers with low marginal response rates, (b) inefficient production of low quality products, and (c) staple consumption of relatively well-off urban residents; (4) there is an enamourment with western economic principles and blind faith among some planners both within China and among the donor community that associated liberal reforms will solve all problems, without transitional difficulties; and (5) there is lack of appreciation of the crucial and financially demanding role of the public sector in market and demand development in rapidly developing countries, particularly in China which has oriented public policy for three decades more toward food supply growth alone and to the suppression of demand for food rather than its development (Lardy, Stone 1985, 1986 a&d, 1987, 1988).

The problem is that even a correct and aggressive policy and public investment orientation will be slow to achieve results. So what will provide rapid development of fertilizer use and agricultural production in the interim? Fortunately, the concentration of agricultural inputs in high application areas has been so extreme that a decade of rapid growth is possible through the shifting of increments to fertilizer supply toward the medium, and a portion of the low application areas (Stone 1986 a&b).

But the reallocation of proportions of fertilizer use will be politically and administratively infeasible without rapidly growing supplies of fertilizer. This is a

fundamental problem. Schedules for plans to increase domestic production capacity have slipped and imports have been vulnerable to sharp cuts triggered by inventory accumulation of low quality products and foreign exchange considerations. The low and medium application areas have much higher marginal response rates and do not require price subsidies to intensify fertilizer use. These rates are so much higher that planners must seriously consider expansion or adjustment of the food procurement and fertilizer allocation network to emphasize their development. During the last decade, high quality fertilizer supplies have increased so rapidly through acceleration of imports and domestic factory completions and expansions that it was almost impossible for the distribution and procurement systems to accommodate the change without appropriate institutional development. But the inefficiencies now engendered by this imbalance are such as to outweigh the added costs in transport and administrative adjustment.

The 1985 reforms in fertilizer marketing are aimed at adjusting allocation at the margin to areas with hitherto low access and high marginal response rates to fertilizer, without jeopardizing the central procurement processes and without excessive governmental costs. Despite a rocky initial year, the small plant system is adjusting quite well. But these measures will fall far short without rapidly increasing aggregate supplies (Stone 1986d).

The evidence is that the slow growth in aggregate supply of fertilizer was the principal limiting factor in China's long-term development of fertilizer use. Furthermore, the more rapid growth in the availability of fertilizer during the last decade was a major reason for the spectacular improvement in farm production and the rural economy. Despite these historical facts, the aggregate supply of fertilizer may again prove a pivotal limitation in the coming era, as the Ministry of Chemical Industry's construction projects are delayed by national planners faced with tough allocative decisions, and imports fall prey to excessive regulation and limitation. This is because China is entering an era when large but temporary inventory accumulations are likely to be common. If this is allowed to combine with agriculture's declining priority so that decisions are taken which limit the future growth in fertilizer supplies, overall development of fertilizer use will inevitably suffer. This will retard the whole rural development process.

Choice of techniques and transition from fertilizer subsidies

Continued rapid development of fertilizer use is still so critical to national objectives that various sources of aggregate supply must be considered complementary rather than competitive. Growth of the small plant production sector should not be allowed to inhibit steady growth in imports, while further development of efficient large-scale factories need not imply premature or forced elimination of small factories. Each has their role. Rapid development of diammonium phosphate use is probably critical to continued reliance on rapid foodgrain production growth in North China, while growth in supplies of NPK compound fertilizers and potash are increasingly important to the highest application areas around the country. Continued rapid growth of urea supplies is crucial to diversification toward more fertilizer-intensive products in high application areas and toward the medium and low yield areas.

Although it should be immaterial whether these products are supplied via imports or domestic production, experience with large agricultural countries like

China suggests that complete reliance for growth on one or the other results in a slower growth path. This is particularly true of excessive import reliance. Yet, import development has a vital role to play in the current Chinese context.

The principal advantage of small plant development, though clearly inefficient by narrow technical and economic criteria, is that these plants have provided an important mechanism for local savings and investment generation, and a fulcrum of local development. In many areas, these products are used more efficiently than previously. They have also improved packaging, product quality, production efficiency, and storage conditions over time, via the pressures created by the close interface between producers, distributors and users within counties. These factors partially account for the virulent resistance to their elimination by county governments which has been encountered by the national administration. However, if the current subsidies for conversion of many of these facilities for urea and DAP production, and to artificially support inefficient production of single superphosphate and ammonium bicarbonate are allowed to jeopardize investment in efficient large scale plants or a steady program of imports expansion for high quality products, then China's rate of foodcrop production growth and overall economic health will be seriously threatened.

County governments will ultimately need to find and develop new foci of savings, investment and local economic development, rather than placing such heavy dependence on small fertilizer factories, and many counties have already done so. In the interim, national and provincial governments should not press too hard for their closure. But subsidization of these plants must not be prolonged without careful consideration of the opportunity costs of these resources for more efficient development of the food and fertilizer sectors. One would think that further subsidization should depend upon approval of a locally generated plan to eliminate the need for subsidization.

An important interim mechanism for these plants to maintain a profitable basis is to sell at more distant locations where higher prices can be received because farmers there have little access to fertilizers and no access to high quality fertilizers. The government, in turn, must not pressure the plants to sell at lower prices in such locations, but rely on competition among the small plants both within and from outside the county, to keep fertilizer prices from becoming too high in these more remote areas where marketing will be more difficult, risky, and costly.

Transition from consumer subsidies

China is currently attempting to eliminate many products from state marketing channels, allowing private markets to develop for an increasing number of goods. This is ultimately important in order that the state can concentrate its focus on only the most critical areas causing serious concern. Yet the staple foods remain one such area and existing subsidies are a large budgetary burden representing an important fiscal drag on the economy, and an important source of inefficiency. Ultimately, the way out is through higher urban incomes and more efficient food production. Yet in the interim, to raise urban staple prices without raising wages is still difficult and raising wages jeopardizes national capital formation. The transition may be eased by aggressive state development of some preferred food items which could be sold in increasingly large volumes, and at higher prices

without much difficulty. These commodities might include higher quality rice or noodles, lean pork, high valued poultry, and dairy products from a concentrated livestock sector. If set up on an efficient basis, such a production and marketing initiative in a few select categories could provide profits to offset staple subsidies while the latter are being phased out, without jeopardizing equity concerns. Again, with an efficient concentrated production sector and without eliminating competition from smaller, independent suppliers, consumption of such products will increase and consumption of the subsidized cheaper staples will decline, reducing the budgetary burden and improving equity-oriented targeting.

INDIA

Since it became independent in 1947, India has increased chemical fertilizer use from about 50,000 tons of nutrients to 8.7 million tons by 1985–86. On a per sown hectare basis, this amounts to growth from less than 1 kg to about 51 kg. Over this period, production of fertilizers also increased substantially reaching 5.8 million tons in 1985–86.

Together with development of irrigation (from about one-sixth to nearly one-third of sown area) and spread of HYVs (55% of cereals' area), growth in fertilizer use has been the foundation of technical transformation of Indian agriculture. It is this transformation which has sustained the long-term growth rate of agricultural production after the mid 1960s when there was little scope for further expansion in cropland (Desai and Nanbhoodiri).

Accelerated growth of fertilizer use is critical to the future technical transformation of agriculture in India. The level must reach about 20 million tons by the year 2000 to raise the production of food and other commodities to need-based levels. This section discusses problems and policy requirements of further growth in fertilizer use by presenting a perspective on the past growth and focusing on the changed circumstances under which it will have to occur in the future.

A perspective on past growth of fertilizer use

Growth of fertilizer use in India has not been as impressive as in China. Why? The question is pertinent because developments in certain spheres of the four dynamic processes mentioned earlier appear more impressive in India than in China. These include development of (1) credit institutions to serve farmers, (2) a vast fertilizer distribution network with private, cooperative and public agencies, (3) technological capability in setting up large modern fertilizer factories, and (4) national markets for farm products. The relative price environment was not the fundamental difficulty, inasmuch as India's was more favorable to farmers than China's during most of the period.

The answer lies in two types of reasons. First and foremost, as indicated in the previous section, China could temporarily circumvent the lack of institutional market development, particularly with respect to credit, fertilizer and farm products, in tapping the agronomic potential for fertilizer use. India, on the other hand, could not do so. And raising fertilizer use with simultaneously developing market-oriented institutions is a time consuming process at low levels of economic development. The historical experiences of many countries clearly support this view.

Other reasons, however, lie in four interrelated and mutually reinforcing deficiencies specific to India. First, the initial conditions for intensive agriculture were not as propitious in India as in China. Second, agronomic potential for fertilizer use in India was lower and has increased less rapidly than in China. Third, unlike China, India could not mobilize vast amount of local resources (manpower and materials) to complement public resources for massive efforts in developing intensive agriculture. Finally, the aggregate fertilizer supply did not grow rapidly enough to generate sustained pressures on agricultural extension, credit and fertilizer distribution systems to expand and intensify the efforts to convert the existing potential into actual fertilizer use (Desai and Stone).

One or other aspect of the development of the fertilizer sector in India has received attention from many researchers. Reviewing this literature leads to three unmistakable conclusions. First, government policies to accelerate food production have played a key role in the growth of fertilizer use through their influence on the four dynamic processes outlined earlier and interactions among them. Second, between price and non-price factors, the latter have been more important in determining both the pace and pattern (geographical as well as cropwise) of growth in fertilizer use. Third, under the prevailing environment with respect to fertilizer response functions and prices, growth in fertilizer use could have been faster but for the deficiencies in the processes converting the potential into actual use (Desai, 1982, 1983, 1986a&b, Desai and Singh, 1973; Desai, Chary and Bandyopadhyay, 1972).

Some of the salient features of the government policies were investment in irrigation, development of agricultural research, extension, credit-linked fertilizer distribution systems, establishment of national markets for farm products, active role in developing modern technology based domestic fertilizer industry, maintenance of uniform prices of fertilizers throughout the country, and keeping relative prices of crops and fertilizers at relatively stable and reasonable levels. Incidentally, these prices were less favorable to farmers than in many developing countries during most of the past four decades. All these policies were developed in an environment of chronic dependence on large imports of foodgrains and the national objective of eliminating these imports. Especially after the mid 1960s, this objective was pursued with great zeal, but often without sufficient coordination of the different elements.

Consequently there were certain weaknesses in the four basic processes and interactions among them. The impact of processes expanding potential of fertilizer use and converting it into farmers' effective demand for fertilizers was constrained because of sub-optimal distribution of financial resources between ongoing and new projects; constraints in using external sources of funds; technological deficiencies in design and execution of irrigation systems as well as inadequate organizational arrangements and financial provisions for their maintenance; poor participation of local communities and individual farmers in land development; institutional hurdles and pro-irrigation bias in credit supply; and limitations of the efforts to promote HYVs. The latter included less than perfect suitability of the new varieties to different agro-climatic environments, poor water control, deficiencies in seed production and distribution systems, partial success in containing pests and diseases, and lacunae in developing and transferring location-specific knowledge on agronomic practices.

On the fertilizer supply side, the following major deficiencies constrained sustained rapid growth in fertilizer use: repeated shortfalls in planned domestic production, wide annual fluctuations in fertilizer imports, slow geographical expansion of fertilizer distribution network, inadequate development of relevant physical infrastructure, and working capital constraints of the distribution system. Because of these deficiencies, the supply side did not exert sustained pressure on the processes generating growth in farmers' effective demand for fertilizers even though there was untapped potential under the prevailing price environment. In fact, the supply and distribution systems, as they developed over years, remained dependent on the demand generating processes noted above to create additional demand to absorb growing supplies.

Under the environment characterized by the above features, most of the past growth in fertilizer use was an outcome of diffusion on irrigated land and upward movement in rates of application on this land due to the replacement of traditional varieties by HYVs. Consequently, there has been persistent geographical and cropwise concentration in fertilizer use pattern.

Changed circumstances of future growth in fertilizer use

The past growth in fertilizer use has undoubtedly contributed to substantial growth in foodgrains production by raising yields. This, in turn, has eliminated India's chronic dependence on large imports of foodgrains. But it has also decisively altered the circumstances of future growth in fertilizer use (Desai, 1986a).

Both fertilizer use and HYVs have spread to virtually all irrigated land; and at least on a subset of this land, the rates of application have also reached fairly high levels and lowered the marginal productivity of fertilizer. In addition, the burden of food and fertilizer subsidies on the budgetary resources of the government has vastly increased. In just three years between 1982-83 and 1985-86, these subsidies have gone up from Rs. 13,610 million to Rs. 37,000 million.

The food subsidies are mainly due to the policy of supporting procurement prices at 'incentive' levels in the face of inadequate growth in effective demand for foodgrains. This, in turn, is due to poor growth in employment. The fertilizer subsidies are mainly due to high cost of domestic fertilizer production. It must, however, be noted that the high cost of domestic production is largely due to the administered prices of fertilizer raw materials, feedstocks etc., fiscal policies affecting investment costs in fertilizer plants, and enhanced cost of setting up fertilizer plants after the oil crisis of the early 1970s. Thus, not all of the budgetary subsidy on fertilizers is either economic subsidy or due to inefficiencies in the domestic fertilizer industry (Desai, 1986b).

These subsidies have contained upward pressure on farmers' real price of fertilizer and thus facilitated growth in fertilizer use in the face of declining marginal productivity of fertilizers in high consuming regions. But, as noted above, their burden on budgetary resources of the government has mounted rapidly in recent years.

With virtual elimination of large food imports and increasing evidence of constraints on rapid growth in effective demand for food, it is clear that future growth in fertilizer use and technical transformation in agriculture must be accomplished with greatest economic efficiency. Without this, growth in agricul-

tural production cannot eliminate poverty, create near full employment conditions, and generate self-sustaining economic growth by the year 2000, the three basic national objectives enunciated in India's Seventh Five Year Plan.

Under these changed circumstances, the pace of future growth in fertilizer use has become critically dependent on (i) tapping the unexploited potential for fertilizer use, (ii) accelerating the processes expanding potential for fertilizer use, and (iii) raising efficiency not only of fertilizer use but also of various systems involved in growth of fertilizer use.

Required orientation in policies

Most of the unexploited potential is on more than 70% of unirrigated land (Desai, 1983). To accelerate fertilizer use on this land, location specific knowledge on fertilizer response functions, and fertilizer practices and other agronomic matters (like sowing time, choice of variety and plant population) need to be generated through strengthened, decentralized research and effectively spread among farmers. These efforts are even more critical in rainfed areas because without optimal fertilizer and agronomic practices, returns on fertilizer use are lower and more uncertain than on irrigated areas. On the other hand, with appropriate practices, returns to fertilizer use on rainfed areas could be considerably enhanced.

The above efforts need to be simultaneously supplemented by adequate and timely flow of credit to farmers and development of efficient fertilizer distribution system. Small increases in distribution margins may not suffice to accelerate expansion of fertilizer distribution system in rainfed areas especially if vigorous efforts to promote fertilizer use are absent and fertilizer turnover remains low. The working capital requirements of the input distribution systems also need special attention since timely availability of seeds and fertilizers in rainfed areas is more critical than under irrigated conditions (Desai 1985).

Neither promotional efforts nor expansion of distribution system in unirrigated regions could be sustained unless aggregate fertilizer supply stays ahead of growth in fertilizer demand in current and newly irrigated areas. This would depend on fertilizer import policy. Despite planned dependence on imports, fertilizer supply policy has received lopsided attention. The long-term goal of self-sufficiency in supply through development of domestic industry has not received sufficient attention, especially in the last two decades. But fertilizer import policy has been governed, more often than not, by such short-term and ad hoc considerations as clearing inventories, savings in foreign exchange, and various institutional and infrastructural constraints in distribution of imported fertilizers. Consequently, imports have fluctuated widely. To overcome these limitations, fertilizer import policy need to be based on an understanding of the role of the supply side in accelerating growth of fertilizer use through sustained pressures on the other dynamic processes generating rapid growth in fertilizer use. A policy of 'liberal' imports of fertilizers will most likely be resented by the domestic industry. It may also lead to an increase in inventories in the short run because of many deficiencies in systems handling distribution of imported fertilizer. But this calls for developing effective mechanisms to tackle problem areas rather than rejecting a policy which would accelerate diffusion of fertilizer on unirrigated areas. More so when the budgetary burden of fertilizer subsidies on imported fertilizers is often

lower than on domestic fertilizers and could be further reduced if the distribution cost of imported fertilizers are brought down through improvements in the systems handling imports.

Raising rates of application on fertilized land to optimum levels is another way to tap the unexploited potential. However, these low rates are often due to sub-optimal fertilizer practices, which, in turn, is due to farmers' lack of knowledge. There is ample evidence of deficiencies in these practices, even in states and districts with high levels of fertilizer use. Efforts to remove these deficiencies must, therefore, concentrate on educating farmers in efficient fertilizer practices such as balanced use of nutrients, correct timing and placement of fertilizers, and wherever necessary, use of micronutrients and soil amendments. This will increase the efficiency of fertilizer use and thus raise private as well as social returns on it. Without such efforts, the strategy to increase fertilizer use on land which is already fertilized at fairly high rates (especially of nitrogen) would aggravate the pressure for lower fertilizer prices and higher support prices for crops.

To increase the economic potential of fertilizer use, accelerated development of irrigation potential and its fuller utilization are a must. In addition, the agricultural research system needs to be strengthened to improve the response functions on both irrigated and unirrigated areas. In order to exploit the economic potential of these policies, however, deficiencies in irrigation management and water control, in agricultural extension (especially with respect to its interface with the research system), and in credit as well as fertilizer supply and distribution systems must be removed. Past experience indicates that inadequate appreciation of the complementarity between policies which increase fertilizer potential and those which rapidly convert it into actual use through developing various systems eventually results into long time lags in full exploitation of the potential and lowers the cost effectiveness of public investment in developing intensive agriculture.

Because of the constraints on lowering real prices of fertilizers, above non-price policies will be more crucial than ever before in determining the pace of future growth in India's fertilizer use. This, however, is no ground for pessimism. The relative prices of fertilizers and crops are still reasonable. They need not become continuously more favorable to farmers for further growth in fertilizer consumption to occur unless we assume that under the prevailing price environment there is neither untapped potential for fertilizer use nor scope to raise profitability of fertilizer use through improving the response functions environment. There is no evidence to support these assumptions.

EMERGING CONCLUSIONS

Record of fertilizer market development in China and India

Long-term development of the fertilizer market in a developing country is composed of a complicated array of sub-processes and their potentially complex interactions. The task involves a wide variety of investment initiatives, institutional developments and policy adjustments, including those that are commonly associated with fertilizer and agriculture, and many that are not. Viewed in these terms, the records of both countries seem impressive, given the major differences between their initial conditions, sociopolitical conditions, and the structure as well as modus operandi of their economies.

15

Both countries could have raised their fertilizer use faster than they actually did. China could have done this primarily with faster growth of aggregate fertilizer supply. India, on the other hand, also needed more vigorous and coordinated efforts to convert the potential into farmers' effective demand for fertilizers.

Major factors and policies in the two countries

In both countries, many non-price factors and policies have played a more important role than price policies in the past growth of fertilizer use. Among these, policies which shifted the response functions upwards through development of irrigation, improvements in water control and management, and development and diffusion of fertilizer responsive varieties were crucial. However, efforts in these directions alone would not have sufficed.

Public policies played a key role in converting the enlarged potential into actual use in both countries, though their respective policies differed, through developing a wide variety of institutions and mechanisms in the spheres not only of fertilizer supply, allocation, distribution, and demand but also marketing of farm products and development of many other types of markets, as well as the agricultural sector in general. A feature distinguishing Chinese and Indian performance has been the attitude toward private market development: China has relied entirely on public initiatives to circumvent the shortcomings of market underdevelopment and it has suppressed private market development in many spheres. India, on the other hand, has tended to encourage private market development, supplemented by public initiatives which were less comprehensive and effective than China's.

This explains why fertilizer use increased more impressively in China even though the relative price environment was more favorable in India. This also highlights China's current predicament now that the original public mechanisms for converting potential for fertilizer use into effective demand are no longer appropriate for generating further growth in fertilizer use.

In terms of investment, the larger scale and greater effectiveness of efforts in China were not due to greater allocation to agriculture from the national government's budgetary resources; but instead due to the success in mobilizing local resources to complement state budgetary allocations, to a generally efficient choice of types of expenditures within agricultural allocations, and to a firm commitment at the state planning level to do whatever was necessary to keep available aggregate fertilizer supplies moving onto farmers' fields.

Further development of fertilizer use in China and India

Despite the high level of consumption China has already achieved, there is still a need to raise it further. The reasons for this, the nature of difficulties to be overcome in sustaining rapid growth in fertilizer use, and the importance of maintaining a national policy commitment for continued rapid growth in fertilizer use and agricultural production were discussed above. The urgency of this national policy commitment is highlighted by India's difficulties in developing national markets for farm products and fertilizer supply based on large modern fertilizer plants.

In the case of India, the need for accelerating growth in fertilizer use is evident from the gap between the present level of consumption and the level to which it

must be raised by the year 2000 to achieve the growth in agricultural production on which depends the fulfillment of basic national objectives. The complexities in this task, and the orientation in policies required to tackle them, were discussed in the previous section. The urgency of such an orientation in policies is clear from a critical evaluation of the past experience, growing burden of food and fertilizer subsidies on the budgetary resources of the government, and major lessons emerging from China's success.

Policy lessons for other developing countries

The experiences of China and India clearly suggest that there cannot be a uniform policy prescription for sustained rapid growth of fertilizer consumption in all developing countries. This is because their initial conditions differ, and also because the task involves a wide variety of issues which can be most effectively tackled in different ways depending on the specific circumstances of each country. Yet it is not too early to venture some broad but fundamental reflections on the process of growth in fertilizer use.

First and foremost, there is apt to be considerable unexploited fertilizer potential in the existing agronomic environment of most developing countries. Under typical circumstances, what is critically needed to generate sustained rapid growth of fertilizer consumption is to tap this potential by speedy removal of the most binding constraints in the processes of conversion of agronomic potential into effective demand for fertilizers, and development of initiatives to continuously strengthen these processes. Price incentives are no substitute for these tasks, and continued reliance upon them ultimately proves infeasible. Often, they also distract the attention of policy makers from the more demanding tasks of developing the systems which influence more fundamental dynamic processes.

Second, the tendency for private and public planners to provide substantially lower aggregate supplies than can be absorbed in a given year (or within a few years once appropriate adjustments relieving other constraints are made), and to cut back on aggregate supplies when inventories accumulate regardless of cause, almost inevitably results in a much slower growth rate than can be achieved. Pressure from plentiful aggregate supplies, particularly when responsibility for inventory accumulation is accepted at the highest governmental levels, may initiate the relief of constraints developing among the other three dynamic processes. Concerted long-term commitment to raise pressure from the supply side is pivotal to triggering rapid growth in fertilizer use. Maintaining regionally disaggregated stocks of fertilizers at much higher levels than those commonly believed to be economic is a necessity for rapid long-term growth. A flexible and sensitive system to move fertilizers quickly from regional stocking areas to localities, as well as larger levels of, and more dispersed local stocks are required. Of course this aggressive supply growth must be backed up by monitoring and evaluation of other constraints among the three dynamic processes of growth in fertilizer use.

Third, in choosing among policies or initiatives to resolve existing constraints, the habit of employing particular short-term expedients must be examined to understand their accumulated long-term implications for the health and efficiency of the dynamic processes. Thus, for example, if price adjustments are consistently used to eliminate inventories rather than either facing up to the task of expanding

the distribution system (when fertilizer use is geographically too concentrated) or investing in technical change to increase returns to fertilizer use in existing areas of concentration, then successive adjustments may be degenerative. Similarly, the possibility must be regularly evaluated that lack of credit may constrain the realization of effective demand for fertilizers. But if the expedient of pumping in large volumes of agricultural credit is continually adopted to resolve all inventory accumulation problems, without understanding which component of demand realization is binding, or whether the distribution system is a major contributing factor, then the entire dynamic process may be perverted.

Fourth, the path of growth in fertilizer consumption based on initiation of fertilizer use on farmlands previously unfertilized is apt to differ sharply from that which leads to intensification of rates from low levels to higher levels on land already fertilized. Both of these differ from that based on further intensification of rates which begin to approach the agro-economic potential of fertilizer use. And all three differ from the path based on processes which generate growth in fertilizer consumption by continuously shifting fertilizer response function upwards, and thus raising that potential. If institutional orientation leads to considerable reliance on one or two of these paths, to the exclusion of the others, a day of reckoning may follow in which prolonged growth plateaus are experienced.

REFERENCES

- Desai, Gunvant M. "Fertilizer in India's Agricultural Development," in *Agricultural Development of India, Policy and Problems*, ed. C.H. Shah, Bombay: Orient Longman Ltd, 1979.
- *Sustaining Rapid Growth in India's Fertilizer Consumption: A Perspective Based on Composition of Use*, Washington DC: IFPRI, 1982.
- "Fertiliser Use on India's Unirrigated Areas: A Perspective Based on Past Record and Future Needs." Paper prepared for the ICRISAT-ISAE seminar on "Technology Options for Dryland Agriculture," Hyderabad August 22-24, 1983.
- "Market Channels and Growth of Fertilizer Use in Rainfed Agriculture: Conceptual Considerations and Experience in India" in *Agricultural Markets in the Semi-Arid Tropics*, pp. 41 - 53, Patancheru: ICRISAT, 1985.
- "Fertilizer Use in India: The Next Stage in Policy." *Indian Journal of Agricultural Economics* 41(1986a):248 - 70.
- "Growth in Fertilizer Consumption: Price and Non-Price Policies." *Fertilizer Producer Pricing in Developing Countries, Issues and Approaches*. ed. E.L. Segura, Y.T. Shetty. and M. Nishimizu pp. 109 - 36, 1986b.
- "Policy for Rapid Growth in Use of Modern Agricultural Inputs," in *Food and Agricultural Price Policy in Developing Countries*, ed. John W. Mellor and Raisuddin Ahmed, Baltimore: Johns Hopkins University Press (forthcoming), 1988.

- Desai, Gunvant M., P.N. Chary, and S.C. Bandyopadhyay. *Dynamics of Growth in Fertiliser Use at Micro Level*, IIM, Ahmedabad: Centre for Management in Agriculture, 1972.
- Desai, Gunvant M., and Gurdev Singh. *Growth of Fertiliser Use in Districts of India: Performance and Policy Implications*. IIM, Ahmedabad: Centre for Management in Agriculture, 1973.
- Desai, Gunvant M., and John W. Mellor. "Changing Basis of Demand for Fertilisers," *Economic and Political Weekly*, September 27(1969):.
- Desai, Gunvant M., and N.V. Nambodiri. "The Deceleration Hypothesis and Yield Increasing Inputs in Indian Agriculture," *Indian Journal of Agricultural Economics* 38(1983): 497 - 508.
- Desai, G.M., and B. Stone. "Fertilizer Market Development and National Policy in China and India: A Comparative Perspective." Paper prepared for the IFA-FADINAP Southeast Asia and Pacific Regional Fertilizer Meeting, Kuala Lumpur, July 22 - 25, 1987.
- Ishikawa, Shigeru. *Economic Development in Asian Perspective*. Tokyo: Kato Bumeisha Printing Co., Ltd.
- Lardy, N.R. *Agricultural Prices in China*. World Bank Staff Working Paper 606. Washington, DC: World Bank, 1983.
- Lee, T.H. *Intersectoral Capital Flows in the Economic Development of Taiwan 1895 - 1960*. Ithaca: Cornell University Press, 1970.
- Mellor, John W. *The Economics of Agricultural Development*. Ithaca: Cornell University Press, 1966.
- Stone, Bruce "The Basis for Chinese Agricultural Growth in the 1980s and 1990s: A Comment on Document No. 1, 1984," *China Quarterly* 101(1985): 114 - 21.
- "Chinese Fertilizer Application in the 1980s and 1990s: Issues of Growth, Balance, Allocation, Efficiency and Response" *China's Economy Looks Toward the Year 2000* Vol. 1 *The Four Modernizations*, ed. U.S. Congress Joint Economic Committee, pp. 453 - 96, Washington DC: U.S. Government Printing Office, 1986a.
- "Chinese Socialism's Record on Food and Agriculture," *Problems of Communism* September-October(1986b):63 - 72.
- "Fertilizer Sector Development in the People's Republic of China: With Emphasis on Chinese Experience and Research on Fertilizer Use Efficiency," *Proceeding of the International Seminar on Fertilizer Use Efficiency*, Lahore: Fauji Fertilizer Company, 1986c.
- "Systematic and Policy Adjustment in the Administration of Chinese Fertilizer Development." Paper prepared for the World Bank, Washington, DC, June 12, 1986d.
- "Foodcrop Production and Consumption Performance in China and India." Paper prepared for the Annual Meetings of the American Association for the Advancement of Science, Chicago, February 15, 1987.
- "Relative Foodgrain Prices in the People's Republic of China: Rural Taxation Through Public Monopsony" ed. J.W. Mellor and R. Ahmed *Food and Agricultural Price*

Policy in Developing Countries, Baltimore: Johns Hopkins University Press, (forthcoming), 1988.

Stone, B. and Gunvant M. Desai, "Fertilizer Policies in China and India: Implications for International Trade and Financing Arrangements." Paper prepared for the International Fertilizer Industry Association Roundtable Meeting at the World Bank on Fertilizers for Third World Supplies, Washington, DC, September 17 - 18, 1987.