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Environmental and Economic Implications of Agricultural Trade and Promotion Policies in Kenya: Pest and Pesticide Management

by

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and
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List of Acronyms

CIMMYT	International Center for the Improvement of Maize and Wheat (Mexico)
ELCI	Environment Liaison Centre International
FREAK	Fresh Produce Exporters' Association of Kenya
EPA	U. S. Environmental Protection Agency
FAO	United Nations Food and Agriculture Organization
GIFAP	Groupement International de Fabricants de Produits Agrochimiques/ International Group of National Associations of Manufacturers of Agrochemical Products
GTZ	Gesellschaft für Technische Zusammenarbeit (Agency for Technical Cooperation, Germany)
HCDA	Horticultural Crops Development Authority
ICIPE	International Centre for Insect Physiology and Ecology
IIBC	International Institute of Biological Control
IPM	Integrated pest management
JICA	Japan International Cooperation Agency
KARI	Kenya Agricultural Research Institute
KEDS	Kenya Export Development Support Project (USAID)
KIOF	Kenya Institute of Organic Farming
Kshs	Kenya shillings
MIAC	Midamerican International Agricultural Research Consortium
MT	Tonnes (metric tons)
NARL	National Agricultural Research Laboratories
NARP	National Agricultural Research Project (multidonor)
NEAP	National environmental action plan
NGO	Nongovernmental organization
ODA	Overseas Development Administration (United Kingdom)
PCAK	Pesticide Chemical Association of Kenya
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development

Foreword

This report is one of a series of reports on the environmental and economic implications of agricultural policy reform and trade and promotion policies in sub-Saharan Africa completed for the U.S. Agency for International Development's Bureau for Africa. Pesticides are the particular focus of this and related studies. Pesticides are recognized as essential inputs to promote agricultural productivity, but they are also unique among agricultural inputs in the potential risks they pose to human and environmental health. Major economic restructuring has been sweeping sub-Saharan Africa in the past five years, yet little attention has been paid to the implications of these reforms for the use and distribution of pesticides.

Several dilemmas and challenges for the development process have been introduced by the withdrawal of government from a role in the distribution of pesticide inputs, and by the associated restructured pricing and subsidy policies. In part, the dilemmas are unique to this subsector, simply due to the intrinsically toxic properties of pesticides, which sets them apart from other agricultural inputs and from other commodities of commerce such as fertilizers. For these reasons alone, pesticides deserve a special examination. Specific attention is also paid to the opportunities for promoting alternative pest-management technologies and strategies.

This report is directed at analysts, decision makers and policy makers having a stake in these issues, in interested governmental and nongovernmental organizations in Kenya, as well as among donors and international financial institutions. Related reports examine pesticides and the agrichemical industry in sub-Saharan African; the policies on pest and pesticide management of major bilateral donor agencies; and the implications and consequences of policy reforms vis-à-vis pest management in Uganda and Cameroon. The cost of writing and printing the present report is estimated to be about $20,000.

We hope that this report will assist in the process of changing policies and programs to promote the minimized but responsible use of pesticides and the development, availability of, and access to integrated pest-management technologies. The report's utility for its intended users will determine it effectiveness.

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Preface

The present report is prepared in conjunction with the analytical agenda of the USAID Africa Bureau's Policy Analysis, Research and Technical Support (PARTS) Project, which covers a broad range of subjects in agriculture, natural resources, agribusiness and private sector development. This series of studies on pesticide policy was conceived, and is managed, by Walter I. Knausenberger, under the leadership of John Gaudet, Africa Bureau Environmental Coordinator (and head of the Environmental Protection Unit), and Curt Reintsma, Chief of the Division of Productive Sector Growth and Environment within the Office of Sustainable Development. The study and analysis are being carried out through an Africa Bureau PARTS Project buy-in to the Global Bureau of USAID's Environmental and Natural Resources Policy and Training (EPAT) Project.

This study is the result of a two-week visit to Kenya in early 1994. Work had originally been scheduled in Madagascar, but a series of cyclones prevented work in that country. Kenya was thus selected for analysis on short notice, and the authors are especially appreciative of the assistance provided by Thomas Hobgood, Chief, Office of Private Enterprise, Dennis McCarthy, Chief, Agricultural Development, both of USAID/Kenya, and Eric Loken, Regional Environmental Officer, USAID/Regional Economic Development Support Office for East and Southern Africa. Despite the limited time in Kenya, a large amount of data was collected, enabling the team to provide a comprehensive overview of the use and management of pesticides in Kenya. The collection of data would not have succeeded without the assistance given to the team by all who were asked to help. The list of contacts at the end of this report reflects those who should be thanked for their efforts.

This report reflects the detailed and thorough comments of several reviewers: including Walter Knausenberger of the Bureau for Africa; Paul Guenette of USAID's Kenya Export Development Support (KEDS) Project; Richard J. Tobin of the Institute for International Research; Agi Kiss of the World Bank's Regional Office in Nairobi, Kenya; Akinwumi Adesina of the West African Rice Development Association; William J. King of the Natural Resources Institute (United Kingdom); and a representative of the Pesticide Chemical Association of Kenya. The considerable editorial assistance of Tropical Research and Development, Inc., is appreciated.

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Executive Summary

Pest management in Kenya is dependent chiefly on pesticides; however, an integrated pest management (IPM) system has been developed for coffee, and several donor-supported research programs have started work on IPM for vegetables, fruit, cotton, cereals, and cattle ticks. Organic farming has received little support. Intensive pesticide use is associated with cash cropping for both domestic and export markets.

Kenya's agricultural extension system appears to have been unable to provide appropriate safety training related to the use of pesticides and to be unprepared to meet the educational challenge that IPM poses. The International Group of National Associations of Manufacturers of Agrochemical Products (GIFAP) recently sponsored the Safe Use Project, a large-scale pilot extension training program on pesticide safety. Although the project measurably improved farmers' knowledge, long-term funding is uncertain.

Pesticide management, sales, and use are not under effective control in Kenya even though legislation, regulations, and registration procedures exist. The Pest Control Products Board is responsible for pesticide regulation but employs only a handful of professional staff. Observers report many infringements of the International Code of Conduct on the Distribution and Use of Pesticides. The recent donor-supported upgrading of the Kenya Agricultural Research Institute's (KARI) Pesticide Residue Laboratory is a positive development. The laboratory can now analyze both pesticide quality and residues and is monitoring residues on heavily treated vegetables and conducting research on environmental toxicology.

The KARI laboratory may provide residue monitoring services to export growers who must comply with the European Union's maximum residue levels for pesticides on imported produce. Small-scale growers and exporters of nontraditional crops are currently at a competitive disadvantage with regard to maximum residue levels and other management requirements compared to multinationally financed, European-managed agribusiness firms. The lack of publicly funded research on IPM on those crops and poor horticultural extension services exacerbates this inequality. Accordingly, projects such as USAID's Kenya Export Development Support Project are targeting smallholders for information dissemination and technical support.

Kenya is developing a national environmental action plan. In general **the government does not appear to place high priority on environmental protection**, so the plan's likely impact is questionable. Citizens' groups and concerned government agencies have, however, initiated pesticide pollution monitoring around Lakes Naivasha and Nakuru. Little is known yet about pesticide pollution in Kenya. Some pesticide-related health problems have been identified, including alarming organochlorine insecticide residue levels in human mother's milk.

Many donors are encouraging African countries to eliminate subsidies on agricultural inputs and to privatize pesticide markets. Although the private sector dominates pesticide supply in Kenya, in the past the government subsidized the provision of pesticides through tax exemptions, distribution of donated pesticides at below-market prices, and other measures.

Nevertheless, pesticide consumption decreased from the early 1980s to the early 1990s. Pesticide prices have risen as fast as, or faster than commodity prices, and the credit supply is limited.

Based on trade and policy trends, **the present report tentatively projects a small to moderate increase over the next three to five years in pesticide use on tea, maize, and horticultural crops for export**. Unless farmers change their practices and pesticide and environmental regulations are enforced, this projected increase in pesticide use can be expected to worsen already existing pesticide-related hazards: acute and chronic poisoning of applicators and consumers, harm to nontarget species, water pollution, and ozone depletion. New initiatives for training on pesticide safety and research on IPM can mitigate such hazards over the longer term.

Research and data collection on the economics of pesticide use and alternative pest management technologies, including the costing of health and environmental impacts, are important for identifying safer and more sustainable measures to protect crops. Remaining pesticide subsidies and nonemergency pesticide grants from donors should be phased out. **Alternative pest-management measures are unlikely to be developed and implemented in Kenya unless government, donors, nongovernmental organizations (NGOs), international lending agencies, and agribusinesses make a substantial long-term commitment to the research and extension of IPM and organic farming and to the implementation of pesticide and environmental regulations**. This collaborative effort should involve the agricultural, health, environmental, and educational sectors and much interagency cooperation.

East African governments should harmonize their pesticide registration and regulations, collaborating on enforcement and problems of mutual interest. **Donors should require environmental reviews of assistance that can affect pesticide use even indirectly (for example, credit programs and export crop promotion projects) in order to identify opportunities for supportive IPM research and hazard mitigation. Projects promoting nontraditional export crops should continue to help Kenya's small-scale entrepreneurs and to monitor project beneficiaries, thus ensuring the equity of the benefits.**

1. Introduction

This is one of three country studies in sub-Saharan Africa that examine the economic and agricultural policies of governments, international lending agencies, and bilateral donor that affect pesticide use (Meltzer, Matteson, and Knausenberger 1994; Matteson and Meltzer 1994). The objective is to assess the direct and indirect impacts of those policies on the environment, on public health, and on the likelihood of increased reliance on IPM. Policy recommendations follow from the findings.

The report begins with an overview of pest and pesticide management in Kenya, including Kenya's ability to regulate and monitor pesticide use. The report then describes the status of alternative technologies for reducing pesticide use (including IPM and organic farming), and research activities in those domains. A summary of information follows about the health and environmental impacts of pesticide use to date. The central portion of the report discusses economic and policy factors that will affect pesticide use in future, including the agricultural and environmental policies and initiatives of government, lending agencies, donors, and NGOs. These factors provide the basis for projecting change in pesticide use in Kenya by crop for the next three to five years. The projections, combined with information about hazardous pesticides and pesticide use patterns, are used to identify potential environmental and health hazards. The report concludes with recommendations for improving crop protection and pesticide management in Kenya such that pesticide-related hazards will be mitigated and the benefits of improved crop protection technology will be distributed equitably.

The projected impacts of economic and policy factors are tentative in that they are based on sometimes incomplete or conflicting information and on conditions that can change unpredictably. Economic reforms are in progress now, and their pace and extent are still uncertain. Both the political and the economic situation (particularly prices of export commodities) are volatile.

The patterns of pesticide use for crops and veterinary purposes were chosen as a function of their importance, the amount of pesticides applied, the availability of data, and opportunities for comparison among countries. These use patterns include pesticide application to the traditional export crops coffee and tea, to the foodcrops maize and vegetables, to nontraditional export crops (fruit, flowers, and exotic vegetables), which the Government of Kenya is promoting, and to cattle for the control of ticks.

2. Pest and Pesticide Management in Kenya

2.1. The importance of agricultural pests

Little information on the economic value of crop damage to pests is available for Kenya (Sutherland and Kibata 1994). The importance of losses due to stem borers, considered to be a major insect pest of maize, is disputed (Darling 1993).

Surveys indicate that small-scale farmers perceive pests to be a significant constraint. Almost all the 150 farmers interviewed during a 1986 survey in Kendu Bay and Oyugis Divisions in Western Kenya reported severe crop losses due to insect pests at some time during the previous five years, with armyworms, shootflies, and stem and pod borers causing the most damage (Saxena et al. 1989). KARI and the International Center for the Improvement of Maize and Wheat (CIMMYT) surveyed small-scale maize farmers in 1992 in almost every agroecological zone. Those farmers ranked pests (*Striga*, other weeds, stem borers, chafer grubs, streak, head smut, other pests) second only to drought as a production constraint and higher than low fertility and financial constraints (Hassan and Corbett 1993; Hassan and Salasya 1993; Hassan, Corbett, and Njorge 1993).

The design of surveys influences the reported importance of pest problems in relation to other production constraints. A nationwide survey of over 2,100 smallholder farmers carried out in 1991 elicited farmers' explanations of yield trends. Some yield declines were attributed in large part to diseases (for coffee, cashews, and rice) or insect pests (for cashews, rice, and legumes other than beans). Nonetheless, problems with climate, finances, and the procurement of inputs were perceived as more important. The report points out that the relative unimportance of pest problems would have been hidden if the questionnaire had not considered the farm situation in a whole-enterprise context (Darling 1993).

2.2. Patterns of pesticide use

2.2.1. Pesticide use on cash crops

Agricultural pesticides are used most on cash crops such as coffee, temperate cereals, horticultural crops, maize, cotton, and for animal health. Some large-scale coffee plantations still apply pesticides liberally (H. Partow, personal communication, 1994), and market growers who can afford to buy pesticides use them from nursery to postharvest, including against maize stalk borers (J. Ngatia and J. Ondieki, personal communications, 1994).

Large-scale growers of cash crops can be expected to have more working capital for buying agricultural inputs than other farmers. Although pesticide use has been correlated with increasing farm size, cash cropping appears to be even more important as a determinant of farmers' crop protection practices. Based on survey evidence, Darling (1993) reports that the use of pesticides, purchased seeds, and other agricultural inputs rises with increasing farm size. Those findings appear in a somewhat different light, however, in the context of an in-depth study of farmers' field

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and postharvest crop-protection practices (Goldman 1987, 1991). The latter study indicates that farmers who grow cash crops are most likely to use pesticides, and that where pesticides are available and familiar, small farm size can even increase their use.

Goldman's study was carried out in three contrasting Kenyan agricultural zones: Kigumo Division, a major smallholder coffee-growing area about 90 km north of Nairobi; Makueni Location in eastern Machakos District, a leading cotton producing area; and Mbita Division in South Nyanza District, where farmers grow food crops and groundnuts for home consumption and sale. Cotton and coffee were impossible to grow profitably without pesticides, given the technology recommended to farmers at the time. In Kigumo and Makueni, cash cropping meant that credit, pesticides, and spraying equipment were readily available and farmers were familiar with pesticide use. Pesticides bought for cash crops "spilled over" onto food crops: Kigumo farmers sprayed coffee and potatoes with fungicides at the same time; in Makueni, cotton chemicals were used on pigeon peas and cowpeas.

The study indicated that Kigumo Division had both the smallest farms and the highest pesticide use. Lack of arable land made farmers unable to compensate for pest losses by planting larger fields and unwilling to lose much of their small food crop harvest to pests. Moreover, Goldman (1991) remarks that in areas with high population density, where farms are small and even marginal land is cropped, traditional pest control practices that depend on bushland plants become impossible for lack of resources. Farmers in Mbita Division used the least pesticides in both field and store and depended most on traditional crop-protection practices.

Three other studies tend to confirm the linkage between the use of pesticides and cash crops. Forty percent of 150 small-scale farmers growing cotton and coffee in western Kenya used insecticides on their food crops (Saxena et al. 1989). One hundred percent of 1,797 surveyed households growing coffee, tea, maize, and horticultural crops in Githunguri location, 50 km northwest of Nairobi, use pesticides extensively (Mwanthi and Kimani 1993). In contrast, Hassan and Salasya (1993), in a more extensive survey, found that only 15 percent of small-scale maize farmers use chemicals to control field pests.

There are two partial but important exceptions to this linkage. Tea is grown without pesticides except for herbicides, and fruit is generally grown without insecticides. Fruit diseases are largely handled through host-plant resistance now, but fungicide use may grow if sea shipment of mangoes, avocados, and other fruits increases (KARI staff, personal communications, 1994).

2.2.2. Pesticides used to control tick-borne diseases in cattle

Tick-borne diseases such as East Coast Fever (causative agent: *Theileria parva*), anaplasmosis (causative agent: *Anaplasma marginale*), babesiosis (causative agents: *Babesia bigemina, B. bovis*), and heartwater (causitive agent: *Cowdria ruminatium*) are considered a constraint to livestock production in Africa. For example, Mukhebi, Perry, and Kruska (1992) estimated that the losses associated with East Coast Fever in eleven countries amounted to US$168 million per year. Cattle are often dipped in acaricides in order to control the ticks that transmit these diseases. The most

commonly used acaricides have been organophosphates, including dioxathion, toxaphene, and quintiophos (Moll and Lohding 1984; Morzaria et al. 1988; Young et al. 1990). Synthetic pyrethroids such as flumethrin are becoming widely used as well.

Dipping has been routine in Kenya since before the Second World War. Government programs that have attempted to provide dipping services for a large number of cattle have dominated the history of dipping. Dipping was compulsory in certain areas. Where tick infestations were heavy, cattle were often dipped twice per week. Currently about 35 percent of the Kenyan national herd, which numbered 9.8 million head in 1989, are dipped an average of 26 times per year. In 1989, the estimated cost of this operation was US$12.4 million. Since dipping is subsidized heavily, the Kenyan government bears much of the cost (A. Mukhebi, personal communication, 1994). The government plans to increase dipping charges gradually to full cost recovery levels (Government of Kenya 1993b).

2.3. Pesticide application and safety

Aerial spraying of pesticides is common among the large-scale cereal farmers of Narok, Nakuru, and Jasin Gishu Districts in the Rift Valley. Boom sprayers are also frequently used on large farms. Small-scale farmers apply pesticides with their hands or twig brooms and occasionally with knapsack sprayers, which are manufactured domestically (Pierrard 1992; Partow 1992; Mbakaya et al. 1994). The availability of spare parts and the high cost of the equipment are major constraints to sprayer use (FAO 1993a). Unsafe pesticide application practices endanger the lives of crop-duster flaggers, applicators, field workers, nearby residents, and consumers (Partow 1992).

Protective clothing is imported. Its use is limited because of unavailability, high cost, unsuitability for use in the tropical climate, and farmers' ignorance about pesticide hazards (FAO 1993a). A recent study of 1,797 households in Kiambu District found that all farmers interviewed use pesticides, but only 24 percent regularly take safety precautions during application (Mwanthi and Kimani 1993). Field investigators studying pesticide use in major pesticide consuming districts in 1991 never observed the use of protective clothing by small-scale farmers, and use by employees of large farms was erratic. All the applicators interviewed sometimes experienced poisoning symptoms after application, but most did not make the connection between the symptoms and pesticide use (Partow 1992).

Pesticides are called "dawa" in Swahili and "muthaiga" in Kikuyu. Both words mean "medicine" or "poison" interchangeably, which can be dangerously misleading to farmers who are ill-informed about pesticides' toxicity to humans (Mwanthi and Kimani 1993). Inadequate extension and enforcement of labeling regulations increase the likelihood of pesticide misuse (see sections 2.4.1 and 2.4.2). In the absence of special training for users, however, the utility of pesticide labels as they are presently written is limited. Sixty percent of literate farmers among 1,797 pesticide users surveyed in Kiambu District admitted that pesticide instructions were too technical for them to understand (Mwanthi and Kimani 1993). The scales of measurement used on labels are unfamiliar and farmers do not have the required measuring equipment (Partow 1992).

Farmers often do not know how to mix pesticides properly and frequently under- or overdose (H. Muhia, personal communication, 1994). Of course, most farmers are illiterate and depend on traders and extension officers for advice on proper use.

2.4. Kenya's ability to regulate and monitor pesticide use

2.4.1. Agricultural extension

Extension in Kenya is the responsibility of the Ministry of Agriculture. The World Bank established the training and visit agricultural extension system through its National Extension Programme Phases I and II, starting in 1982 and 1990, respectively. The National Extension Programme Phase II is harmonizing various extension efforts and expanding coverage to forty of forty-five districts, including arid and semi-arid lands (Harris and Muthugu 1992).

The extension system receives high marks from Kenyan researchers for its willingness to collaborate with them. Cooperation between the Ministry of Agriculture, KARI, and the Horticultural Crop Development Authority (HCDA) are excellent at the national level. Crop protection researchers maintain a linkage to farmers and extension through advisory services, including plant clinics at the National Agricultural Research Laboratories (NARL). Every province and district has a horticultural extension officer assisted by field officers from the HCDA. Nonetheless, this research-extension-farmer interface is tenuous as regards pest management, leaving room for salesmen to be influential (G. Kibata, personal communication, 1994).

The agricultural extension service is underfunded (PCAK, personal communication, 1995), and its service to farmers apparently leaves much to be desired. According to Harris and Muthugu (1992), most vegetable growers, many of whom are smallholders, receive poor service. Technical literature does not appear to penetrate beyond senior extension agents. Fruit growers also cite poor horticultural extension as a major production constraint (Wenner and Escudero 1994). Similarly, medium-sized flower growers often disregard extension officers, saying they know more than the officers do (R. Malik, personal communication, 1994). Many small and medium-sized exporters operate with little understanding of the export marketplace, including pesticide-related regulations.

Extension coverage is weak. A survey of 150 farming households conducted in Kendu Bay and Oyugis Divisions in western Kenya in 1986 revealed that extension services were inadequate for the majority of farmers in both divisions. Eighty percent of Kendu Bay's farmers and 30 percent of Oyugis's farmers never received extension visits, and 76 and 29 percent of those visited, respectively, did not think the visits were useful (Saxena et al. 1989). Hassan and Corbett (1993) found that extension fails to reach more than 40 percent of maize farmers.

A possible contributing factor is that women are in charge of a sizable number of maize-producing households. Extension and credit service coverage of female farmers is particularly inadequate. In 1992, 64 percent of male maize farmers but only 55 percent of female maize farmers had ever been contacted by an extension agent (Hassan and Salasya 1993). This is not surprising. Kenya's agricultural establishment, like that of many countries, is male-dominated.

According to USAID (1992), only 25 percent of extension staff and 48 of 532 KARI's scientists are female.

2.4.2. Legislation and enforcement of regulations

Although legislation, regulations, and registration procedures exist, pesticide use in Kenya is largely uncontrolled. Economic reforms do not appear to have influenced this situation. The Pest Control Products Board employs only a handful of professional staff to cover all of its responsibilities and needs to be strengthened. Indeed, a comprehensive field study of pesticide use in East Africa in 1989–1990 concluded that "existing regulatory mechanisms are ineffective and require a thorough review" (Mbakaya et al. 1994). As is the case in most African countries, the enforcement of pesticide regulations in Kenya is unlikely to be realized without significant additional support and technical assistance.

The Pest Control Products Act of 1982 and related regulations govern pesticide use in Kenya (Government of Kenya 1985). The regulations predate the Food and Agriculture Organization's (FAO) *International Code of Conduct on the Distribution and Use of Pesticides* (hereinafter referred to as the International Code of Conduct) and are largely but not entirely consistent with it. The Pest Control Products Board is responsible for implementing the pesticide regulations, including pesticide registration. The fourteen-member board draws expertise from many quarters, including two farmers, a representative of the Pesticide Chemical Association of Kenya (PCAK), and scientists from KARI and the Ministries of Water, Environment, Health, and Agriculture. Kenya's eight-person Pesticide Registration and Pesticide Disposal Committees are drawn from among the members of the Pest Control Products Board (G. Kibata, personal communication, 1994).

Pesticides are registered by crop, normally for a three-year period, on the basis of toxicological and environmental data collected abroad and efficacy tests conducted in Kenya. KARI, the Coffee Research Foundation, and the Tea Research Institute are among the government institutions that conduct efficacy testing. Previously, three seasons of testing were required; present requirements depend on how much is already known about a given chemical (G. Kibata, personal communication, 1994). The list of registered products is revised constantly and is not a matter of public record (K. Mogoi, personal communication, 1994).[1] A few chemicals are officially banned or restricted (Appendix A).

[1] When this report was being drafted in mid-1994, not even representatives of international lending organizations and donor agencies had been able to obtain information on Kenyan pesticide registrations. It is highly unusual for registration to be kept confidential. This confidentiality is disturbing because regulators cannot be held accountable by the public for their decisions regarding a commodity that not only is valuable but also affects human health and the environment. In February 1995, however, a representative from PCAK wrote that the Kenyan pesticide registration list had subsequently been made freely available.

Pesticides are normally imported through agrichemical companies, subject to an import permit which the Pest Control Products Board issues (Government of Kenya 1985). Kenya is a signatory to the international Prior Informed Consent agreement concerning proposed shipments of hazardous pesticides.[2] As the designated national authority for pesticide import decision making, the Pest Control Products Board can choose to import Prior Informed Consent chemicals. Enforcement of import restrictions at ports of entry is apparently poor (Partow 1992).

A standing technical committee comprised of specialists from KARI, the Ministry of Agriculture, universities, museums, and, sometimes, the International Centre for Insect Physiology and Ecology (ICIPE), is developing guidelines for the import and export of all types of biopesticides in response to import requests from the private sector. Decisions have been ad hoc thus far (G. Kibata, personal communication, 1994).

Pesticide manufacturing as well as storage and sales premises are to be licensed annually, but the adequacy of government storage depots varies and most retailers' storage facilities are inadequate (Pierrard 1992). Salespeople, many of whom are incapable of advising customers properly, sell highly toxic, outdated, restricted, and banned chemicals for general use (Partow 1992).

The regulations also address pesticide labeling, advertising, and packaging. The use of pictograms on labels was initiated recently in Kenya. Pesticide adulteration and mislabeling (including forged labels and repackaging or decanting into unlabeled containers) are common, especially at dealers' and users' levels (H. Muhia, personal communication, 1994). No Kenyan pesticide labels are written in local languages, and many lack required instructions in Swahili. A field survey in 1991 found widespread infringements of label regulations, such as failure to indicate safety recommendations, information on first aid, preharvest intervals, and advice on the disposal of used containers. Commercial advertisements often infringe the International Code of Conduct through lack of hazard warnings, invalid safety claims, and the depiction of unsafe practices (Partow 1992). Improvement is needed in the size and quality of Kenyan pesticide containers (Pierrard 1992).

The PCAK, an associate member of GIFAP, was created in 1959 and had fifty-five members in 1992, including international pesticide manufacturers as well as local distributors. GIFAP member companies are required to sign the International Code of Conduct, and GIFAP plans to improve pesticide management in Kenya by raising professional standards and encouraging better training for farmers. Kenya is a pilot country for GIFAP's Safe Use Project, a major pesticide safety training initiative (Box 1).

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[2] The Prior Informed Consent provisions in the International Code of Conduct, added to the Code in 1989, directly address trade. Under Prior Informed Consent, governments may register a refusal to allow the import of pesticides that have been banned or severely restricted in other countries for health and environmental reasons, or which cause health or environmental problems under the conditions of use in developing countries (Dinham 1993).

Subregional collaboration among neighboring countries facing similar pesticide regulation problems would help them implement the International Code of Conduct. Possibilities include the harmonization of regulations and requirements for registration, the sharing of data collected on topics of mutual interest, exchange of information on unwanted but unexpired pesticide stocks, and the optimum use of scarce expertise. Despite the desirability of such a system, it has not yet been developed (FAO 1993a, 1993b).

Box 1. Pesticides and safety training in Kenya

Kenya is a pilot country for GIFAP's Safe Use Project, a major pesticide safety training initiative. The Kenyan Pest Control Products Board and the national training and visit extension program are the chief counterpart agencies. The three-year project, which began in 1991, reflects the agrichemical industry's realization that pesticide-use patterns in developing countries must be perceived as capable of improvement.

In order to address all aspects of using pesticides safely, the Kenyan program has trained over 2,000 pesticide retailers, 2,000 agricultural extension officers, and 250,000 farmers (via the extension service). Training emphasizes understanding pesticide labels, handling and storage of pesticides, calibration and use of spraying equipment, and the hazards of using pesticides. The project has established five pilot poisoning treatment centers, sponsors a popular series of weekly radio programs (*Use Pesticides Safely*), and has inventoried Kenya's stocks of unwanted agrichemicals and earmarked them for appropriate disposal.

Both GIFAP and PCAK consider the Kenyan program a success. An interim audit survey conducted in early 1993 showed significant improvement in farmers' knowledge and attitudes about pesticide safety, though much remains to be done. The project has been embraced eagerly by exporters of agricultural commodities who wish to respond to the challenge posed by maximum residue levels. Many other African countries have requested that the project be expanded to include them.

Nevertheless, the sustainability of the initiative is an issue. GIFAP has not assumed long-term responsibility for this level of pesticide stewardship and is now challenged to find other sources of support for continuing the project in Kenya. In addition, GIFAP members may not be willing to fund project implementation in other countries.

Critics can cast doubt on the quality and impact of the Safe Use Project by citing the shortcomings of government extension services and the self-interest of the agrichemical firms that evaluate and publicize it. Be that as it may, safe and judicious pesticide use, including integrated pest management implementation and compliance with maximum residue level regulations, will be impossible without many years of increasingly sophisticated training aimed at even larger audiences. The resources and expertise of agrichemical firms are valuable in this regard.

Sources: GIFAP, 1994a, 1994b; P. Guenette, M. Owino, D. Rocco, personal communications, 1994.

2.4.3. Pesticide laboratories

KARI's Pesticide Residue Laboratory, part of the NARL at the headquarters of the Kenya Agricultural Research Institute in Nairobi, was established in 1971. The equipment became outmoded by 1979. Until 1992, the facilities were used only for the Pest Control Products Board's quality control of marketed products. No such work has been done recently, but the laboratory is moving to a large new building with a quality-control wing and a backup generator.

A joint crop-protection project of KARI and the United Kingdom's Overseas Development Administration (ODA) has provided new equipment and training since 1992, and this has given the laboratory the capability to analyze pesticide residues. Human resources are still a limitation. The residue laboratory can not yet monitor insect growth regulators but can detect most other agricultural chemicals, including organochlorines, pyrethroids, most herbicides, and phosphorous and sulfur compounds.

Several research projects are underway: the degradation of postharvest insecticide dusts because insecticide overdosage in storage is frequent; herbicide leaching in soil, particularly chlorsulfuron, a urea herbicide used in wheat; preharvest intervals for French beans; and collaborative work with the pyrethrum board on pyrethrin residues in tea as part of the evaluation of pyrethrin as a possible replacement for permethrin and deltamethrin. In addition, staff members of the Mwea Irrigation scheme have asked the laboratory to analyze water and fish for the insecticides and fungicides its farmers use because knapsack sprayers are filled at the source of drinking water, and the pesticides are mixed nearby. The laboratory is also helping investigate the possible translocation of pesticides into Lake Naivasha from the many horticultural farms around the lake (see section 3.3).

The residue laboratory's capacity for other purposes is limited since priority is given to KARI's research. Nevertheless, a small number of random farm and market samples (about 170 in 1993) are taken of four crops chosen on the basis of the amount and frequency of pesticide applications they receive: cabbages, kale, tomatoes (high local consumption), and French beans (exported, many pesticides used). Tomatoes are tested for the fungicide mancozeb, which is often visible on marketed produce. This project is implemented in collaboration with the HCDA, which directs sampling to areas of high pesticide use: four districts in Central Province, Nakuru in the Rift Valley, four districts in Eastern Province, and one in the Coast Province. No sampling is being done in the Western, Nyanza, or Northeastern Provinces. Special attention is being paid to Tanzanian border areas and the use of smuggled organochlorines.

Tomatoes frequently carry excess levels of mancozeb, but no problems have been reported for French beans. However, the number of samples taken is too small for trends and most problem use patterns to become clear. The new laboratory facilities should allow the number of samples to increase to a maximum of thirty per week (J. Ngatia, personal communication, 1994).

The HCDA would like to have access to laboratory services for the testing of pesticide residues and has approached KARI about processing produce samples for payment. The present staff and facilities are inadequate for that purpose, but the joint KARI-ODA crop-protection project is interested in developing the necessary laboratory capabilities and imposing gazetted charges (P. Kimweli and J. Sutherland, personal communications, 1994).

The pesticide residue laboratory does not collaborate with the Ministry of Health or share information except for routine circulation of the NARL's annual reports. Although these reports discuss pesticide residues, the Ministry of Health apparently has never asked for further information (J. Ngatia, personal communication, 1994).

The Kabete campus of the University of Nairobi has a toxicology program and has just established one for environmental chemistry. Kenyatta University also has an analytical laboratory. Firsthand information about university laboratory capabilities was not available because of a university strike. Informants believe that both facilities and staff capabilities at the universities need to be upgraded (A. Latigo, J. Ngatia and J. Sutherland, personal communications, 1994).

2.4.4. Disposal

Although some facilities for the disposal of unwanted pesticide stocks exist in Kenya (PCAK, personal communication, 1995), the disposal of obsolete pesticides and empty containers remains a problem. Pesticide drums and small plastic pesticide containers are often reused as containers for farm and household products, including for food and drinking water (Partow 1992).

2.5. Alternative technologies, approaches, and enterprises to promote reduced pesticide use in Kenya

Although there are IPM-related research initiatives underway in both the public and private sectors, coffee is the only Kenyan agricultural commodity for which a functional IPM system has been developed. Relatively few Kenyan farmers grow produce for the organic market. Although organic farming depends on nonchemical pest control measures that can be useful to all farmers, government institutions have made little effort to involve organic farmers in their crop protection programs.

2.5.1. Status of IPM in Kenya

Kenya's current national development plan cites IPM as the desired crop protection approach (A. Kiss, personal communication, 1994). In response to intensifying problems caused by pesticide overuse (pesticide resistance, pest resurgence, and the emergence of secondary pests), focused research throughout the 1980s produced an IPM system for coffee (Box 2). This success was the product of political will expressed as sustained research funding, a strong research-extension-farmer interface, and cultural and socioeconomic acceptance. The new pest management approach is being promoted through monthly coffee circulars, bulletins, leaflets, farmer field days, and training courses.

Apart from the new coffee initiative, crop protection based on pesticides is still dominant. Work is being carried forward now on IPM for cotton, cereals, fruit crops, and vegetables. To the extent possible, nonchemical pest control measures such as crop rotation, the planting of pest-resistant cultivars, field sanitation, and manipulation of planting dates already figure in recommendations to growers. The Ministry of Agriculture's *Horticultural Crops Protection Handbook* (Beije et al. 1984) takes a balanced approach, placing information on preventive and nonchemical pest-management measures before chemical recommendations.

Box 2. Components of the IPM system for Kenyan coffee

Host-Plant Resistance. Current research is focused on pest-resistant coffee. Recently a high-quality Arabica hybrid named Ruiru 11 was released. Ruiru 11 is considered a breakthrough because it is completely resistant to the two major coffee diseases, leaf rust and coffee berry disease.

Cultural control measures. Mulching controls thrips, while pruning for open tree canopies reduces numbers of *Antestia* bugs.

Biological control measures. A wasp parasitoid which was introduced from Uganda, *Anagrus kivuensis*, controls the coffee mealybug. Other parasitoids and predators attack scale insects, giant looper, and leaf miners. Pruning of overhanging branches and insecticidal banding of tree trunks prevent black ants from tending honeydew-producing scale insects on the coffee trees, giving predatory insects such as ladybird beetles the opportunity to keep such pests under control.

Mechanical control measures. The yellow-headed borer is removed from coffee branches by inserting a sharp wire into their feeding holes.

Chemical control measures. The use of organochlorine and broad spectrum organophosphate insecticides has been discontinued. They have been replaced by more selective insecticides and application methods, used only when pests attain an economic threshold level. For instance, some producers have moved from as many as 14 calendar sprays per year against leaf miners to regular crop monitoring and spot applications as needed, significantly reducing pesticide use. Granular formulations of systemic insecticides (e.g., disulfoton applied to the soil) have replaced foliar sprays for control of leaf miners. Similarly, bait sprays (insecticide plus an attractant) are applied on selected trees to control fruit flies and chemicals that regulate insects' growth (antimoltants) keep the giant looper in check. This approach avoids unnecessary destruction of the natural enemies that suppress populations of the major coffee pests.

Sources: Partow 1992; Kibata 1993; P. Guenette and D. Rocco, personal communications, 1994.

Alternatives to intensive cattle dipping are being researched and developed. Although "true" vaccines against many important tick-borne diseases have yet to be developed fully, recent research has shown that infection-and-treatment "vaccines" can be effective (Morzaria et al. 1988; Young et al. 1990). Costs for such methodologies have ranged from US$2.50 to US$20.00 per head for lifetime immunity (Mukhebi et al. 1990). Further, research on heartwater has shown that dipping frequency can be reduced markedly by using an economic damage threshold (Meltzer and Norval 1993). In such a scenario, epidemics of tick-borne diseases are prevented by managing tick populations to ensure that all calves are challenged by tick-borne diseases at an early age. Challenge at an early age maximizes the calves' chances of being immunized naturally (Meltzer, Norval, and Donachie 1994).

2.5.2. Research on crop protection

Research at most Kenyan institutions (e.g., KARI, the Coffee Research Foundation, and the Tea Research Institute) and at ICIPE is oriented toward IPM. In general, host-plant resistance and cultural and biological pest control are receiving increased attention, though host-plant resistance is a lower priority in KARI's cereal breeding programs than yield and early maturity (R. Hudgens,

personal communication, 1994). At KARI, emphasis is shifting away from basic research toward adaptive on-farm research for which scientists, farmers, and extension officers collaborate in problem identification, experimentation, and technology adoption.

KARI's headquarters are in Nairobi, and it has several donor-supported research centers in other parts of Kenya. The Institute's crop-protection coordinator, whose pest management unit is based at NARL in Nairobi, has a central program there and also works with scientists at the research centers.

The crop-protection coordinator is the counterpart officer for the joint KARI-ODA crop-protection project. This project is an institutional-strengthening effort with a full-time advisor and technical support from specialists in the United Kingdom. Forty-four Kenyans are being trained, including nine Ph.D. students. Research support is a major focus of the project. Research priorities are still being developed, but they include Irish potato in high potential areas, sweet potato in high-rainfall areas, smallholder flower production, and insect-transmitted vegetable viruses, with an emphasis on disease-resistant cultivars and augmentation of natural enemies of vectors. Control of the parasitic weed *Striga* cuts across commodity and research center mandates. Work on this problem is proceeding at Katumani and Kibos research centers in collaboration with colleagues from CIMMYT (Sutherland 1993 and personal communication, 1994). Cox (1994) has compiled a list of pesticide-related strategic research needed to support horticultural production in Kenya.

A KARI-CIMMYT survey of maize farmers in 1992 perceived production constraints identified *Striga* and other weeds, disease control (especially head smut and streak virus), and field and storage pests (especially stalk borers) as three of the top five priority problems recommended for KARI's research. Farmers had observed relatively high tolerance to *Striga* in certain maize cultivars, as well as some tolerance to head smut, drought, and lodging (Hassan, Corbett, and Njorge 1993).

KARI's National Horticultural Research Centre at Thika has seven sections (vegetables, beans, fruits, Macadamia nuts, crop protection, postharvest, and Socioeconomics) and several plant protection scientists. One entomologist specializes in bean IPM and another in fruit pests. There is also a plant pathologist on staff. Although Asian vegetables (e.g., cucurbits, chillies, okra, eggplant) are important export crops, only one research officer covers them. The Asian vegetable work is mostly agronomic, and there is little breeding activity. Plant protection staff help with farmer's field pest problems on Asian vegetables on an ad hoc basis (KARI staff, personal communication, 1994).

A 1991 national horticultural research review workshop designated plant protection as a priority topic. Organic crop production is not considered to be a high priority, and KARI's scientists have no interaction with organic farming groups. Although research at Thika on vegetable pest and disease management is supposed to be oriented to IPM, current research strategies are biased strongly toward pesticide use because of limited resources and inadequate research facilities. Biological control is relatively undeveloped although the natural enemies

frequenting major crops are known. No programs exist for the augmentative release of parasitoids and predators. Host-plant resistance to pests is largely unexplored, inhibited by a strong market preference for certain cultivars and overdependence on imported seeds. Concern about pesticide residues has stimulated work on agronomic practices (e.g., changed plant populations, water management, and intercropping) that might reduce pesticide requirements (Kibata 1992).

USAID has begun to fund KARI's horticultural research through the second phase of a multidonor National Agricultural Research Project (NARP) and is planning to share support of plant protection research for fruit and vegetables with the German Agency for Technical Cooperation's (GTZ) IPM–horticulture project (see section 4.3.1.1). This should be beneficial because the horticulture advisor associated with USAID's Midamerican International Agricultural Research Consortium (MIAC) has been attempting to identify routine packages for pesticide application for recommendation to growers. Among the topics proposed for the IPM–horticulture project are IPM for French beans, *Brassica* insect pest control, and the economics of pesticide use in horticultural crops. The project emphasizes biological control methods and the necessity for African exporters to comply with European maximum residue levels (Lohr 1993; R. Malik, personal communication, 1994).

Horticultural expertise is also available at Kenyan universities. Jomo Kenyatta University of Agriculture and Technology has a horticulture department (including one floriculture lecturer). Egerton University has a horticulture department, and the University of Nairobi's Kabete campus has a crop science department. No Asian vegetable work is undertaken (KARI staff, R. Malik and J. Ondieki, personal communications, 1994). Linkages between KARI's research programs, the universities, and the Central Bureau of Statistics need to be strengthened. All three institutions have data and research capacities relevant to farming systems in Kenya and elsewhere in the world--information that must be available and interpreted for the guidance of agricultural research and extension (USAID 1992).

The floriculture program at the National Potato Research Center in Tigoni began in 1980 under the guidance of the present MIAC horticulture advisor, who is a floriculturalist. Some variety trials were conducted before the program became relatively quiescent for nearly a decade. Several varietal evaluation experiments, which include scoring for vulnerability to insect pests and diseases, are now underway. The ODA is sponsoring a KARI researcher who is working on crop protection for smallholder flower growers (J. Sutherland and R. Malik, personal communications, 1994).

ICIPE's leadership changed in 1994, and this should allow the Centre to recover from a long period of mismanagement during which it lost its original standing as a productive world-class research institution. ICIPE's research focus is the nonchemical control of insect pests that attack subsistence food crops (sorghum, maize, and cowpea) and spread human and animal diseases. Approaches investigated include intercropping and other cultural practices, plant resistance to pest attack, and biological control and behavioral manipulation of insect pests. Farmer participation is emphasized, and ICIPE collaborates with KARI. ICIPE's current programs include work with rural women on controlling malaria with insecticide-impregnated bed nets,

involving rural farmers in the control of tsetse flies using traps, and biological control of maize stem borers (Saxena et al. 1989; J. Ondieki and W. Overholt, personal communications, 1994).

Some of Kenya's large-scale flower and vegetable exporters are initiating research on IPM in response to pesticide-related market concerns in Europe. Kenya's importation guidelines are to be developed so that beneficial insects produced in Europe can be tested in horticultural farms as biological control agents (J. Allard and N. Visser, personal communications, 1994). The International Institute of Biological Control (IIBC) has a contract with a carnation grower at Lake Naivasha to develop IPM systems for controlling red spider mite (the worst problem), thrips, *Helicoverpa*, rust, and leaf spot (B. Nyambo and G. Allard, personal communications, 1994). Similarly, ICIPE has been advising larger flower exporters. This has led to current plans for the Fresh Produce Exporters' Association of Kenya (FREAK) to publicize IPM as an economically viable conservation measure (P. Guenette, personal communication, 1995). It is not clear whether knowledge generated by this privately funded research will be made public.

2.5.3. Regional cooperation

As noted above, Kenya participates in the GTZ's regional IPM horticulture project and the FAO's regional project for management of the larger grain borer, *Prostephanus truncatus*, a serious introduced pest of stored maize and cassava. This pest, accidentally introduced into Tanzania in the late 1970s, has already spread into Kenya. In order to avoid disruption of regional maize trade, Kenya must ensure that its exported maize is free of live beetles. This requires strengthening grain management systems, including inspection and special control procedures in maize stored for export. Periodic surveys of beetle distribution are necessary. GTZ funds work on the extension of chemical control methods. The KARI–ODA crop-protection project will investigate IPM methods as part of an ODA-funded research program conducted in Togo, Mexico, and the United Kingdom (Tyler et al. 1990).

Kenya is a member of the African Regional Pest Management Research and Development Network for the integrated control of crop pests and livestock disease vectors, better known as "Pestnet," coordinated from ICIPE. Pestnet's objective is to unite the national IPM research programs of twelve countries, promoting collaboration in research, training, and information exchange so that scarce resources can be used to full advantage. The network publishes a newsletter, *Network News*, and listings of new acquisitions of ICIPE's Library and Documentation Services, as well as convening conferences (J. Ondieki, personal communication, 1994). Pestnet's activities have been curtailed sharply in recent years, however, due to budget constraints.

2.5.4. Producing for the organic market

Growing organic produce for export is still in its infancy. It has been undertaken thus far by a few innovative farmers with the assistance of private market contacts. Government agencies have not supported organic farming until recently, and that support is modest.

In the past there was friction between the Kenya Institute of Organic Farming (KIOF) (see section 4.3.1.3) and Kenyan agricultural agencies. Extension agents dislike being badgered by farmers for training and information on alternatives to expensive pesticides because the agents do not have the knowledge to comply. In contrast, skeptical researchers at KARI have demanded data on the economic competitiveness of organic production, and KIOF does not yet have that information. Collaborative activities between KIOF and government agencies are just now in the embryonic stage, consisting of some collaborative research as well as demonstrations, training, and follow-up conducted jointly with the extension service.

Partly in response to questions that KARI posed, KIOF initiated a research component in 1992 and is developing a resource center. An on-farm economic comparison of production of farmers associated with KIOF with that of farmers supervised by government agents was completed in 1994. The focus is composting and double-digging as opposed to the application of fertilizers and manure. Animal husbandry practices and crop protection are to be addressed later (van der Werf 1993). Crop protection research will probably center on a comparison of the relative costs of locally produced botanical pesticides and conventional pesticides applied to protect vegetables such as green beans, kale and cabbage. KARI and KIOF are testing neem-based pesticides in collaboration with an Asian businessman.

Donor projects, in general, appear to have made little effort so far to investigate potential markets (European or domestic) for Kenya's organic produce or to provide organic growers with specialized information, training, or technical assistance. Although USAID's Kenya Export Development Support (KEDS) Project did not include Europe's organic markets in an initial series of market surveys (T. Hobgood, personal communication, 1994), such markets were the topic of subsequent market inquiries. The information gathered was shared with exporters in a "Herbs and Spices" seminar in August 1994. A consultant producer/wholesaler broker visited farms and evaluated the feasibility of organic exports. Initial research has indicated that the United States has the strongest potential for organics. Despite this finding, transport costs and certification problems may obstruct Kenya's export of significant quantities of organic products (P. Guenette, personal communication, 1995). A staff member of the HCDA, which works with the KEDS Project, underwent training recently at KIOF. Nevertheless, some HCDA officers remain skeptical about the quality of organically grown produce (P. Kimweli, personal communication, 1994).

3. Health and Environmental Impacts of Pesticide Use

3.1. Hazardous pesticides

Many publications describe pesticide availability, use patterns, and recommendations in Kenya (Beije et al. 1984; Moll and Lohding 1984; Government of Kenya 1989; Saxena et al. 1989; Morzaria et al. 1988; Young et al. 1990; Malik and Njenga 1992; Partow 1992; Darling 1993; Kibata 1993; Malik 1993; Mwanthi and Kimani 1993; Mbakaya et al. 1994; *Daily Nation* 1994b). Many pesticides in circulation for general use, including several which Japan donated to Kenya recently (see section 4.2.3), have been cancelled or designated as restricted-use chemicals in the United States because of health or environmental hazards. For example, fully half of the pesticides Kibata (1993) terms "popularly used" for vegetable production fall into this category. Appendix C summarizes hazards presented by pesticides used on coffee, tea, maize, and horticultural crops, and for livestock dipping.

3.1.1. Organochlorine insecticides

The carcinogenicity, reproductive effects, and other chronic effects associated with a high body burden of organochlorine pesticide residues are of concern with reference to humans as well as to wildlife (U.S. Environmental Protection Agency 1990). Widely used in Kenya for agriculture and public health from the mid-1940s through the late 1970s, these pesticides have been officially banned or confined to restricted uses since 1986 (Appendix A; Mugachia, Kanja, and Maitho 1992).

In spite of these restrictions, field surveys indicate that organochlorines were widely available and commonly used by smallholder farmers as recently as 1992. A field study conducted in East Africa in 1989–1990 by researchers belonging to the East Africa Pesticide Network Group found dieldrin, endosulfan, and DDT being used on a wide range of food and cash crops in Kenya (Mbakaya et al. 1994). Consistent with those findings, all twelve stores of the Kenya Grain Growers' Cooperative Union monitored in the Rift Valley, Central, and Eastern Provinces for a 1991 field study were selling banned or severely restricted pesticides, among them dieldrin, aldrin, and lindane with general use labels, and DDT (Partow 1992). A survey conducted in Kiambu and Nakuru Districts in 1992 found DDT to be the most commonly used pesticide (Kamfor 1992, cited in Partow 1992). The Kiambu survey of Mwanthi and Kimani (1993) also named DDT among the most-used compounds.[3]

It appears likely that organochlorines are still in circulation, albeit less as old stocks have become depleted, and largely superseded by newer compounds. The origin of the organochlorines on the market merits investigation. Are longstanding stockpiles indeed still being exhausted? Are organochlorines restricted to public health use (DDT), seed treatment (lindane), and termite control

[3] Some farmers apparently use "DDT" as a generic term when referring to any pesticide, which could lead to mistaken conclusions.

(aldrin, dieldrin) finding their way to the open market for general use? Has the Kenyan Pest Control Products Board granted exceptions to pesticide restrictions prohibiting agricultural use, and are part of those stocks being diverted? Are illicit imports now responsible for most of the supplies on hand? If so, from where are they coming?

3.1.2. Methyl bromide

Methyl bromide is a highly toxic acute poison and also depletes the ozone layer. This chemical is thought to be responsible for approximately 10 percent of global ozone losses, which have reached alarming levels in many parts of the world. The resulting increased levels of UV-B radiation are expected to harm human health and natural ecosystems.

Kenya consumes large amounts of methyl bromide, a fumigant used to kill fungi, insects, and other pests in soil, perishable agricultural produce, and stored commodities. Approximately 300 tonnes are used annually. Producers of cut flowers, strawberries, and other export crops, most of them large-scale farmers, account for 70 percent of this consumption. The balance is used for fumigating storehouses and other structures (Schonfield, Wamukonya and Glendening 1994).

3.2. Health effects

Kenyan farmers typically wear no protective clothing when using pesticides and are generally ignorant of pesticide safety practices. Thus the risk of applicator poisoning is high. Synthetic pyrethroid insecticides appear to be implicated in some serious cases of intoxication even though they are believed to be relatively safe to humans (Forget 1991). Ugandan trade unions recently claimed that the widely used herbicide paraquat causes impotence among male workers, in addition to skin damage (Aryamanya-Mugisha 1993).

Organophosphate pesticides constitute the worst acute danger because of their relatively high toxicity. About 90 percent of 133 agrichemical poisoning cases treated at Kiambu District Hospital between 1987 and 1990 involved organophosphates (57 percent of cases were of undetermined cause, 35 percent were suicide attempts, and 8 percent were accidents) (Mwanthi and Kimani 1990). Similarly, organophosphates caused 446 of the 455 pesticide poisonings reported by district hospitals in 1989-1990 (Mbakaya et al. 1994).

A recent study estimated that of the seven million people in Kenya's agricultural sector, 7 percent (350,000) per year are poisoned by pesticides, at an annual economic impact of US$11.2 million (Choudhry and Levy 1988, cited in Mwanthi and Kimani 1993). Admissions to hospitals due to pesticide poisonings are much lower. Perhaps those numbers are comparatively low because they reflect only the most serious, acute cases (ignoring chronic poisoning) for which the cause of the victim's illness was apparent (neither farmers nor medical officers are well informed about the symptoms of pesticide poisoning when the victim lived close enough to a hospital for transport to be feasible (most farmers live too far from a hospital to seek medical help). Suicide attempts are likely to fit this profile.

This scenario is supported by Mbakaya and his colleagues' (1994) study of the 455 pesticide poisoning cases, including 46 deaths, reported in Kenyan in-patient district hospital medical records in 1989-1990. These records revealed that most poisonings of children were accidental, but most adults were poisoned because they attempted suicide. There was hardly any record of occupational poisoning. The study also found, however, that the majority of health-care providers interviewed were unable to recognize instances of pesticide poisoning.

Accidents are common because of the widespread re-use of empty pesticide containers for storing food and water and the decanting of pesticides into smaller, unmarked containers. A survey of 1,797 households in Kiambu District in 1987–1990 found that more than 60 percent of respondents stored agrichemicals in their living quarters, with almost 70 percent of the chemicals in unlabeled secondary containers (Mwanthi and Kimani 1993).

Some information is available on the long-term health effects of excessive exposure to pesticides in Kenya. Exposure to pesticides and other agrichemicals is implicated in the pathogenesis of childhood aplastic anaemia (Riyat, Kasili and Mwanda 1990). With regard to mercury-based pesticides, Meme et al. (1981, cited in Mwanthi and Kimani 1993) found elevated levels of mercury in the blood, as well as chronic mercury poisoning, of farmers and their families. Recent studies indicate that even single episodes of organophosphate poisoning can cause harmful medium- and long-term effects in humans (Senanayake and Johnson 1982; Senanayake and Karallidde 1987; Rosenstock et al. 1991).

Organochlorine residues have received the most scrutiny, although the human health implications of findings from Kenya can only be estimated. Samples from animals lower on the food chain than humans have shown the pervasiveness of residues, but seldom at concentrations exceeding maximum residue levels. Fish sampled from locations including the Athi River estuary, the Tana River, Lake Naivasha, and Lake Victoria over the last twenty years have contained a wide array of organochlorine residues, chiefly DDT and its metabolites (Mugachia, Kanja, and Maitho 1992). Most of the residue levels were within the acceptable range for the respective pesticides. Lindane residues in some carp captured above the Masinga Dam in 1989 were an exception, indicating that the dam could be acting as a sink for pesticides used in the Tana River catchment and a recently established irrigation scheme near the dam (Mugachia, Kanja, and Gitau 1992).

Samples of chicken fat collected from seven areas in Kenya between 1980 and 1982 contained residues of many organochlorine pesticides. A few samples had lindane, dieldrin, and total DDT residue levels above maximum residue levels, but for all pesticides the mean residue values were below maximum residue level (Kahunyo, Maitai, and Froslie 1986). One hundred five chicken egg samples taken from seven regions of Kenya in the mid-1980s contained residues of nine organochlorine compounds including aldrin, dieldrin, HCH, and DDT and its metabolites. High DDT contamination of 18 samples resulted in a mean DDT content of 0.68 ppm, exceeding the "practical residue limit" of 0.5 ppm. Individual and mean residue levels for the other pesticides were well within their respective residue limits (Kahunyo, Froslie, and Maitai 1988).

Organochlorine residue findings from humans in Kenya give cause for alarm. Kanja et al. (1986, cited in Kanja, Skaare, and Lokken 1991) studied 302 milk samples from human mothers in eight regions of Kenya. All the samples were positive for DDT and DDE, and fifty-three were positive for dieldrin. Residue levels were extremely variable. The authors calculated that, on average, mothers' milk exceeded the acceptable daily intake of DDT by eight times, while the samples positive for dieldrin exceeded the acceptable daily intake of dieldrin by an average of eighteen times. Commercial infant milk formulas sold in Kenya have been found to contain DDE and dieldrin on occasion, and regular surveillance of such products is needed (Kanja, Skaare, and Lokken 1991).

3.3. Environmental impact

All environmental pollutants including pesticides fall under the purview of Kenya's National Environment Secretariat (Pierrard 1992). Until recently there has been no systematic environmental monitoring in Kenya except that done privately (and confidentially) by floriculture operations. Few data on pesticide pollution are available (A. Latigo and D. de Treville, personal communications, 1994).

Lack of data does not necessarily mean the absence of problems. Regions with intense horticultural production (e.g., Nyeri and Lake Naivasha floriculture), especially lake wetlands and watersheds, are a particular concern. Many of these areas are among the most heavily populated in the country. Scientists and citizens' groups fear possible agricultural pollution of Lake Naivasha. The ODA has funded a study of pesticide residues in the lake area at the request of the Riparian Association. Agricultural runoff and streams that feed the lake are being monitored and sampling of lake water, sediments, fish, and crabs is planned. Thus far, pyrethroid insecticides have been found in runoff and streams (J. Ngatia, personal communication, 1994), and the soil sterilant aldicarb has been detected in at least one stream (A. Kiss, personal communication, 1994). Similarly, the Kenya Wildlife Service is involved in environmental monitoring around Lake Nakuru, a major horticultural center, because wildlife experts are apprehensive about possible pesticide effects on flamingoes and other animals in Lake Nakuru National Park (J. Else, personal communication, 1994).

Pest resurgences after intense pesticide treatment, which imply that natural enemies of the pests were decimated, have been reported in Kenya. Cotton bollworm, tobacco budworm, cotton aphids, spider mites, and looper caterpillars became increasing problems in cotton treated heavily with DDT and toxaphene in the Kitali region. In the Central Province, suppression of entomopathogenic fungi by the fungicide benomyl lead to increased survival of velvet bean caterpillars and cabbage loopers (United Nations Environment Programme 1987, cited in Partow 1992).

Cattle dip solution has always been added to the natural drainage system without any treatment. First arsenical compounds, then organochlorines were the standard acaricides for cattle dipping in Kenya. They have been prohibited now due to insect resistance and environmental hazard. The organophosphates and pyrethroids that replaced them are highly toxic but more

rapidly biodegradable. Maitai et al. (1975) described the investigation of the poisoning of cattle on a Kenyan farm. Postmortem examination showed that the toxic substances were arsenic and toxaphene. Arsenic was detected in water from an abandoned cattle dip on the farm, and soil samples collected near the dip contained both arsenic and toxaphene.

Other than such cases, little information exists about pesticide impact on nontarget species in Kenya. Many insecticides, herbicides, and fungicides that are used widely and considered relatively safe for applicators are extremely toxic to nontarget species such as birds, bees, and fish.

4. Economic and Policy Factors Affecting Pesticide Use

4.1. Economic factors

4.1.1. Growing population: The need to increase agricultural output

Kenya has had a population growth rate of almost 4 percent per annum in recent years. This growth rate is one of the highest in the world and is expected to remain unchanged through 2000, when the population will number approximately 38 million. Kenya's population will reach 83 million by 2025 if current growth rates continue (World Bank 1989). This situation means that there will be continued pressure on resources to produce ever larger amounts of food for internal consumption. The Government of Kenya is aware of this problem, as evidenced in the following quotation:

> The rapid population growth and a shortage of arable land in the main high potential areas create an imbalance in the relationship between the national supply of, and demand for food. The country no longer enjoys the advantage of regular surpluses of foodstuffs to cushion the impact of a fall in production in years of crop failure (Ministry of Agriculture, Livestock Development, and Marketing 1993)

Kenya has a formal National Food Policy. Under the heading of "Potential for Increasing Production," the policy states: "In order to maintain self-sufficiency in maize production up to the year 2000 and beyond, the strategy to be adopted will include intensification of production per unit area" (Ministry of Agriculture, Livestock Development, and Marketing 1993). The policy paper also declares that:

> During the next decade, however, expansion of food production will need to be based primarily on increases in yields. The aim is to start a "green revolution."
>
> This may be achieved by:
>
> · increasing intercropping,
> · increased multiple cropping,
> · improved soil analysis and increased and efficient use of fertilizers,
> · increased use of other inputs,
> · the progressive introduction of improved seeds and improved livestock breeds,
> · other improvements in cultural practices,
> · use of organic manures.

Agriculture is also vital to Kenya's economic development. For the past six years, exports of food and beverages have accounted for 50 to 60 percent of Kenya's exports (Central Bureau of Statistics 1993). Approximately 80 percent of the labor force is employed in agriculture (World Bank 1989).

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4.2. Crop production trends

4.2.1. Determinants of growth

The crop-specific relative importance of two determinants of growth and productivity, crop area and yields, are shown in Table 1. In the case of maize, increases in yields were more important than increases in area cultivated. Expansion in horticulture was due more to increases in area cultivated than to increases in yield.

Table 1. Determinants of growth: Expansion in area versus growth in yields

	1975–80			1980–88		
	Average growth in output	Share of total growth due to change in:		Average growth in output	Share of total growth due to change in:	
Crops		Area	Yield		Area	Yield
Maize	7.1%	17%	83%	4.3%	35%	65%
Wheat	2.6%	-82%	182%	2.3%	169%	-69%
Horticulture[a]	10.2%	63%	37%	8.8%	77%	23%
Coffee	4.4%	91%	9%	3.6%	127%	-27%
Tea	9.7%	42%	58%	7.3%	18%	82%

Source: Block 1992.
[a] An aggregate comprising 60 percent of the total value of horticultural crops.

Perhaps the most important constraint to continued growth in productivity is land. Kenya has 56.9 million hectares of land, of which only 9.9 million hectares (17 percent) are classified as high- or medium-potential (Central Bureau of Statistics 1991). About 60 percent of this high- and medium-potential land is devoted to crop and milk production, with the remainder used for extensive production and ranching. The 42.1 million hectares classified as being low potential are suitable for extensive farming and ranching (Government of Kenya 1993b). Most of the available arable land is currently cultivated, though there is some potential for expansion in the Nyanza and Western provinces and considerable tracts of land in the Rift Valley and Coast provinces are reported to be underutilized (Ministry of Agriculture, Livestock Development, and Marketing 1993).

Given the constraints on expansion of the area cultivated, future growth in crop production will depend primarily on the ability of Kenyan farmers to intensify production per unit area. Intensification may require the increased use of purchased inputs, including pesticides. Despite

this prediction, there is evidence of problems in delivering the needed inputs and technologies to farmers (see section 2.4.1).

4.2.2. Foodcrop production

The data in Table 2 and Appendix B both show that foodcrop production in Kenya has, on average, increased over time. The large differences between the high and low outputs for any given time period indicate the impact of poor growing conditions, primarily drought. Widespread drought is a fact of life in Kenya, and it can occur quite frequently. For example, the 1992–1993 agricultural season was the poorest since the 1984 drought, and 1993–1994 crops have also been ravaged by drought (*Daily Nation* 1994c, 1994d).

4.2.3. Trends in export crops

Three important points concerning export agriculture are revealed by Table 3, which lists the value of Kenyan exports over time. First, food and beverages have consistently comprised approximately 60 percent of the value of all exports. Second, coffee, tea, fruit and vegetables dominate the category of exports labeled "Food and Beverages." Third, the value of exported coffee peaked in 1986 and then fell, while the total value of exported fruits and vegetables has continued to grow. The overall trend of increase in the value of horticultural exports (current values) continues. Preliminary data show that horticultural exports for 1993 were worth K£235 million (*The Standard* 1994). These data establish horticulture as the second highest foreign exchange earner after tea. Given the relative importance of coffee, tea, and horticulture to Kenya's export economy, these crops represent some of the most important targets for increased production through intensification of production. Intensification may include the increased use of pesticides.

Given the dominance of coffee, tea, and horticulture in Kenya's export economy, it is important to consider the incentives to produce and to intensify production of these crops. One of the most important incentives is price. Trends in the constant prices for coffee, tea and horticultural crops are shown in Figure 1. The constant price of coffee has fallen since 1986, when there was a "mini coffee boom" on the world market (Central Bureau of Statistics 1989). Although coffee prices rose in 1988, prices fell again in 1989 and 1990 as the International Coffee Organization's quota scheme to stabilize prices collapsed. Constant tea prices also had a short-lived boom in 1984, but fell by approximately 25 percent the following year. Since then, constant tea prices have been stable relative to coffee prices. Export prices for horticultural crops have been available only since 1988. The data show that constant prices for horticultural crops remained steady between 1988 and 1992.

Table 2. Trends in foodcrop production in Kenya: 1970–1991

	1970/71–1978/79 ('000 MT)			1979/80–1984/85 ('000 MT)			1985/86–1990/91 ('000 MT)		
	High	Low	*Mean*	High	Low	*Mean*	High	Low	*Mean*
Maize	1,671	835	*1,313*	2,560	1,500	*2,123*	3,140	2,400	*2,790*
Beans	199	65	*130*	333	196	*278*	435	315	*381*
Millets	49	9	*27*	37	32	*33*	80	29	*51*
Sorghum	88	14	*42*	80	54	*65*	139	53	*92*
Bananas[a]	708	304	*577*	1,185	864	*1,044*	1,635	1,402	*1,551*
Groundnuts	38	5	*16*	20	3	*12*	23	5	*12*
Potatoes[b]	701	311	*520*	1,348	288	*660*	810	671	*779*

Source: Appendix B.

[a] Start data series at 1972–1973 and end at 1987–1988.

[b] Start data series at 1973–1974 end at 1990–1991.

Table 3. Value of exports from Kenya: 1982–1992

	Value of Exports (K£ millions[a])										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Food and beverages											
Coffee	145	160	204	231	388	195	245	204	221	218	206
Tea	78	123	189	191	173	163	185	272	315	382	475
Fruit and veg[b]	38	55	54	53	66	77	95	112[b]	160[b]	185[b]	209[b]
Subtotal	261	346	447	475	627	435	525	567	664	785	890
Other [c]	18	26	27	21	38	40	46	52	109	33	39
Subtotal	279	372	474	496	665	475	571	619	773	818	929
Basic Materials											
Sisal[d]	11	12	13	14	11	10	12	16	19	18	17
P. ext[e]	10	9	10	10	11	10	12	17	21	32	37
Petrol.[f]	150	135	143	128	108	104	119	127	153	255	236
Total Exports	546	633	755	785	958	753	918	1,000	1,23	1,53	1,70
Food & Beverage as % of total	51%	59%	63%	63%	69%	63%	62%	62%	63%	53%	54%

Sources: Central Bureau of Statistics 1989, 1991, 1993.

[a] K£1 = 20 shillings.

[b] Central Bureau of Statistics (1989) does not indicate whether this total includes cut flowers. The other sources do specify that horticulture includes cut flowers, and both sources list the value of processed and fresh vegetables and fruit.

[c] In Central Bureau of Statistics (1989) "other" includes live animals, meat and meat preparations, milk, cream, butter and ghee, eggs, fish and fish preparations, unmilled maize meal and wheat flour, animal feeds, beverages and tobacco, and other.

[d] Includes tow.

[e] Pyrethrum extract. Pyrethrum flowers are a separate category, included under "other."

[f] Includes petroleum byproducts, which are included under "other."

Coffee production

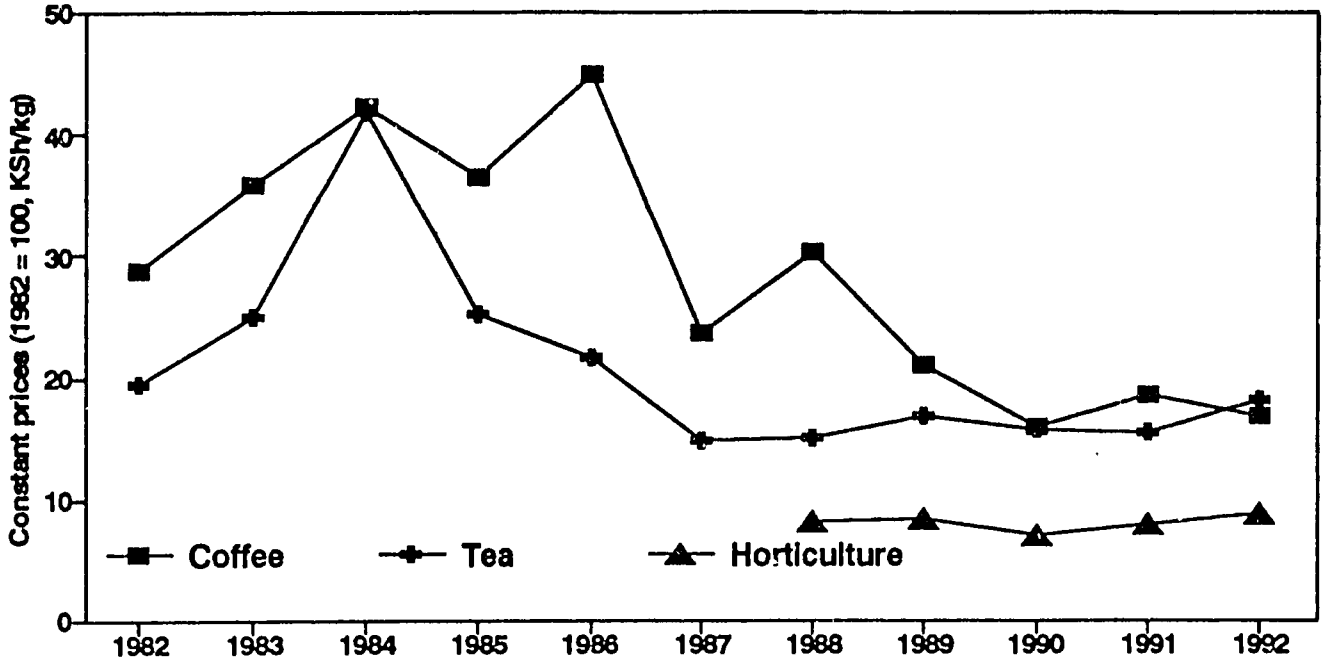
The impact of trends in constant prices on the production of coffee and tea are shown in Figures 2a and 2b. Coffee production generally increased from the early 1960s to the early 1980s (Figure 2a). However, although producer coffee prices continued to increase in the late 1980s (Figure 2c), the decline in the constant coffee prices (Figure 1) helped cause a four-year decline in production. Another factor causing the decline in coffee production is the shift in production from large estates to smallholders. In 1964, smallholders held 61 percent of the area planted to coffee and produced 34 percent of the total crop. By 1990, smallholders owned 75 percent of the coffee production area and accounted for 66 percent of total production (Gitu 1992). The average yield obtained by smallholders is only 597 kilograms per hectare (1987–1992), compared to 999 kilograms per hectare obtained on estates (Central Bureau of Statistics 1993).

Tea production

In contrast to coffee, the area planted to tea has increased slowly and rather steadily for almost thirty years (Figure 2b). Increases in output matched the increases in area until the early 1980s, when there was a noticeable relative increase in tons produced. This pattern indicates an improvement in yield per unit area. Given the fluctuations in producer prices (Figure 2c), price can not have been the sole stimulus for both the expansion in area planted to tea and the increase in yields. Part of the increase has been due to "improvements in physical infrastructure and elimination of crop deterioration, coupled with favorable weather conditions and better tea husbandry, [which] have resulted in the increase in yield and production, particularly by the small holder" (Central Bureau of Statistics 1989).

As in the case of coffee, small-scale farmers own most of the land planted to tea: approximately 66 percent of total tea area during the years 1988 to 1992 (Central Bureau of Statistics 1993). Unlike for coffee, the tea area planted by large estates has increased by 10 percent in the last five years. While this is still smaller than the 22-percent increase in smallholder tea area, the increase indicates that tea is considered a viable investment by both types of producers. Besides differences in production trends, tea production differs from that of coffee in that herbicides are the only pesticides used (see section 2.2.1). Thus, the increase in area and yield seen in Figure 2b only imply increases in herbicide use.

Figure 1. Constant export prices for Kenyan coffee, tea, and horticulture



Sources: Central Bureau of Statistics 1989, 1993.
Note: Prices were deflated using a weighted Fisher's Index of official exchange rates, using 21 exchange rates as of December 31 of each year.

Figure 2a. Area and production levels of Kenyan coffee

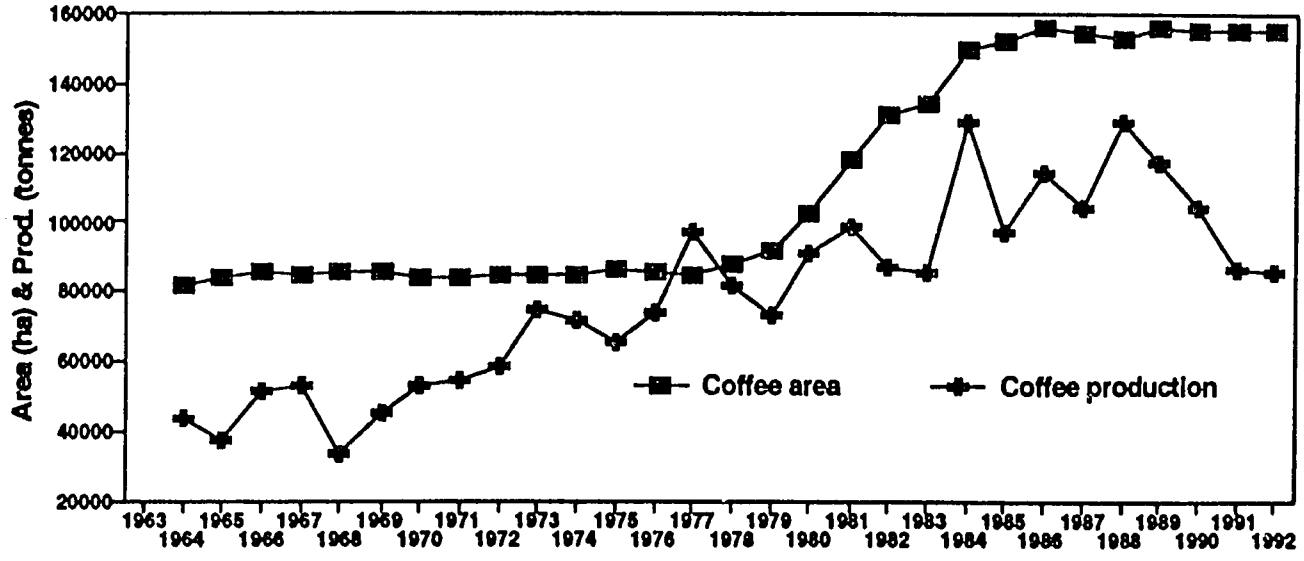


Figure 2b. Area and production levels of Kenyan tea

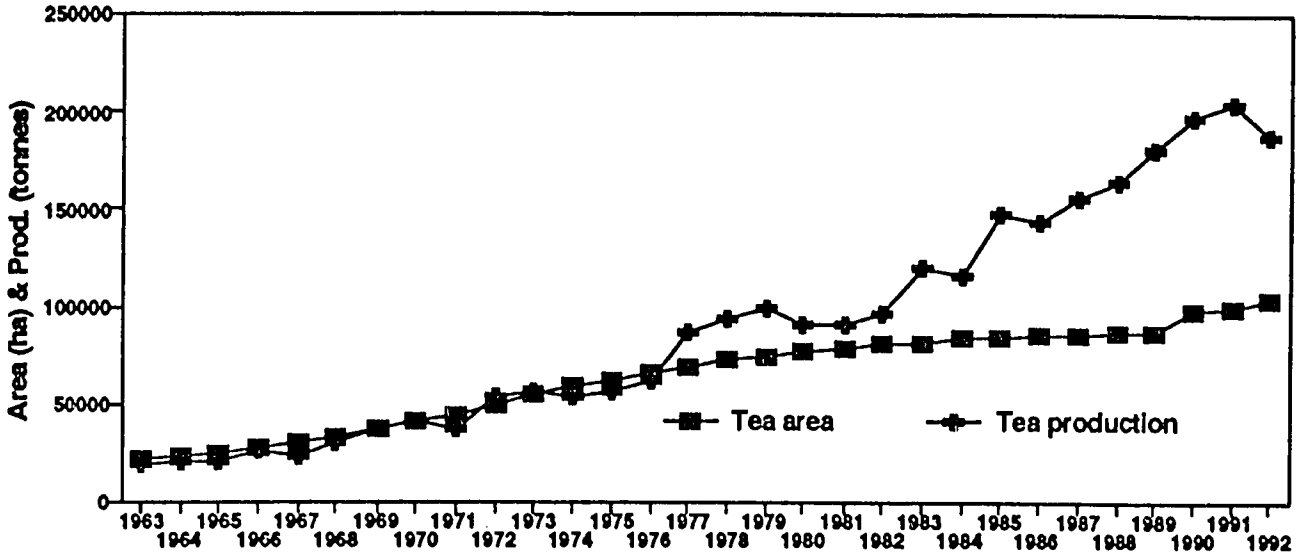
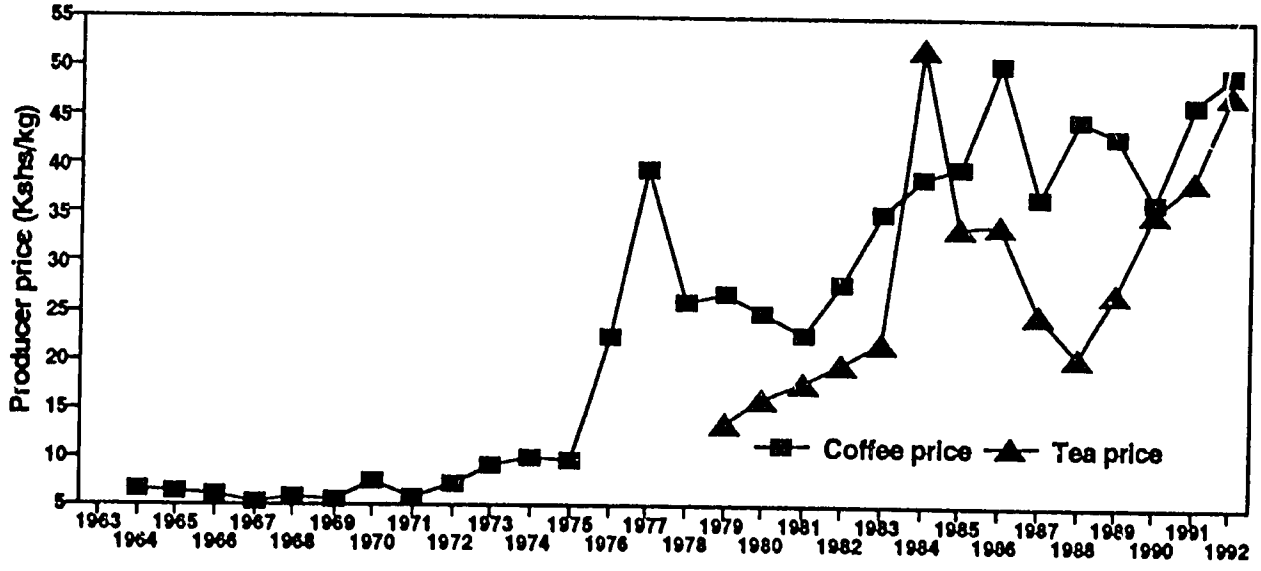


Figure 2c. Producer prices for coffee and tea



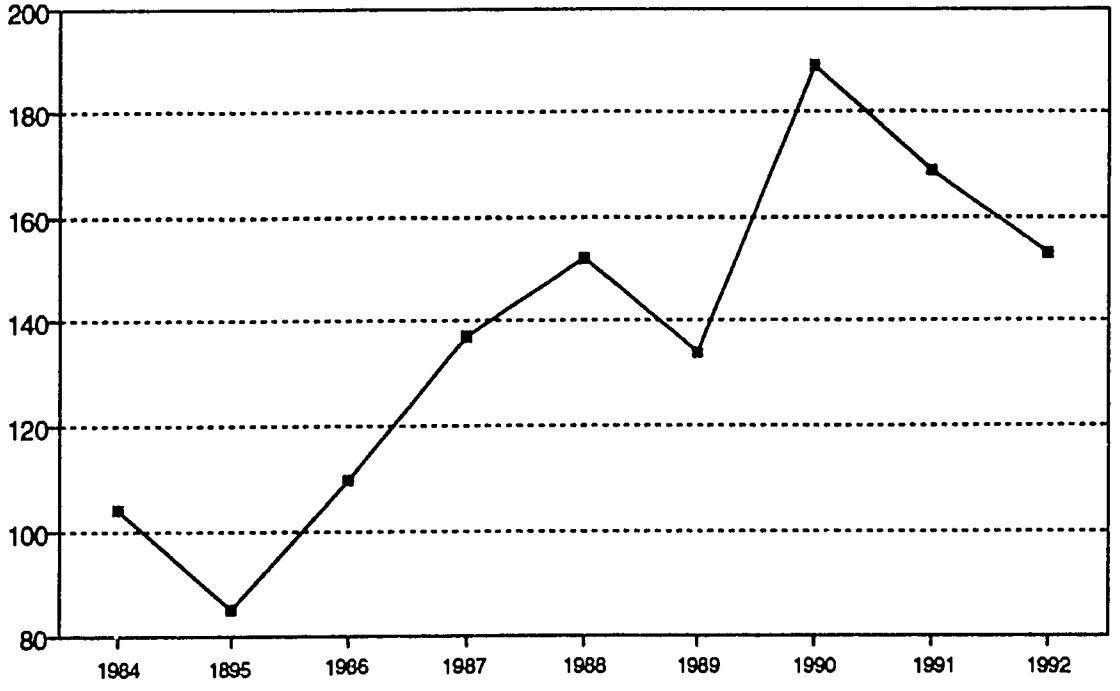
Sources: Gitu 1992; Central Bureau of Statistics 1986, 1993.

Production and export of horticultural crops

No readily available data exist to indicate the total area devoted to vegetable and fruit production or yields. Therefore, increases in horticultural exports have to serve as a proxy for measuring changes in horticultural production. The volume of horticultural exports over time are given in Figure 3. Obviously, exported horticultural products are only a certain percentage of all horticultural products produced in Kenya. There is considerable smallholder production for both household consumption and sale at local markets.

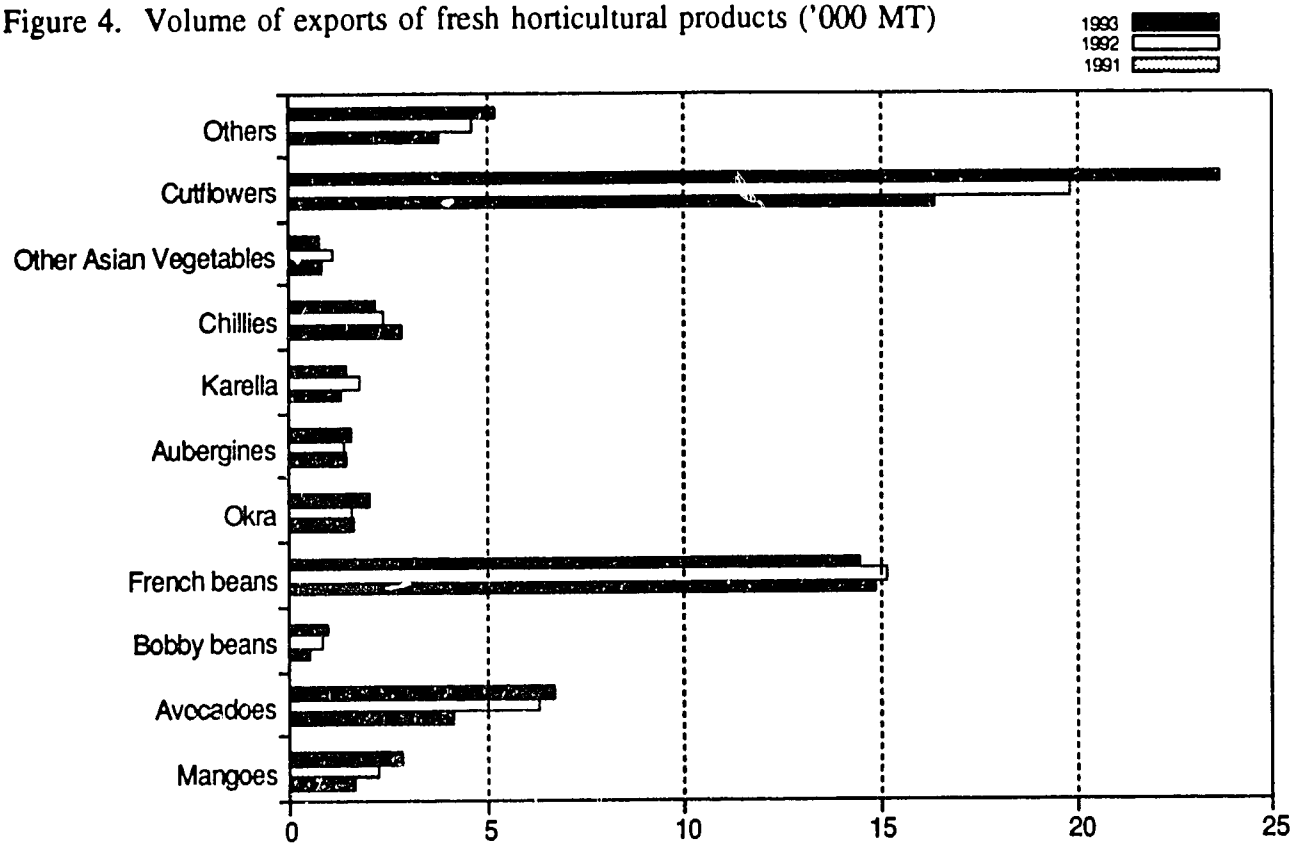
French beans and cut flowers represent approximately two-thirds, by volume, of all exports of fresh horticultural produce (Figure 4). Mangoes and avocados are the most important fresh fruits exported. The differences between the total amounts shown in Figures 3 and 4 are due to the export of processed horticultural produce. Two to three times more processed horticultural produce is exported than fresh produce. Canned pineapple dominates processed horticultural exports. Some of the decline in volume of exports (Figure 3) is attributed to oversupply, and a consequent fall in prices, on world markets for canned pineapple and the "immense expansion of competitive pineapple processing plants in South East Asia" (Harris and Muthugu 1992).

Figure 3. Exports of horticultural produce (volume '000 MT)



Sources: Central Bureau of Statistics 1989, 1993.

Figure 4. Volume of exports of fresh horticultural products ('000 MT)



Source: HCDA, unpublished data sheets, various dates.

[a] The category of "Others" includes pineapples, strawberries, passion fruit, melon, pawpaw, lemon/lime, miscellaneous fruits, capsicums, courgettes, tomatoes, leeks, carrots, miscellaneous vegetables, miscellaneous roots and snow peas. Asian vegetables included in the category of "Others," and excluded from the category of "Other Asian vegetables" include mooli, dudhi, valore, and guwar. Less than one MT of each of these items was exported in any one year from 1991–1993.

[b] Total is for fresh products only. The difference between the totals in Figures 3 and 4 is accounted for by exports of processed horticultural products.

Although there have been impressive gains in the value of horticultural exports, the volume of horticultural exports has reached something of a plateau in recent years (Figures 3 and 4). The total volumes of fresh horticultural produce exported in 1991, 1992, 1993, and 1994 were approximately 50,000 MT, 57,000 MT, 62,000 MT, and 65,000 MT, respectively (Figure 4 and P. Guenette, personal communication, 1995). Some of the increases in value of horticultural exports are due to inflation of the local currency (see also Harris and Muthugu 1992). Nevertheless, price stagnation is not the prime problem facing the export of horticultural products, especially fresh produce. The most immediate problem is limited handling, storage, and air freight capacity. The government recognizes the existence of at least some of these problems, particularly the limited precooling and storage facilities at Jomo Kenyatta International (Government of Kenya 1993b). Only recently have Japanese designers arrived in Kenya to design an expanded system,

which is predicted to be operational by 1996 (P. Guenette, personal communication, 1995). Handling and storage at the airport are not the only problems facing horticultural exporters. Table 4 lists some of the other important postharvest constraints that producers and export agencies face.

Table 4. Post harvest problems faced by exporters of fresh horticultural produce

Problem	Description
Export packaging	Compared to what is available to overseas competitors, cardboard cartons manufactured in Kenya are of inferior quality, especially in terms of wet strength and stacking strength. Large-scale exporters import cartons, adding to their costs.
Domestic transport	Poor roads hamper transport of fresh produce to the packing plants.
Airport facilities	The airport has one large semi-open shed for reception, inspection, weighing, and palletization of fresh produce. The parastatal operating the facility, Kenya Airfreight Handling Ltd., is inefficient.
Storage	There is one large cooling room at the airport, which is often non-functional. Further, it does not have the capacity to cool produce rapidly, and it is too small to handle the current volume of exports.
Cost of freight	Air freight of horticultural produce is dependent on space on passenger airlines. Currently, air freight is more expensive from Kenya to Europe (U.S.$1.30 to $1.40 per kilogram, 1992) than from Johannesburg to Europe. Since the demand for air cargo space exceeds what the airlines can provide, there is little incentive for them to lower rates.

Sources: Harris and Mathugu 1992; P. Guenette, personal communication, 1994.

Some of the constraints listed in Table 4 have been alleviated to some degree. One initiative has reduced the costs of packaging, and more companies are investing in packaging. Kenya Airways has improved the airport facilities, and private cooling facilities have opened at the airport in direct competition with Kenya Airways (P. Guenette, personal communication, 1995) Despite these improvements, formidable constraints still exist, and the net result is that Kenyan farmers are less competitive in the lucrative world markets. Observers of the Kenya horticultural industry point out that whenever Kenya has faced direct competition from other countries, Kenya usually has lost. For example, Kenyan exports of strawberries have declined from 1,100 tonnes in 1988 to less than 300 tonnes in 1992 (Argwings-Kodhek 1993). Problems with cold storage and delays in shipping meant that Kenya's producers lost much of their market share to Colombian growers, and Egyptian and Israeli exports threaten that which remains.

Attempts are being made to alleviate some of the constraints that Kenyan exporters experience. The government and the World Bank are working on a new export-financing scheme that will provide short-term loans to fund exports. The scheme is intended to replace one that was halted in 1993 due to widespread abuse. Unfortunately, a report on the scheme stated that it "is unlikely to be introduced 'in the near future,' citing 'political ramifications'" (*Daily Nation* 1994a).

4.2.4. Maximum residue levels: The most important constraint to increasing exports?

A new problem facing Kenyan horticultural exporters is that the European Union, which accounts for about 40 percent of all exports (Central Bureau of Statistics 1993), has recently tightened regulations concerning labeling, pesticide residues, packaging waste, and other environmental issues. Previously, exporters from countries such as Kenya were exempt from many of these regulations. In contrast to times past:

> ... producers and exporters [now] need to provide information on a variety of areas, including company details and management ability, procurement and control of raw materials and packhouse operations. Specific requirements will include the maintenance of crop and postharvest handling records, including information on pesticide and fertilizer applications, harvest and field packing operations, and hygiene levels (*African Farming* 1993).

Quality control no longer means simply being able to insure that produce matches the highest standards in terms of the way it looks, feels, and tastes. When exporting to the European Union, quality control now requires compliance with maximum residue levels for pesticides. As of June 1993, the European Union initiated a set of regulations that not only blocks shipments of produce found to have pesticide residues in excess of maximum residue levels, but also makes the exporter pay for the destruction or return shipment of the produce (Argwings-Kodhek 1993). Kenya has reportedly received complaints from Europe and Japan in the past about levels of pesticide residues on exported coffee (Partow 1992). Apparently, no rejection of shipments by European countries has occurred thus far except on grounds of inadequate quality (B. Lohr, H. Muhia, and J. Ngatia, personal communications, 1994).

The European Union prohibits the importation of French beans with detectible residues of many pesticides used in Kenya, including the insecticides DDT and chlorpyrifos, the herbicides glyphosate, paraquat, and atrazine, the fungicides benlate and mancozeb, and the fumigant methyl bromide (European Economic Community 1993). Meeting these requirements will be difficult because farmers customarily harvest vegetables continuously whereas a five-to-seven day preharvest interval is supposed to elapse after application of pyrethroid insecticides and 3 to 14 days for organophosphates (Kibata 1993).

In Kenya, no controls are in place anywhere along the chain of middlemen between grower and exporter, and there is no domestic mechanism for enforcement of maximum residue levels.[4] When KARI's pesticide residue laboratory finds excess residues in farm samples, the farmer is simply alerted and asked about use patterns and follow-up samples are taken. Market samples found to be in violation are not investigated. The HCDA, aware of these problems, is establishing a strict compliance system for its producers (B. Lohr, J. Ngatia, and H. Muhia, personal communications, 1994).

Two production systems contribute to Kenyan export agriculture. Large-scale, internationally financed, highly integrated operations dominate the export industry for cut flowers and also play an important role in fruit and vegetable exporting. Large growers employ expatriate managers and tap European resources and advice but do not share technical information. At the same time, smallholders produce as much as 75 percent of exported fruits and vegetables, often on a contractual basis for exporters who supply seeds and other inputs on credit (USAID 1994). Increasing demands for high-quality production may prompt movement toward nucleus estates with satellite outgrowers, the latter receiving a full complement of extension and support services from the estate.

An association of exporters (i.e., FREAK) has conducted several meetings and workshops over the past 18 months to raise the consciousness of horticultural growers about maximum-residue requirements. FREAK also has a code of conduct that exporters are expected to follow, to ensure that exports do not exceed maximum-residue limits. FREAK and USAID's KEDS Project have also worked to encourage and improve relations among growers, exporters, and organizations that can provide them with the technical information needed to help ensure that Kenya's exports are in compliance with European import regulations (P. Guenette, personal communication, 1995).

Despite these efforts and progress, many smallholders and small-scale exporters may still lack capital and access to credit, improved seed and pesticides, receive insufficient extension advice, and find marketing uncertain (Harris and Muthugu 1992). Government and donor promotion of nontraditional crops for export, combined with a paucity of IPM research and extension on those crops by the public sector, have led to a technology gap that now hampers small-scale Kenyan producers and entrepreneurs and presents health hazards. Almost total reliance on pesticides to produce high-quality crops such as French beans and flowers is not only expensive and dangerous but also invites difficulties meeting maximum residue level requirements. Exporters lack adequate facilities to test shipments before loading them onto the aircraft (P. Guenette, personal communication, 1994).

The equity of benefits derived from donor support of nontraditional agricultural exports and the portion of proceeds that remain in Kenya may thus be diminished. USAID's NARP II Social Soundness Analysis Update states that these difficulties can be addressed only through subsidies

[4] Kenya has adopted maximum residue levels recommended by the Codex Alimentarius Commission.

of seeds and the necessary marketing and transportation infrastructure, making horticultural research, extension, and productivity national concerns rather than concerns of individual farmers (USAID 1992).

In accordance with that recommendation, programs such as the national workshop that KEDS and FREAK sponsored in March 1993 have helped to raise the level of awareness over the past four years. Media publicity and many training and extension programs have helped to carry the message of the importance of adhering to residue limits (P. Guenette, personal communication, 1995). In addition, the HCDA is searching for laboratories that could provide residue testing services to exporters (see section 2.4.3).

4.2.5. Implications of trends and constraints in production

The data on production trends, export volumes and values, and constraints to the increase of both production and exports have implications for the incentive to use pesticides. These incentives apply to different types of pesticides depending on the crop.

Foodcrops

Given the high rate of population growth and the limited land available to increase area planted to crops such as maize, the government has concluded that it must focus on policies that will result in increased yields. In order to achieve the needed increases in yield, the government has pledged to lower the prices of inputs. This is to be achieved by: (a) removing all import tariffs and value-added taxes on agrichemicals; and (b) assisting cooperatives, companies, and groups to obtain foreign exchange to import agrichemicals (Government of Kenya 1993a). These measures can be expected to increase the amount of pesticides applied to foodcrops, notably the insecticides and herbicides used in maize production.

Export crops

The relative decline of coffee and the rise in importance of tea and horticultural crops has distinct implications for patterns of pesticide use. By one estimate, until the late 1980s, 60 percent of all pesticides used in Kenya were applied to coffee (D. Rocco and H. Partow, personal communications, 1994). Coffee was treated chiefly with copper-based fungicides but also with herbicides and insecticides. Rising input costs and falling output prices then reduced the amounts of pesticides applied in coffee, shrinking fungicides' share of the national pesticide market. Small-scale farmers' shift toward coffee production also has implications for the use of pesticides. Smallholders may lack the resources, such as working capital, to purchase all the pesticides and other inputs needed to intensify production.

Smallholder tea growers may have credit constraints as well. The expansion of tea has probably increased herbicide use, however, particularly the widely used compounds paraquat and glyphosate.

Relatively stable aggregate prices for horticulture have obviously been one factor in encouraging increased production. These increases in output have probably meant an increase in the use of pesticides on horticultural crops, especially on those crops for which visual appeal is important in determining overseas market prices. Fifteen percent of all pesticide used in Kenya is applied to grow flowers for the cut flower market. Soil sterilants, fungicides, insecticides, and fumigants are all used extensively for producing flowers. Vegetables grown for export are generally treated with fungicides and insecticides.

The list of problems presented in Table 4 indicates, however, that further expansion of Kenyan horticultural production may encounter great difficulties. Producers and exporters also face the challenge of compliance with maximum residue levels as well as competition from other countries. Thus, it is possible that the current level of horticultural exports from Kenya will represent some form of a "high tide" not to be replicated in the foreseeable future. In the near future, these constraints could result in minimal growth in agricultural production for export, resulting in little increase in pesticide use.[5]

4.3. Returns to purchased inputs

Although production trends and the constraints facing the intensification of production provide an indication of future trends in pesticide use, the economic returns to pesticide use furnish a more direct measure of the incentive to use pesticides. Unfortunately, there appears to be no readily identifiable data base in Kenya that details the financial and economic returns to using purchased agrichemicals. Information needs are the topic of discussion between representatives of ICIPE and KEDS and will likely be the focus of a forthcoming workshop, which KEDS, FREAK, and ICIPE will sponsor (P. Guenette, personal communication, 1995).

4.3.1. Increase in crop yields

Lack of information regarding the correlation between pesticide use and crop yields makes it difficult to evaluate how much of a financial benefit farmers obtain from using pesticides. In the absence of such data, it can be hypothesized that concern about potentially catastrophic pest-related crop losses influences a farmers' decision to use pesticides. Gaining some given percentage increase in yield would obviously be a desirable side benefit. In the case of horticultural crops grown for export, some pesticides are probably applied to prevent cosmetic pest damage, which would reduce the price received in the overseas markets.

[5] Personnel associated with USAID's KEDS Project have a different view of the potential for growth in exports. They believe that the volume of exports will continue to increas (P. Guenette, personal communication, 1995).

4.3.2. Trends in expenditures and import prices

The trends in the value of total purchases (constant prices) for insecticides, fungicides, and herbicides are shown in Figure 5. Overall, by 1988, purchases of all three categories of pesticide were lower than those of the period 1979 to 1982. The one exception is the large amount of fungicides purchased in 1989. This could be the result of farmers' and estates' stockpiling inputs before an anticipated rise in prices or a hedge against a sporadic flow of supplies.

One reason for the decline in purchases of pesticides is that the prices at the port of entry, in constant terms, have remained steady from 1983 onward (Figure 6a). The stability of pesticide prices was not matched by a weighted average of deflated prices of four crops--wheat, maize, coffee, and tea.[6] Figure 6b shows that the ratio of constant pesticide prices to constant crop prices has declined over time, indicating that crop prices have not increased as fast as pesticide prices.

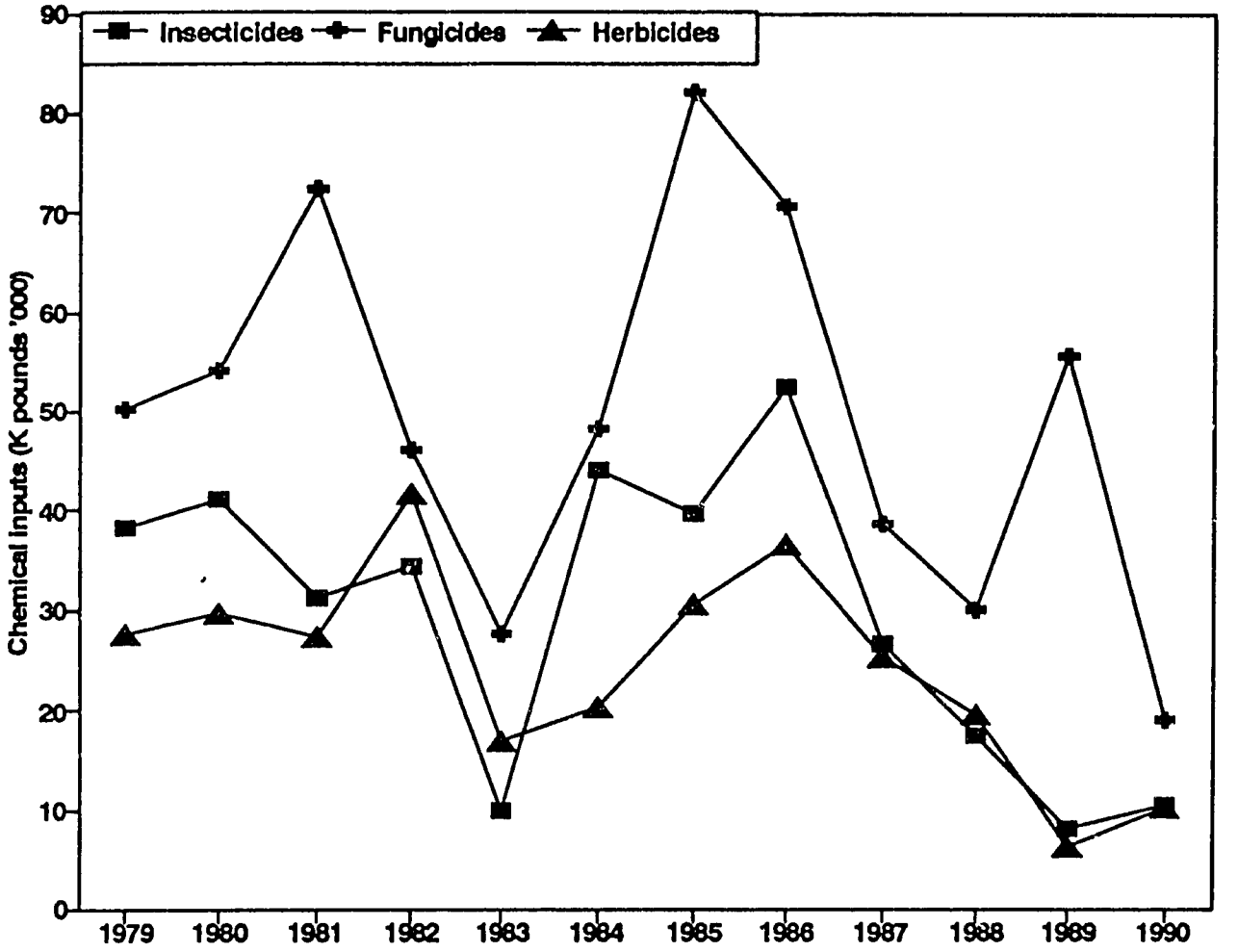
4.3.3. Prices of inputs and outputs at farmers' markets

In general, farmers have faced steep increases in the retail prices of inputs, including insecticides, fungicides, and herbicides (Table 5). For eleven items listed in Table 5 with sufficiently complete time series from 1980 to 1992, the average price increase was 662 percent. The price increase for Round-up (glyphosate) seems to be unusually high (almost 3,200 percent) and could possibly be the result of a recording error. Removing the increase in the price of Round-up reduces the average of the remaining ten items to 418 percent.

It is important to note the sources of the data shown in Table 5. The Ministry of Agriculture and Livestock Development formerly collected data on input prices from all districts once a year. This was stopped in 1990 because prices began to rise too fast to collect accurate data on a yearly basis (R. Randall, personal communication, 1994). Some post-1990 data may be obtained by reading individual district reports (see Table 5), which occasionally contain prices recorded at the end of the year. These reports are inconsistent and cannot be considered a reliable source of data.

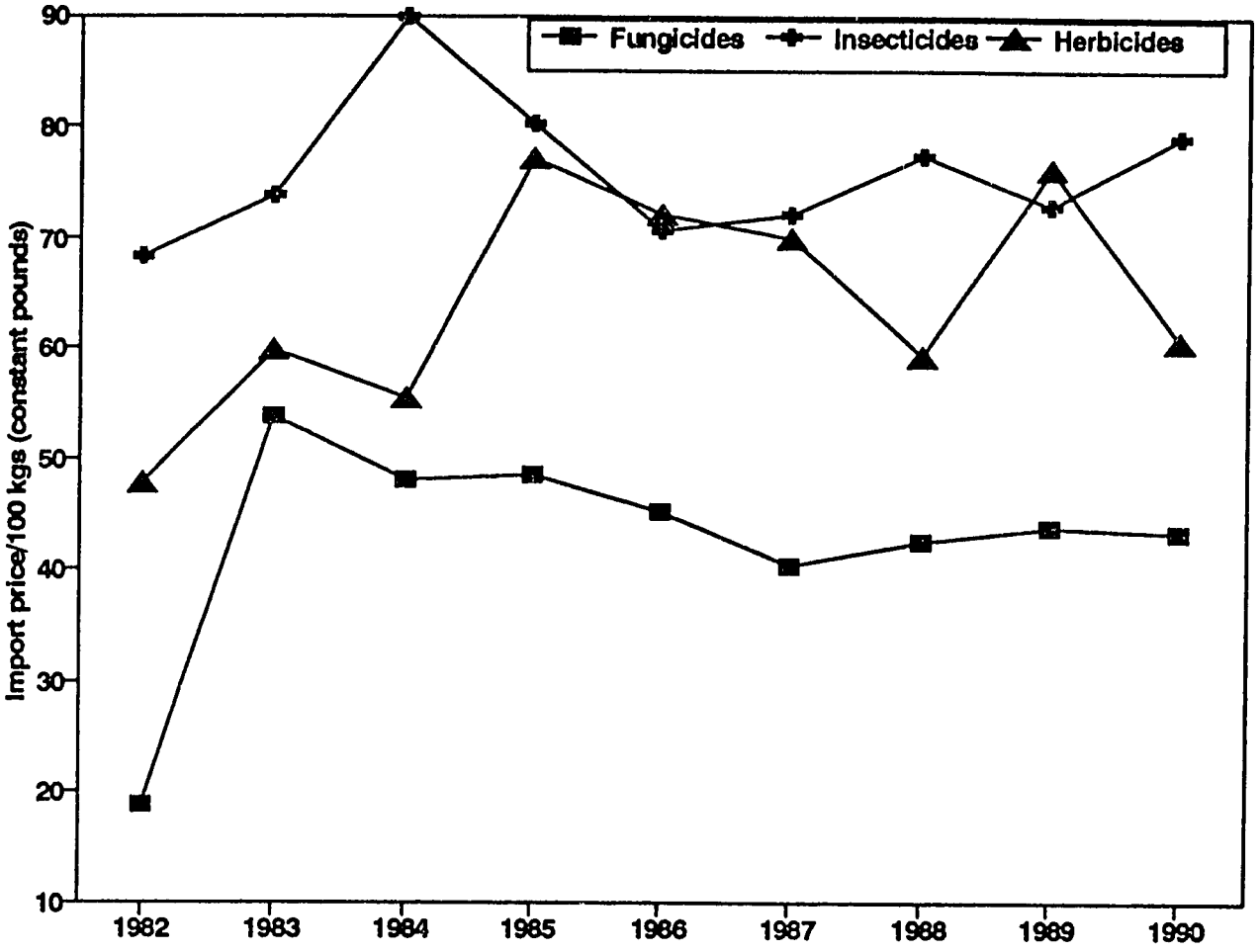
[6] The weighted average for crop prices was based proportionately on quantities sold, as recorded by marketing boards. Wheat, maize, coffee, and tea prices were chosen to represent crop prices because they represent two foodcrops and two export crops. Combined, they represent about one million MT of produce delivered for sale. The weighted average for pesticides was constructed using the proportions reported used for the 1993 harvest year (Szmedra 1994).

Figure 5. Expenditurcs on pesticides (constant prices)



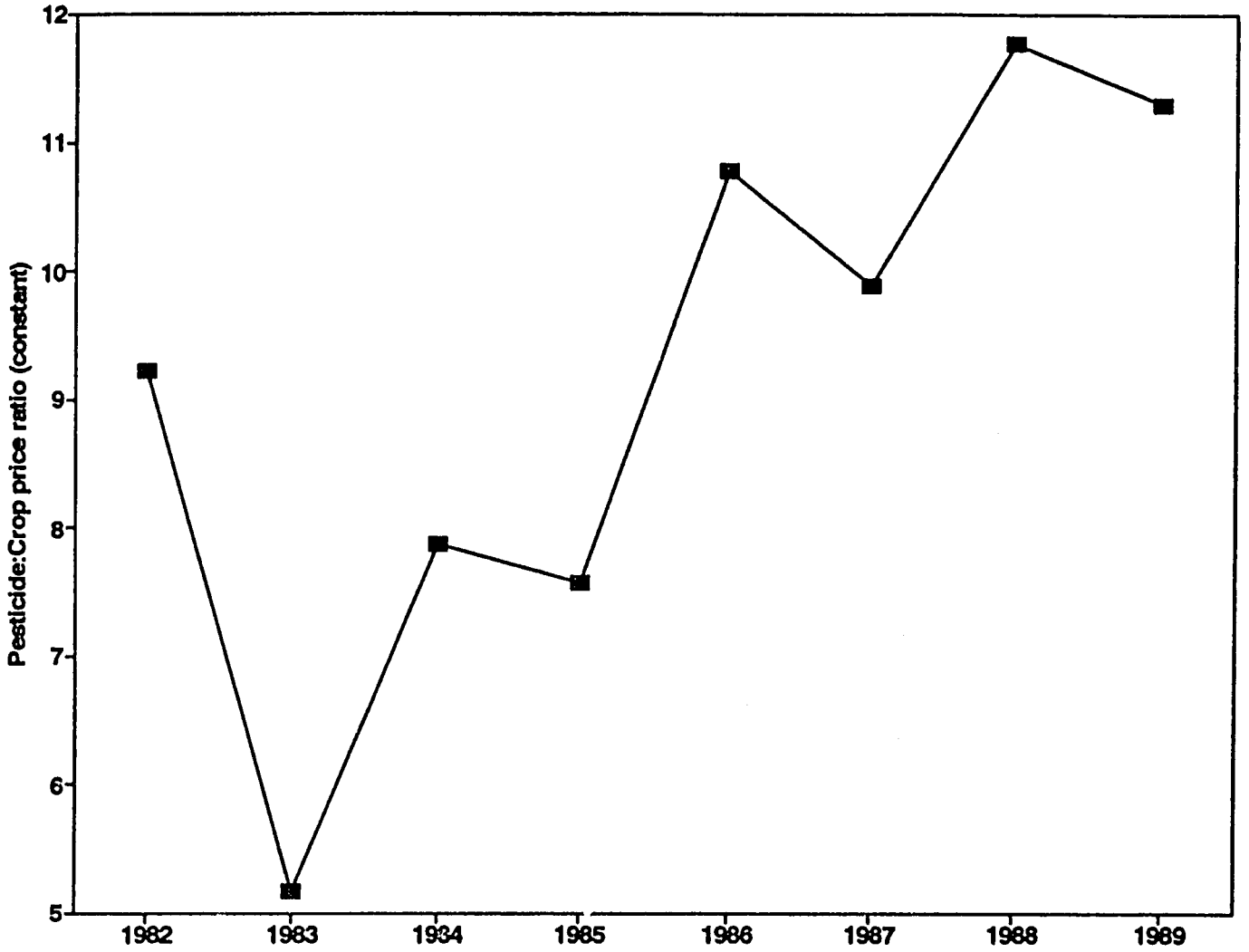
Sources: Central Bureau of Statistics 1986, 1991, 1993.
Note: Current prices were deflated by a weighted foreign exchange index.

Figure 6a. Import prices at constant prices (1982 = 100)



Sources: Central Bureau of Statistics 1986, 1991, 1993.

Figure 6b. Ratio of weighted average pesticide prices: Weighted average crop prices



Sources: Central Bureau of Statistics 1986, 1989, 1991, 1993

Note: Prices are deflated by a weighted foreign exchange index (1982 = 100). Crop prices given are a weighted average of prices for wheat, maize, coffee, and tea (see footnote in text). Weights for pesticides are based on proportionate use in 1993 (Szmedra 1994).

Some of the farmers' reactions to constantly rising input prices can be judged by the following quotations:

"There were no shortages of farm inputs reported in the District except complains [sic] of exorbitant prices for fertilizers, seeds and chemicals" (Bungoma District 1992).

"Adoption of use of most farm inputs was limited by the high prices and low liquidity status at farm level" (Kirinyaga District 1990).

"The rate of adoption [of recommendations from the National Extension Programme] either dropped in some cases (coffee) or they remained at the same as per the 1991 levels. This drop/stagnation was partly attributed to:

(1) Constant rises in input costs whereby farmers could not effectively implement the recommendations.

(2) The poor returns from coffee has [sic] also lowered the adoption rate" (Kirinyaga District 1992).

A large number of farmers grow crops for local markets, and their decision to use pesticides will be based partly on the prices they receive. Wholesale prices from various markets for maize, cabbage, and tomatoes are shown in Figure 7. For all three crops, prices rose dramatically from mid-1992 onward. This rise in prices could be due to a combination of inflation, drought-related shortages, and price deregulation.

The trends over time for three output-to-input price ratios, using local market prices, are presented in Figure 8. Essentially, from 1983 onward the ratios remain quite stable, indicating that any increases in input prices were matched by proportional increases in output prices. Thus, economic reforms do not appear to have significantly altered the price incentives for farmers to use pesticides.

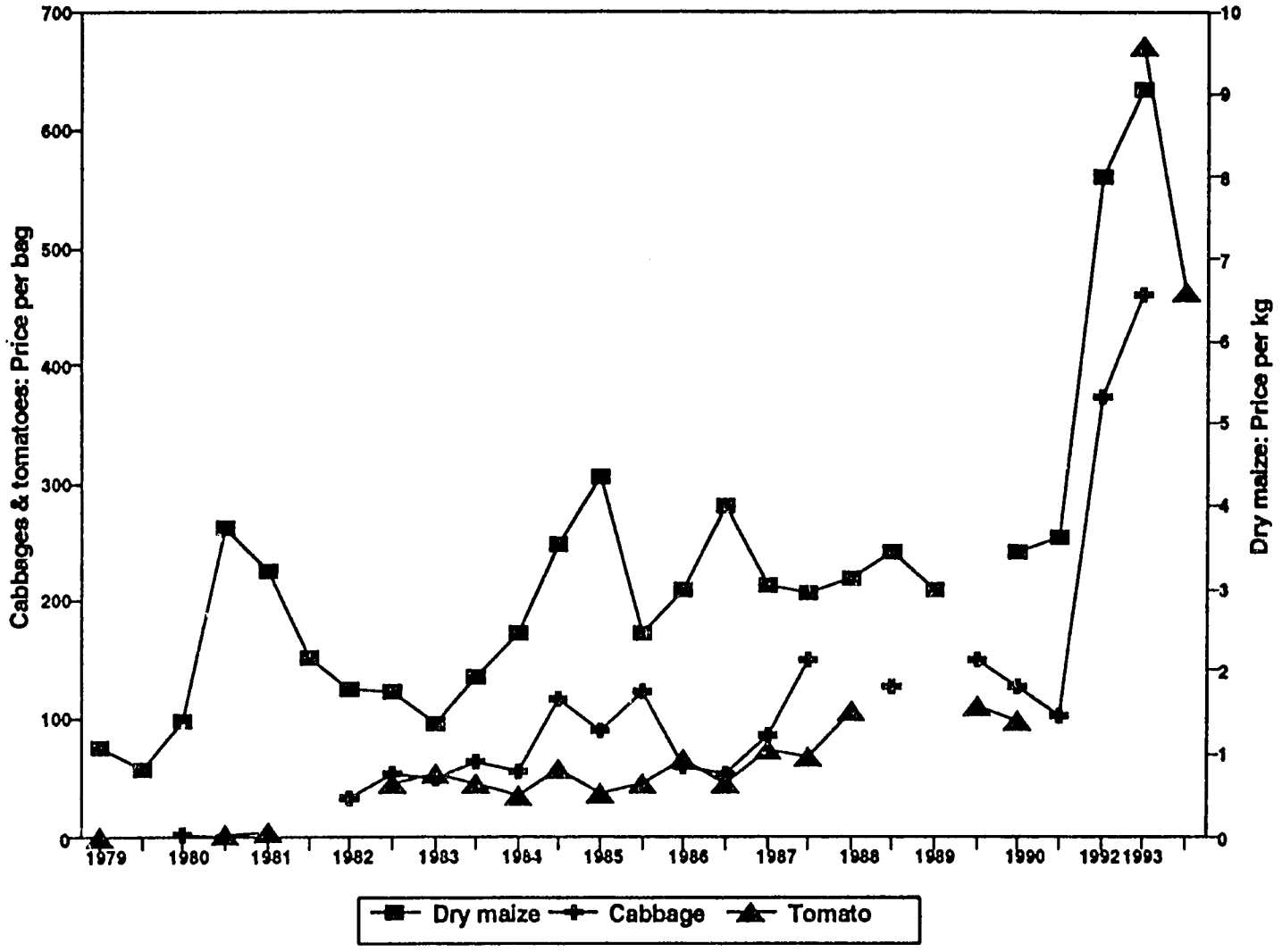
Table 5. Prices of inputs at farmers' markets

		Price: Kshs per unit					
	Unit	1980	1983	1986	1989	1990	1992
Seeds							
Maize hybrid	10 kg	40	72	87	124	124	280
French beans	1 kg	40	35		43		65
Cabbage	1 kg	177	231	231	367	470	
Fertilizers							
D.A.P. 18-46-0	50 kg	207	231	289	444	313	780
20-20-0	50 kg	133		264	350	313	600
Insecticides							
Propoxur	100 gm		372	483	483		
BHC	400 gm	2		14	17		
Diazinon	1 liter		180	214	234		400
Carbaryl	500 gm			172	184		
Fenitrothion	1 liter	55	120	224	272		315
Dimethoate	1 liter		84	103	103	315	625
Permethrin	1 liter	150	206	216	254	260	721
Fungicides							
Dithane M-45	1 kg	43	86	104	140	179	480
Ridomil	1 kg					386	950
Herbicides							
Round-up	1 liter	60	337	438	463	586	1960
Gramoxone	1 liter	55	71	113	125	139	315

Sources: Ministry of Agriculture and Land 1980; Ministry of Agriculture and Livestock Development 1983, 1986, 1989; Kirinyaga District 1992, 1990.

Note: Prices are mainly from Kirinyaga district.

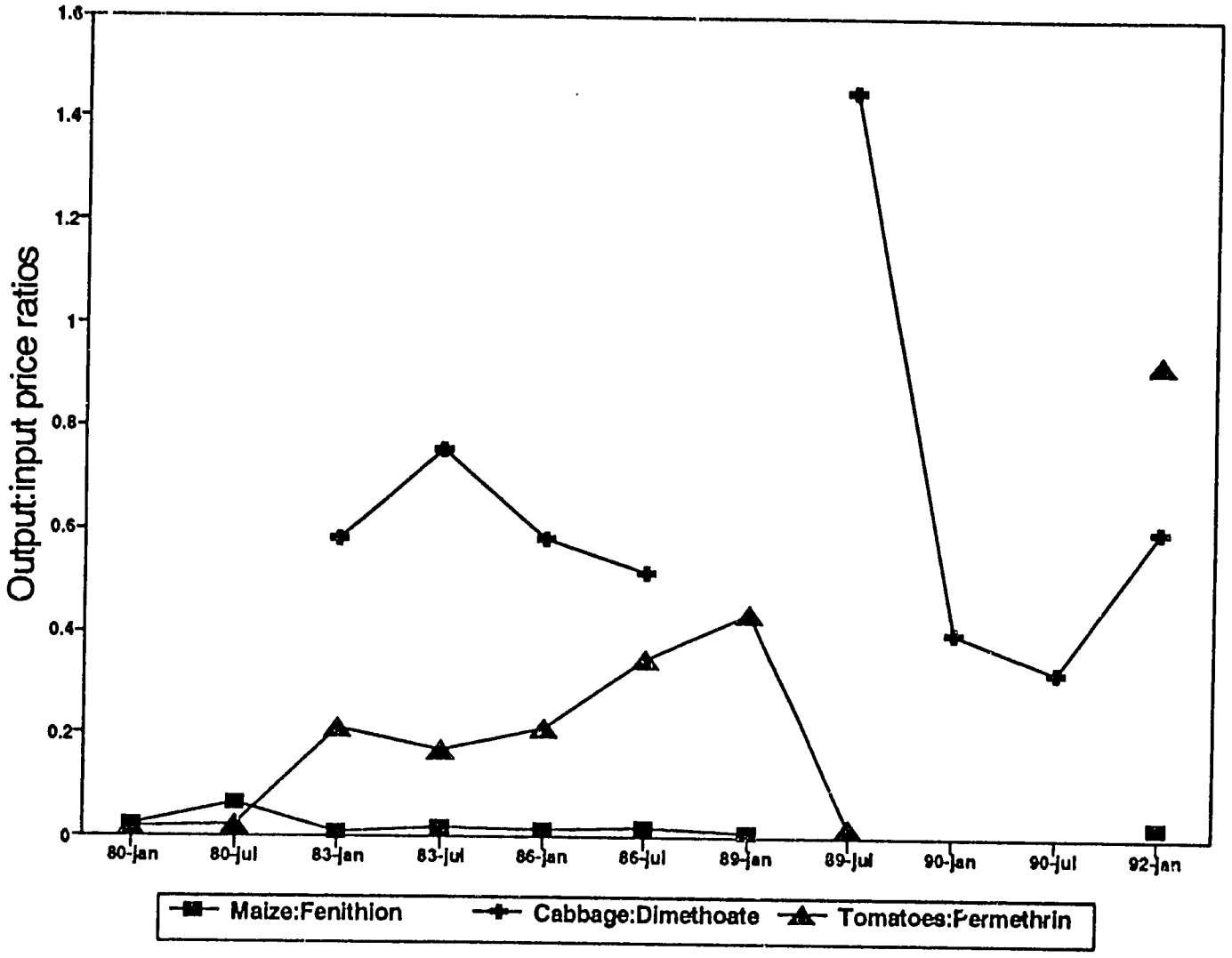
Figure 7. Prices of dry maize, cabbages, and tomatoes at local markets



Sources: The data from 1980 to 1990 are from Gitu (1992). For 1992 and 1993, data are from the Marketing Information Branch (1993).

Note: In order to form a complete data set for cabbages (Kshs/bag) and tomatoes (Kshs/small box) over time, prices were used from different marketplaces: Nyeri 1982, 1983, 1984, 1986; Kisumu 1980, 1985, 1987; Kitale 1989, 1992, 1993; Meru 1989, 1990. The average wholesale price of dry maize is given (Kshs/kg) for the eastern province. Data for January and July of each year. If a data point is missing, then data from the nearest month is used. Data for 1992 and 1993 are for December.

Figure 8. Ratio of outputs: inputs (local market prices).



Source: Computed from data in Table 5 and Figure 7.

4.3.4. Wage-to-Herbicide Ratios

Herbicides are unlikely to be purchased as "insurance" against catastrophic crop loss. Rather, their use indicates that farmers recognize an inverse correlation between weed growth and crop yield. Until 1990, the average wage rate rose at least as fast as the price of the widely used and relatively inexpensive herbicide Gramoxone (paraquat), and sometimes faster (Table 6). Thus, if farmers wished to weed their fields they might have calculated that it was cheaper to use herbicides than to hire labor. Between 1990 and 1992, however, there was a far greater increase in herbicide prices than in average wage rates (Table 6). If this should continue, it will become comparatively more cost-effective to hire labor for weeding than to use herbicides.

Due to large increases in Kenya's population, and small increases in the Gross Domestic Product in real terms, there has been a small to negative growth in real wages (Central Bureau of Statistics 1993). Thus, unless herbicides become relatively less expensive over time, it is a reasonable hypothesis that the wage-to-herbicide ratio will remain higher in the 1990s than in the 1980s.

Table 6. Price ratios of various wage rates to a given herbicide[a]

Year	Private sector[b] Ag. & Forestry: Herbicide	Public sector- Ag & Forestry: Herbicide
1986	0.30	0.18
1989	0.25	0.15
1990	0.24	0.16
1992	0.42	0.30

Sources: Central Bureau of Statistics 1993, 1986.

[a] The herbicide used to compare prices over time is Gramoxone (paraquat). Average wages per employee on a per annum basis.

[b] Private sector. This figure is more representative of large-scale commercial operations, with coffee and tea plantations accounting for 40 to 45 percent of all wages in private agriculture and forestry. Self-employed persons and family workers who do not receive regular wages are excluded.

4.3.5. Cash-flow considerations

Another important variable determining farmers' demand for pesticide is whether they have sufficient funds to purchase the pesticides when they are needed. Unfortunately, reliable and consistent time series of crop gross margins and budgets do not appear to exist in Kenya, or are

not readily available. Thus, analysis of the cost of pesticides relative to other production inputs over time is not possible.

A single-year crop budget for intercropped maize and beans in the Nakuru district was available (Policy Analysis Matrix, Egerton University, unpublished data). Labor accounted for 60 percent of all costs, and fertilizers and seeds accounted for 15 percent. Only 1 percent of the total budget was spent on pesticides. The recorded amount of pesticide purchased is noticeably different from some of the levels recorded in the Kirinyaga district in the late 1970s and early 1980s. However, pesticide use was highly dependent upon agro-ecological zone. For one particular agroclimatic zone, the average amount of insecticide used was 7 kg/ha. In the same district, but in a different agroclimatic zone, average insecticide use was only 2 kg/ha (Jaetzold and Schmidt 1982).

4.3.6. Availability of credit

Another constraint affecting the demand for pesticides is the availability of credit. Although pesticides do not represent the single largest cash expense, constraints in the availability of cash to purchase agrichemical inputs will dampen demand. Agriculture receives only 10 percent of the total credit extended to the whole economy (Ministry of Agriculture, Livestock Development, and Marketing 1993).

Not only is there a shortage of funds available for credit, but the parastatal Agricultural Finance Corporation distributes a large portion of the available credit in a biased fashion. The Agricultural Finance Corporation reaches about 45,000 farmers, but 50 to 60 percent of its loans are directed to large-scale farmers. Small-scale farmers receive only 20 percent of Agricultural Finance Corporation's loans. Disbursement of credit is also biased against food crops, with plantation crops receiving 60 percent of total credit (Ministry of Agriculture, Livestock Development, and Marketing 1993). In terms of the amount of money lent, the Agricultural Finance Corporation is the largest single lender of agricultural credit (Government of Kenya 1993b), although the cooperative movement apparently supplies up to 115,000 farmers with small loans (Ministry of Agriculture, Livestock Development, and Marketing 1993).

The government has devised policies to overcome credit constraints. One proposed method is to increase the legal minimum amount of credit lent by commercial banks to agriculture from 17 to 20 percent and by nonbank financial institutions from 10 to 15 percent (Ministry of Agriculture, Livestock Development, and Marketing 1993). Nonetheless, minimum lending requirements have not been fully met in the past. A major factor was the "relatively low profitability of farming compared to other investments." The report also anticipates that the liberalization of the economy will "permit a more rational allocation of resources to agriculture and other sectors." There is no discussion of what to do if a "rational allocation" does not occur.

There are plans to improve the liquidity of the Agricultural Finance Corporation by allowing it to accept funds on deposit and establishing a loan-guarantee fund to reduce the loan-default rate. There are some inconsistencies in these plans. Parts of the plans call for increasing

the rates the Agricultural Finance Corporation charges, while another segment calls for the government to "from time to time, provide the Agricultural Finance Corporation with funds to be lent at a subsidized rate of interest, to specific target farmers for the promotion of the development of specific crops or livestock" (Government of Kenya 1993b).

Agrichemical inputs are generally considered as a group for purchase with crop loans. None of the plans differentiates money for purchasing pesticides. Farmers and lenders may place a higher priority on using scarce credit to purchase improved seeds and fertilizer, with pesticides having a lower priority. Even if more credit is extended, it is questionable whether pesticides will receive top priority for those funds.

4.4. Summary of the economics of using pesticides

There is little information about the returns, such as increased yields, from using pesticides. Farmers are using pesticides based on their experience to boost output or as a form of insurance against catastrophic losses. In the case of horticultural crops for export, pesticides are used to prevent cosmetic damage that may reduce revenue on overseas markets.

Although long-term data for gross margins do not exist, data on the relative prices of inputs and outputs show that pesticide prices have risen at least as fast as increases in price of outputs. Given this price increase and the limited supply of credit, Kenyan farmers spent less on pesticides in the early 1990s than in the early 1980s (Figure 4).

Overall, the terms of trade for the agricultural sector have fallen compared to the early 1980s (Central Bureau of Statistics 1993). This means that it has become increasingly expensive for the agricultural sector to import pesticides and other purchased inputs. Unless the ratio of output to input prices shows a marked and sustained increase, there is little reason to believe that Kenyan farmers will wish to increase pesticide purchases in the near future.

Farmers who export, and perhaps can afford to apply ever higher levels of pesticides, face other challenges. Logistical problems, the lack of cargo space, and the high cost of air freight all threaten to restrict the growth of the horticultural export industry. The maximum residue levels imposed by the European Union represent a further problem. Unless farmers have the necessary crop protection technology and management skills, farmers producing for export risk losing money through improper pesticide use.

Overall, the current economic situation discourages both large-scale and small-scale farmers from increasing their pesticide use. Unless agriculture rapidly becomes more profitable it is unlikely that there will be a large increase in pesticide consumption in the short- to medium-term (three to five years).

4.5. Procurement, distribution, and marketing of pesticides

No pesticides are manufactured in Kenya. Consequently, the supply of pesticides begins with the importation of the active ingredient or of formulated product, often in bulk. Local, privately owned companies then formulate or repackage the imported chemicals and distribute them for retail sale.

Parastatals or government agencies also play a role in distribution and marketing. For example, pesticides donated to Kenya by Japan are distributed through local agents of companies, the Irrigation Board or the HCDA. The pesticides are sold to farmers at a heavily subsidized price (G. Kibata, personal communication, 1994).

4.5.1. Pesticide imports

Total values (in current values) and quantities of imported pesticides are shown in Figure 7, along with the value in constant terms (1982 = 100). The most striking aspect of the data is that the quantity imported has remained almost static for 13 years (5,600 ± 280 tonnes). With such stability in the amount imported, it is curious that the value should fluctuate so much. Even the constant prices are not as stable as the quantities imported. The per unit value of the imports (Figures 4a and 4b) appears more stable over time than the total values. Part of the reason for this anomaly may be that the sources of the data list the data category as "Insecticides, fungicides, disinfectants, etc." To discover the influence of items other than pesticides on the data sets plotted in Figure 7 would take a thorough study of the original data bases (e.g., original customs records). Box 3 discusses other anomalies and potential reasons for those anomalies.

Box 3. Pesticide imports and conflicting data sources

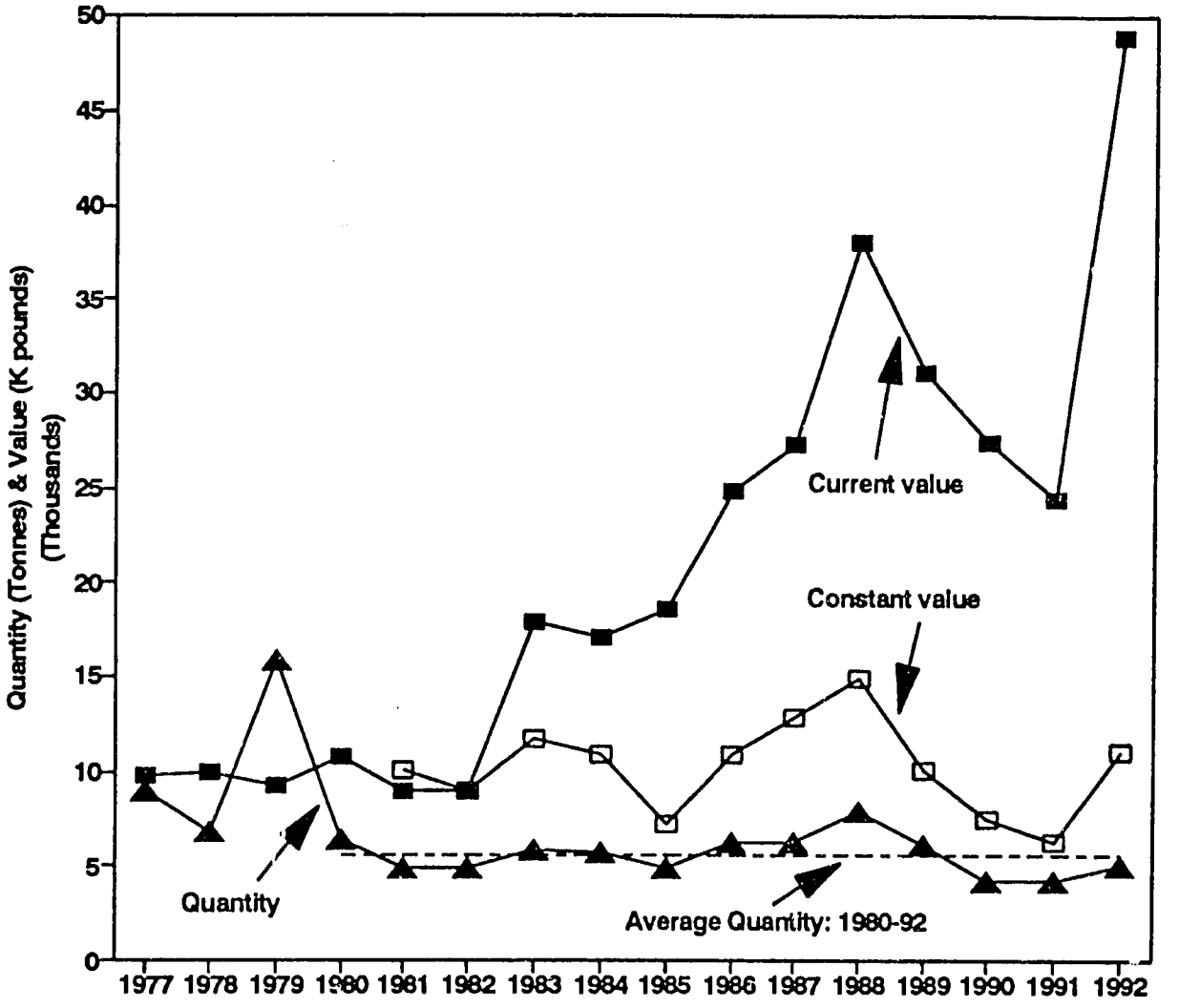
According to data from the Government of Kenya's Central Bureau of Statistics, pesticide imports from 1980–1992 have remained stable. Szmedra (1994) cites a private firm, Landell Mills Market Research Ltd. (United Kingdom) as recording a 56-percent increase between 1982–1984 and 1992 in the amount of active pesticide ingredient used in Kenya. He also cites data similar to that in Figure 7 showing an approximate 50-percent decrease in pesticide imports from 1986 to 1991.

Several factors account for the different estimates of pesticide usage. One may be the difference in considering calendar year versus growing season. Data collection might also generate large errors. For example, Landell Mills collects information on pesticide use in Kenya once every three years. Its methodology includes interviews with farmers, extension agents, and other government officials (Szmedra 1994). The Central Bureau of Statistics relies on government employees to complete forms on a monthly basis showing the amount and value of imports. Another reason for the different estimates could be the definitions used. Landell Mills estimates pesticide use while the government tabulates imports.

The Government of Kenya's data collection is continuous and utilizes the same methodology over a relatively long period, so its import data may be more consistent than other sources. It becomes imperative for any discussion concerning the supply of pesticides that the researchers acknowledge data sources and methodologies.

Sources: Szmedra (1994); Central Bureau of Statistics (1991).

Figure 9. Quantity and values of pesticide imports



Sources: Central Bureau of Statistics 1986, 1991; F. Gathua, personal communication, 1994.

Note: The data plotted are from a category labelled as "Insecticides, fungicides, disinfectants, etc."

4.5.2. Sources

Available import data (e.g., Central Bureau of Statistics 1986, 1991) are too aggregated to determine sources of pesticide imports. From 1987 to 1990, the United Kingdom and West Germany were the two largest individual exporters to Kenya of products labelled as chemicals under the Standard International Trade Classification system. Imports of "insecticides, fungicides,

disinfectants, etc.," however, comprised only about 10 percent of the total value of all chemicals imported (Central Bureau of Statistics 1991). Thus, it is possible that chemical imports from the United Kingdom and West Germany were mostly, if not entirely, industrial and did not include pesticides. A detailed study of original customs documents would be necessary in order to determine with certainty the sources of pesticide imports.

4.5.3. Funding

Private firms, using their own capital, dominate pesticide importation into Kenya. The public sector imports some pesticides as well, however. Certain NGOs import pesticides or purchase them domestically and distribute them to beneficiaries (see section 4.3.1.3). In addition, the Government of Kenya imports pesticides donated by other governments or by international organizations. For example, subregional organizations involved in the control of migratory pests, such as the Kenya-based Desert Locust Control Organization for East and Southern Africa, import insecticides in response to pest outbreaks. Similarly, GTZ and the ODA are temporarily donating pesticides for use against a storage pest, the larger grain borer (Pierrard 1992, G. Kibata, personal communication, 1994). Donor-funded imports are generally small.

Japan's grant aid program has made the only sizable pesticide donations in recent years. These donations have been equivalent to 100 million yen per year, approximately equal to 30 million Kshs or US$0.83 million at 1992 exchange rates (Central Bureau of Statistics 1993; P. Amukoa, personal communication, 1994). Pesticides donated under this program recently (along with sprayers and protective clothing) are listed in Table 7. Several of the donated chemicals are restricted in the United States because they are hazardous to human health or the environment.

Table 7. Pesticides donated to Kenya with Japanese grant aid

Insecticides	Herbicides	Fungicides
carbosulfan	alachlor*	chlorothalonil
chlorpyrifos	atrazine*	copper oxychloride
diazinon	bentazone	mancozeb
fenitrothion	glyphosate	metalaxyl
fenvalerate*	metolachlor	thiophanate methyl
methomyl*	propanil	triadimefon
pirimiphos methyl		
thiobencarb		
trichlorfon		

Source: G. Kibata, personal communication, 1994

* Pesticides that the U.S. Environmental Protection Agency restricts for health or environmental reasons (see Appendix C).

4.6. Policies and projects affecting pesticide use

Donor coordination is increasing in international assistance programs. In the policy arena, donors are supporting structural adjustment (including the discontinuation of many parastatal agencies and agricultural input subsidies), market liberalization, privatization, agricultural trade, and the formulation of National Environmental Action Plans. Assistance is often conditional on such initiatives.

Fleischer (1993) discusses the pest and pesticide management policies of donors and international development agencies. Government, donor, and NGO policies, as reflected in project and nonproject assistance and pest management approaches, will influence the importance of selected commodities and the potential demand for and role of pesticides.

4.6.1. Agriculture

The Kenyan government, with donor support, is seeking a large increase in the production of maize and of nontraditional export crops, particularly horticultural crops. An entire consortium of donors including the World Bank, Germany, Japan, the United Kingdom, and the United States are supporting development of the horticultural subsector (see below; USAID 1994). Credit made available by government and through donors and NGOs will enable farmers to purchase inputs, including pesticides, more easily. These factors might increase the demand for pesticides used on selected commodities. There are no data showing such an effect to date, but aggregated national figures may be masking localized or crop-specific increases.

A factor that would probably decrease pesticide use is the development and application of IPM systems, which minimize or, if possible, eliminate pesticide use. Germany and the United Kingdom are both funding IPM research projects, and many NGOs are promoting low-input or organic agriculture. Both donors and NGOs seek to improve extension services, an important prerequisite for effective pest management of any sort at the farm level.

4.6.1.1. Donors and international development agencies

World Bank. Projects that have a bearing on pesticide use include KARI's farming systems work under NARP (R. Hudgens, personal communication, 1994), the National Extension Project, and an agricultural credit project. The latter project capitalizes rural banks so that they can "on-lend," and their services help farmers purchase agricultural inputs including pesticides (A. Kiss, personal communication, 1994).

The World Bank's Export Development Project ($100 million credit) is aimed at the horticultural export industry and includes supply of improved cargo handling equipment at Nairobi airport, with policy reforms. The project also includes the establishment and development of Export Processing Zones and the Kenya Export Assistance Scheme (Harris and Muthugu 1992).

The European Union and Its Bilateral Donors. Under its contribution to NARP, the European Union paid for building or rehabilitating offices and laboratories at KARI and may donate further equipment. The new facilities will house the Pest Management Unit that coordinates the KARI's research on crop protection (Sutherland 1993; J. Ngatia, personal communication, 1994).

Several European Union member countries are funding portions of NARP. The Swedish International Development Agency is supporting the FAO's research/extension liaison work at KARI's research centers, while the Netherlands is funding NARP's fertilizer research component and several of KARI's regional research stations (J. Sutherland and R. Hudgens, personal communications, 1994). The Netherlands also is funding a classical biological control program for maize stem borers at ICIPE.

The ODA initiated the bilateral KARI-ODA crop-protection project, a component of NARP, in 1990. The project's goal is to strengthen crop protection research activities and capabilities at the NARL and other regional and national research centers. Multidisciplinary crop protection research at KARI is aimed at creating IPM systems for major crops. The first four-year phase of the KARI-ODA project completed a survey of farming systems for establishing priorities, trained staff, and upgraded vehicles and equipment. Currently, the ODA is also supporting two of KARI's regional research centers (J. Sutherland, personal communication, 1994). Under NARP II, KARI's crop-protection coordinator hopes to establish better liaison with KARI's outstations and the extension system in support of adaptive research and technology transfer (Sutherland 1993).

GTZ has been involved continuously in the development of the horticultural subsector for over two decades. GTZ recently funded a detailed survey by HCDA of fruit trees in Kenya, as a baseline for the development of high-volume sea freight exports. The agency plans to support such exports by assisting with trials and providing assistance with developing the necessary postharvest technology (Harris and Muthugu 1992).

The GTZ's regional "IPM Horticulture" project (see section 2.5.2), headquartered within KARI, as well as its central Pesticide Services Project, are examples of the pest and pesticide management technical assistance the agency extends to many developing countries. The IPM Horticulture project seeks partnerships with a variety of institutions (including private ones) in order to improve and introduce IPM systems for vegetable and fruit production (Lohr 1993).

USAID. The Development Fund for Africa seeks to improve agricultural production and productivity while protecting and managing the natural resource base, with particular emphasis on biodiversity. Agricultural priorities include the creation and transfer of improved agricultural technology, better infrastructure (especially for marketing), increased market participation by farmers and traders, and agribusiness development including the growth of nontraditional agricultural exports (Herlehy 1993; Seckler 1993; USAID 1993a).

USAID/Kenya is financing a seven-year, $25 million KEDS Project. KEDS works with the private sector, grower associations, and parastatals involved with exported commodities other

than coffee, tea, and petroleum. Project goals are to earn foreign exchange and create employment through increased nontraditional exports. The project paper includes four major components. First, a public-sector component provides support to the Kenya Export Promotion Programmes Office and the Export Processing Zones Authority for improved administration of export incentive schemes and coordination of export-related infrastructural development.[7] Second, a private-sector assistance component (also targeting sector support parastatals such as HCDA and NGOs such as the Fresh Produce Exporters' Association of Kenya) administers an "Export Development Fund" on a cost-shared basis for business planning, strategic marketing, production, packaging, product improvement and quality control. Third, an Export Processing Zone Swap Facility provides U.S. dollars to local firms wishing to invest in the Zone. Fourth, a policy study and analysis component produces an analytical base for improving Kenya's export climate (USAID 1991b; KEDS 1993, 1994).

USAID supports reforms in national agricultural research programs, including greater accountability to clients, demand-driven research agendas, broader institutional participation in research, and a range of collaborative arrangements with the International Agricultural Research Centers, regional organizations, NGOs, input supply companies, and organizations in donor countries. In Kenya, USAID is one of a consortium of donors supporting KARI's 1986–1997 NARP, now in Phase II. NARP is meant to develop a well-managed national agricultural research system providing the agricultural sector with appropriate technologies that will increase productivity on a continuing basis. These technologies are to be generated through farmer-participatory farming systems research with extension collaboration.

The USAID-funded NARP components are being implemented through a host-country contract between KARI and the Midamerican International Agricultural Research Consortium (MIAC). The work covers research on cereals (sorghum, maize, and millet), high-value horticultural crops (including plant protection), and small ruminants. The focus of the horticulture effort will be on two or three high priority export vegetable crops or closely related crop groups. Limited assistance will be provided for fruits and flowers, primarily via short-term consultants and equipment procurement. MIAC has posted a horticulture advisor and a systems agronomist to KARI and helps support a cereals breeder, a small ruminant expert, and a socioeconomist. Graduate scholarships are being made available to Kenyans. The MIAC Project has produced a "Strategic Plan for Cereals in Kenya (1993–2013)" (MIAC 1993) and is working on a similar plan for horticulture. Together with plans developed for Kenya's other agricultural sectors, these documents will constitute an institution-wide work plan, the various sections of which will be divided among a consortium of donors, as was done for NARP II (USAID 1992; R. Hudgens, personal communication, 1994).

The MIAC Project strongly complements other USAID programs focused on agricultural marketing and agribusiness promotion. The Kenya Market Development Program is supporting

[7] The activity involving the Export Processing Zones Authority has been cancelled (P. Guenette, personal communication, 1995).

the government's cereal-sector reform by expanding the role of private sector participation in all aspects of marketing and processing. The Fertilizer Marketing Reform Program has supported major changes in the fertilizer import and distribution structure that have positioned the fertilizer trade group, the Kenya National Fertilizer Association, to respond more efficiently to fertilizer demand. The training of distributors is an important component of the effort (USAID 1991a, 1992, 1993b).

Japan International Cooperation Agency (JICA). Japan is one of the donor countries promoting Kenyan agricultural exports. The Japanese government has funded a number of technical studies of cargo handling capability and requirements at Nairobi airport and, as of 1992, was thought to be interested in financing the construction of improved facilities, including new and much larger refrigeration facilities (Harris and Muthugu 1992).

Japan has no programs focusing on nonchemical pest control (S. Shibata and Y. Kashihara, personal communication, 1994). Instead, Japan makes large pesticide donations through its Grant Aid for Increased Food Production program, which JICA implements. These donations encourage pesticide use and subsidies, directly influencing the kinds and amounts of pesticides used in Kenya and other countries in sub-Saharan Africa (see section 4.2.3). Pesticides are donated with the restriction that they be used for foodcrops, not cash crops (Government of Japan 1990, 1992, 1993a, 1993b). Maize, beans, and rice are considered to be foodcrops though they are also regionally traded commodities in East Africa. Compliance with the foodcrop guideline is not monitored effectively. Tobin (1994) provides a full description of Japanese pesticide aid and related policies.

4.6.1.2. Parastatals

Horticultural Crops Development Authority (HCDA). The HCDA works with groups of small-scale farmers that produce crops for export. Its services include dissemination of market and price information and export statistics, organizing groups of small-scale growers and advising them on production and postharvest practices (notably the proper use of inputs such as pesticides), and licensing horticultural exports (HCDA 1993a, 1993b).

The HCDA produces a quarterly newsletter, *The Horticultural News*. With the assistance of USAID's KEDS Project, and with technical input from the United Kingdom's Natural Resources Institute, HCDA is producing an *Export Crop Manual* for use by farmers, extension workers, exporters and importers. The manual has three components: Production, Postharvest Handling and Marketing, and Promotion (Fresh Produce Exporters' Association of Kenya 1993). A prototype was circulating for review in early 1994. The prototype production manual appeared to lack plant protection recommendations except for a few references to "pest-resistant varieties."

Nevertheless, pesticides are a priority issue. HCDA obtains pesticide recommendations and information on safe preharvest intervals from the Pest Control Products Board and has been training staff and farmers on maximum residue levels with assistance from the Natural Resources Institute. The KEDS Project and the FMC Corporation sponsored two seminars in 1993 that

involved the HCDA and addressed pesticide use and residues on horticultural produce exported to Europe. Participants included farmers, officers of the HCDA, the Fresh Produce Exporters' Association of Kenya (see below), and the Ministry of Agriculture, exporters, researchers, chemical companies, and manufacturers of packaging materials (HCDA 1993c).

4.6.1.3. Nongovernmental organizations

Fresh Produce Exporters' Association of Kenya. FREAK collaborates with the HCDA on pesticide maximum residue level training for farmers. Half of its approximately 200 members are flower growers, and the other half are vegetable middlemen. The members are increasingly interested in potential maximum residue level problems (L. Laboso, personal communication, 1994).

Kenya Small-scale Farmers' Association. The Kenya Small-scale Farmers' Association has operated in central and eastern Kenya since 1993 as horticultural farmers' own advisory and lobbying organization, distinct from the Kenya National Farmers' Union. It is a nonprofit entity with a license to import agricultural inputs. Members, who pay a 200 Kshs annual fee, are organized into twenty- to forty-member "self-help groups" of neighbors. About 2,100 members comprise 103 such groups, all small-scale farmers growing horticultural crops for export: green beans, snow peas, Macadamia nuts, and chillies, okra, and other Asian vegetables. The technical staff consists of the chief executive, a training officer, and four field coordinators.

Training and export assistance are the major current activities. Seminars cover production, marketing, packaging, agrichemicals (including a small amount of training on pesticide use and maximum residue levels), and community and cooperative organization. The chief executive is planning to approach the GIFAP's Safe Use Project for training materials on pesticide safety. The association has bought consignments of high-quality bean and sugar pea seeds for its members. It also negotiates contracts and prices weekly on their behalf with export companies and domestic distributors. HCDA provides information on market prices in the United Kingdom. The association has received tips about a small but growing market for pesticide-free produce.

The association plans to supply pesticides to its members, with bulk wholesale orders of small packages distributed to local storage facilities. The association would also like to provide produce marketing services via van collection and delivery. It may also establish its own packaging and cold store operation as a subsidiary company with member shareholders (H. Muhia, personal communication, 1994).

Kenya Institute of Organic Farming. This Institute was founded in 1987 with support from Canada's International Development Resource Centre. Present activities are funded largely under the "Toward Sustainable Farming in Eastern Africa" project of the Netherlands' Education and Training Consultants Foundation. The Institute's field training staff of about twenty officers, who have completed two years of postsecondary agricultural college, register and train self-organized farmer groups of at least thirty-five people. About 5,000 farmers producing mainly tea, coffee, maize, beans, and vegetables have paid a one-time fee of 50 Kshs to become involved. The

Institute also offers three-week workshops in organic farming for staff of NGOs, East African government agencies, and church organizations. A one-day IPM workshop was held in Ngong in 1993 (J.-M. Fayemi, personal communication, 1994).

An International Development Research Centre–funded study of technology adoption found that Institute's green bean producers have no problems meeting quality standards, but that doing so requires extra effort and therefore also higher market prices as an incentive. Marketing is the farmers' biggest problem. Some local expatriate customers for organically grown produce have been identified, but export markets have not. The Institute needs assistance in this regard. The Dutch government is helping KIOF develop standards for organic certification of export produce.

The Institute is establishing ties to a number of kindred organizations in order to facilitate its work: to IIBC and ICIPE for adaptive research; to private voluntary organizations active in sustainable agriculture, such as Rodale International, for technical information; and to a network of donor, NGO, and church development projects and training centers in Kenya for implementation of its various activities (KIOF 1993; J. Kariuki and J. Adede, personal communications, 1994). The Institute publishes organic farming manuals and explanatory materials in support of its outreach activities (Donisthorpe and Njoroge 1993; KIOF 1993; Njoroge 1993, 1994).

Environment Liaison Centre International (ECLI). ELCI, Nairobi, is a member of the Pesticide Action Network International, a NGO network that was instrumental in the development and adoption of the International Code of Conduct. The ECLI is now monitoring the Code's implementation in Kenya. A "No Dumping Here" Project with the Kenya National Farmers' Union carried out field monitoring surveys in 1991 and 1993. The surveys have found widespread noncompliance with many provisions of the code (ELCI 1987, 1993; Partow 1992; J.-M. Fayemi, personal communication, 1994).

African Biodiversity Institute. The African Biodiversity Institute is a regional NGO based in Nairobi (formerly part of the African Pest and Environment Management Foundation). This organization specializes in the health and environmental impacts of pesticide use, particularly in relation to biodiversity.

The Biodiversity Institute recently initiated a postgraduate training program, the "Inter-University Programme on Environmental Risk Assessment." Scholarships provided by the German Academic Exchange Service are supporting six M.Sc. and five Ph.D. students. The students had a four-month orientation course and are pursuing their studies, most at African universities. Graduates of the program should be able to meet local project needs for pesticide-related environmental assessments (African Biodiversity Institute 1993a). Such consultant services are another major activity of African Biodiversity Institute staff, who have implemented 11 recent assignments for clients including the FAO, JICA, the African Development Bank, the United Nations Children's Fund, and the World Health Organization.

The African Biodiversity Institute also offers short-term training courses. One is a training program for environmental assessment for government officials from Africa, supported by

international environmental NGOs (World Wide Fund for Nature, the Nature Conservancy, World Resources Institute) and donors (JICA, United Nations Environment Programme). Others include a train-the-trainers course in pesticide safety and management, workshops on conducting gender profile studies, and training on nonchemical control of malaria and schistosomiasis with special reference to irrigation schemes (A. Latigo, personal communication, 1994).

The Institute is interested in establishing a regional laboratory for the analysis of pesticide residues. The laboratory would be used for in-service training and to offer services to many clients, including crop and meat exporters, agricultural and health researchers, and environmental monitoring programs (see section 2.4.3). A proposal has been submitted to the European Union in conjunction with the Monitoring and Assessment Research Centre in the United Kingdom and the Tropical Pesticide Research Institute (African Biodiversity Institute 1993b).

4.6.2. Environment

Most major donors are committed to environmentally sustainable development and require environmental reviews or other environmental analyses to insure that their projects will not cause unacceptable environmental damage. Japan is one exception; its pesticide grants have neither been evaluated for potential environmental impacts nor followed up meaningfully (Tobin 1994).

4.6.2.1. Kenya's national environmental action plan

The International Development Association has a stated commitment to insure that economic development is complementary to sound environmental management and that potential adverse environmental impacts from International Development Agency-financed projects are addressed. Because environmental degradation and pollution most often affect the poorest people and countries, the International Development Agency's borrowers, including Kenya, have been asked to prepare national environmental action plans (NEAPs). These plans set environmental priorities and map investment and other strategies for achieving related environmental goals (World Bank 1993). The World Bank is writing country environmental strategy papers to complement NEAPs (A. Kiss, personal communication, 1994).

Many donors, NGOs, and private voluntary organizations are supporting and participating in the elaboration of Kenya's NEAP and the necessary institutional capacity building. USAID/Kenya is considering whether it will support the plan's implementation. JICA is not involved in formulating NEAPs at present but would entertain requests for involvement (S. Shibata and Y. Kashihara, personal communications, 1994).

A workshop was held in mid-1993 to launch the formulation of Kenya's NEAP. NEAP task forces started work on issue papers in November and produced their first reports in February 1994. Pesticides are relevant to at least four of the nine issue papers: Biodiversity, Water Resources, Environmental Pollution Control and Wastes Management, and Sustainable Agriculture (Sabari 1994). The NEAP was to be completed and formally adopted by May 1994, including specific action plans and policy measures.

The NEAP is highly political and by all accounts its future is not bright. It is a donor- and international bank-driven initiative, whereas government commitment to environmental matters appears to be minimal. Even the effective, lucrative administration of Kenya's National Parks by the Kenya Wildlife Service came under siege in 1994. The Kenya Wildlife Service's director, opposed by politically powerful people likely to benefit financially from lax park protection, quit after the imposition of working conditions that he found unacceptable (Morell 1994). Lack of resolve in environmental matters is also reflected in administrative arrangements: the National Environmental Secretariat is decentralized to district level, with conflict and confusion the result. Together with Kenya's inadequate infrastructure, expertise, and resources, this absence of political will makes environmental monitoring and enforcement unlikely in future and may neutralize the NEAP's potential for success.

4.6.2.2. Local and regional initiatives

Under these circumstances, participatory initiatives by concerned citizens, scientists, and supportive government agencies may hold more promise. The Riparian Association, university scientists, the Kenya Forestry Research Institute, the Kenya Wildlife Service, the Kenya Marine and Fish Institute, and other groups are establishing an information-sharing and action network with a view to taking a proactive stance toward suspected problems at Lake Naivasha (see section 3.3). A literature search has just been completed. Work has begun on baselines and parameters for environmental monitoring as the first steps toward an environmental assessment of farming around the lake. The objective is to initiate ongoing, nonconfrontational consultation between all interested parties, resulting in the landowners themselves developing a long-term strategy for sustainable management of agriculture around Lake Naivasha (D. de Treville, J. Sutherland and A. Kiss, personal communications, 1994).

4.7. Projected impact of economic and policy factors

The economic, agricultural, and environmental policies and initiatives described above all affect pesticide use in Kenya. Effects can be both direct and indirect. As an illustration, enforcement of pesticide or environmental regulations that exclude hazardous pesticides from the Kenyan market would affect pesticide use directly. Inadequate agricultural credit programs have the indirect effect that farmers apply fewer pesticides because of lack of funds to purchase them. Similarly, government and donor promotion of certain crops can be expected indirectly to increase the use of pesticides customarily applied, unless the technologies used to manage pests change.

Trends in pesticide use in Kenya can be projected on the basis of trends in crop production (including the influence of donors and NGO projects), the economics of using pesticides, and factors affecting pesticide import and supply. Projections of pesticide use are presented for several key commodities in Table 8. These projections are for the short term only, namely three to five years. Many of the agricultural trade and policy reforms in Kenya are too recent to predict their long-term effect on crop production, market prices, and the consequent demand for pesticides. In addition, these predictions must be considered tentative in view of the incomplete and sometimes contradictory and incomplete data on which they are based (Box 3).

Table 8: Projected trends in the use of pesticides in crops and for livestock

	Time period—three to five years			
	Potential to expand area cultivated[a]	Incentive to intensify production[b]	Overall change in current pesticide use[c]	Comments/Assumptions
Crops				
Coffee	low	low–medium	low	price of coffee remains low, gradual conversion to IPM
Tea	low–medium	medium	low–medium	price low, but more stable than coffee
Maize	low	medium	low–medium	high government priority to intensify production
Vegetables	low	medium	low	price of pesticides relatively high
Export Horticulture	medium	medium	low–medium	government and donor support for increasing production, but logistics, maximum residue levels and cost of air freight hamper expansion
Livestock				
Tick control	medium	low	low	high cost of dipping prevents expansion of dipping activities

[a] Includes switching of area currently cultivated from one crop to another.
[b] Intensification of production is defined as increasing yields, utilizing agrichemical inputs.
[c] Overall change is defined as the potential to change or increase the volume of pesticides used compared to current usage patterns.

The projection made in Table 8 is that overall pesticide use is unlikely to change dramatically. A low- to medium-potential increase in pesticide use is projected for maize, tea, and export horticultural crops. The two central reasons for projecting only modest change are: (a) the inability to overcome constraints, particularly marketing-related problems, that affect horticultural exports; and (b) there is no evidence to suggest that pesticides have become cheaper or more profitable to use due to economic reform programs.

It is important to note that the low to modest increases in pesticide use projected in Table 8 do not in all cases directly reflect the potential environmental and health impacts of future trends.

There may be large increases in pesticide use in small geographic areas specializing in the production of new export crops requiring frequent pesticide applications (e.g., floriculture). Moreover, farmers producing those crops can be expected to use the same pesticides on their food crops as well (see section 2.2.1). Research initiatives on IPM for nontraditional export crops are new and cannot be expected to limit pesticide use significantly in the short term (see section 2.5.2). Such increases in pesticide use might be almost unnoticeable when measured at a national level but could still cause localized health and environmental problems. Similarly, the overall volume of pesticides used might remain unchanged, but higher prices could cause farmers to favor older, cheaper, and more hazardous pesticides (e.g., use of the cheap and dangerous herbicide paraquat instead of glyphosate, which is a safer but more expensive alternative).

5. Consequences of Projected Patterns of Pesticide Use

Consumption of pesticides in Kenya is still concentrated mainly in the coffee-growing areas: Embu, Kiambu, Kirinyaga, Machakos, Meru, Murang'a, Nyandarua, and Nyeri Districts in the Central and Eastern Provinces. Reliance on pesticides is also heavy and increasing in Nakuru, Narok, and Uasin Gishu Districts of the Rift Valley Province, where temperate cereals are cultivated (Partow 1992). These are the regions of Kenya where the health and environmental impacts of future pesticide use will be felt most.

5.1. The key role of policy implementation

The impacts of projected pesticide use in Kenya will depend greatly on whether government policies and regulations are actually implemented. Regulation of pesticides by the Pest Control Products Board and implementation of the NEAP would be mutually supportive. Doing those things effectively will entail much interministerial cooperation. Extending the collaboration to include the Ministry of Health would further facilitate effective pesticide management. There is a danger, however, that these measures will languish "on paper only" for lack of government interest and resources to implement them.

The degree to which international agencies are committed to effective pesticide regulation is a key question (Fleischer 1993). In the past, these agencies attempted to ensure the availability of pesticides in Africa through pesticide donations and projects to create and equip plant protection services. More recently, most of them have emphasized judicious pesticide use through IPM and the adoption of national pesticide legislation and regulations, as well as the formulation of NEAPs. In the face of alarming poisoning rates and fears for the environment, donors and pesticide companies alike have supported extensive training and information dissemination on pesticide safety (Box 1). In Kenya, the pesticide industry is attempting to isolate unethical companies through the accreditation of dealers and the registration of dealers (PCAK, personal communication, 1995). Yet these mitigative measures are widely recognized as being insufficient for safeguarding human health and the environment.

International agencies must now support actual implementation of the new policies and regulations if they place high priority on safe and correct pesticide use in developing countries. As with the earlier augmentation of national capacities to use pesticides, donors' financial support and technical assistance would be a logical first step. Without question, this will require a long-term commitment of funds, training, and technical assistance. Eventually, responsibility could be transferred to strengthened national institutions.

Unless this sort of concerted support is made available to Kenya, mitigative measures such as those recommended below will not be possible. Adverse health and environmental impacts of present pesticide abuse will only worsen. Lack of pesticide-related health and environmental monitoring will continue to keep the dimensions of the problem hidden, forestalling political pressure for change.

5.2. Health and environmental concerns

Pesticide-related hazards will be greatest where pesticides are used intensely, in association with heavily treated crops, and where particularly toxic, persistent, or mobile pesticides are customarily applied. Linking the projected increases in pesticide use in maize, tea, and export agriculture (Table 8) with the summary of pesticide hazards by use pattern given in Appendix C, it is possible to identify areas of special concern with relation to human health and the environment.

Where potential problems are recognized it is wise to monitor for their occurrence, so that harmful patterns of pesticide use can be recognized and changed before unnecessary damage is done. The geographic extent and degree of pesticide pollution and poisoning, as well as changes over time, must be known to policy makers if they are to produce sound plans for remedial action. Agriculture, health, and environmental agencies should cooperate in monitoring and also in planning and implementing mitigative measures.

After removal of the most dangerous chemicals from the pesticide market (Appendix C), application restrictions, farmer training, and routine monitoring of residues are the measures most likely to protect human health and the environment. Farmers should be offered quality training on a regular basis that covers pesticide health and safety and the judicious and effective use of pesticides. Appropriate clothing and protective devices should be recommended and made widely available.

5.2.1. Continued use of organochlorine insecticides

According to a representative of PCAK, the use of organochlorines declined to almost nil in 1994 as old stocks were depleted (PCAK, personal communication, 1995). Nevertheless, old stocks are not the only possible source (see section 3.1.1); unless Kenya's pesticide regulations are enforced, the continuing use of organochlorine insecticides in agriculture cannot be prevented. Should these chemicals remain on the market, they will be applied to many crops, including maize and vegetables produced for both the domestic and export markets. Persistence in the environment, residues in foodstuffs, and bioaccumulation in the tissues of humans and wildlife are likely to cause health and reproductive disturbances.

Several types of monitoring are advisable where organochlorine pesticides are used. Human and animal milk and tissues and other foodstuffs should be tested routinely for residues. In addition, the population levels and reproductive success of vulnerable wildlife species should be monitored. In Europe and North America, entire populations of certain predatory birds and other predators high on the food chain disappeared because organochlorine pesticide residues destroyed their reproductive capacity.

5.2.2. Acute poisoning of applicators

The projected expansion of pesticide use on maize, tea, and horticultural crops for export can be expected to increase acute poisoning of farmers and other people who handle or apply pesticides frequently. Flower, fruit, and vegetable production currently employ highly toxic soil sterilants, insecticides, and fumigants that are hazardous to applicators. The herbicide paraquat, widely applied by tea producers, is also dangerous (Appendix C).

Accordingly, donor-funded projects and the pesticide industry are increasing application safety measures. Staff of the KEDS Project expects pesticide safety for export horticultural crops to improve as a result of GIFAP's Safe Use Project, environmental awareness (Code of Practive), maximum residue levels, and product traceability (tighter exporter-grower linkages) (P. Guenette, personal communication, 1995).

5.2.3. Chronic poisoning of applicators and consumers

Many pesticides that do not present great risk of acute poisoning are suspected to have chronic deleterious effects on human health. Kenyan examples include most organochlorine insecticides, the fungicide captafol (suspected oncogenicity), and some maize and tea herbicides (e.g., 2,4-D, which is implicated as a carcinogen; Appendix C). Projected expansion of pesticide use on maize, tea, and horticultural crops will add to the importance of this problem.

Improper application of pesticides threatens agricultural workers and cause excessive residues to remain on marketed agricultural produce. The use of persistent compounds such as organochlorines, failure to observe a sufficient interval between the last application and harvest, and improper postharvest applications for cosmetic purposes, pest repellency, or storage pest control can all result in dangerous residue levels.

5.2.4. Water pollution

Certain agricultural pesticides are persistent and move in soil and water such that they can contaminate surface water and groundwater. Among the pesticides used in Kenya, the herbicides atrazine and bromoxynil, applied in maize fields, and the soil sterilant aldicarb, used in flower production, fall into this category. An increase in their use is projected.

If areas in which these and similar pesticides are used regularly have a soil or water configuration that might allow groundwater contamination, mitigative application restrictions and regular water monitoring should be initiated. Several European countries prohibit pesticide application along the borders of streams, wetlands, and bodies of water. In Iowa in the United States, groundwater contamination by maize pesticides is a problem, and the use of atrazine is permitted only under strict conditions. Maximum application rates are set with reference to field erosion potential. Mixing and loading is prohibited within 100 feet of wells and bodies of water, and wide buffer zones are required around bodies of water, drains, and wells.

5.2.5. Toxicity to nontarget species

Many commonly applied pesticides that are reasonably safe for human applicators are acutely toxic to fish, birds, bees, other beneficial insects, and other desirable nontarget species. Pesticides used in Kenyan maize, vegetables, and flowers are no exception.

Applicator training should stress the importance of safety measures that lessen risk to nontarget species. Among them are the avoidance of spraying flowering crops (bees), observing buffer zones around bodies of water, and not washing sprayers or discarding pesticide containers into streams or lakes.

5.2.6. Ozone depletion: Methyl bromide

Methyl bromide comprised 20 percent of the total insecticides imported into Kenya between 1986 and 1992, and sales increased 20 percent per year. According to a survey published in 1992, agriculture-related use of this fumigant is projected to increase by 95 percent by 2000 if current application trends continue (Schonfield, Wamukonya, and Glendening 1994).

Developing countries need funding for the identification and adoption of environmentally sound alternatives to methyl bromide. In 1990, an Interim Multilateral Ozone Fund was established to help such countries comply with the global phaseout schedule proposed by the Montreal Protocol of 1987. The usefulness of the fund is being compromised, however, because several industrialized nations are not meeting their financial obligation to support it (Schonfield, Wamukonya, and Glendening 1994).

6. Conclusions and Recommendations

6.1. The economics of pesticide use

Kenya needs to increase food production because of its rapidly growing population. Due to land limitations, increases in output must come from increases in yields, possibly requiring increased use of agrichemicals. Despite this situation, there may not be an economic incentive for farmers to increase their use of agrichemicals, especially pesticides. From 1987 to 1992, the prices of inputs increased at least as fast as the prices of outputs, and the overall effect has been a decline in the use of inputs. More specifically, expenditures on pesticides in the early 1990s have fallen from the peaks seen in the mid-1980s. Although the deflated import prices of pesticides have remained constant over time, the price ratios of outputs to inputs have also remained quite stable. Thus, although pesticides constitute only a small portion of the budgets for foodcrop production, there appears to have been little change in the incentives to use pesticides. The lack of variability in pesticide imports from 1980 to 1992 supports the conclusion that farmers have had little incentive to increase pesticide use.

The economic incentive to use pesticides to prevent yield loss and cosmetic damage on export crops might be greater than in the case of foodcrops. Nonetheless, stability of prices (constant terms) and a wide variety of logistical problems will continue to slow the growth in horticultural exports. Another problem facing Kenya's growers and exporters is the threat of maximum residue levels imposed by the European Union. Maximum residue levels may be a disincentive to increase pesticide use.

In conclusion, no quantitative data were found that show that economic reforms lowered the price of pesticides or have caused a change in cropping patterns resulting in a noticeable increase in pesticide use. The aggregated, national-level data cited in this report do not reveal localized or crop-specific changes in pesticide use. It was not possible, therefore, to determine whether the promotion of export crops has lead to a de facto increase in pesticide use. Finally, there is no evidence to suggest that the use of, or research into, alternative pest-management technologies has been encouraged or discouraged as a direct result of economic reforms.

Economic policy reforms apparently have not significantly changed the economic incentives to use pesticides, but this does not mean that there are no problems with pesticide use and management in Kenya. Problems associated with pesticide use predate the advent of the economic policy reforms. With or without the reforms, farmers can be viewed as being caught between the need to intensify production (foodcrops) or maintain quality (export horticulture) and the economic necessity of keeping input costs as low as possible.

6.1.1. Information on the returns to pesticide use

There are few or no data readily available in Kenya indicating the returns, financial or otherwise, to using various pest-management technologies. Without such data, policy makers,

extension agents, and farmers do not have a rational basis on which to consider changes in patterns of pesticide use.

Recommendation 1. The Kenyan government and donors should support research into the costs and benefits of various technologies to manage pests. Such research is the foundation of any attempt to improve pesticide use patterns. For example, such research could be linked to joint ICIPE-FREAK studies.

6.1.2. Database needs

In evaluating patterns of pesticide use it is essential to have available a database that allows researchers, government analysts, and decision makers to evaluate trends in factors affecting the demand and the supply of pesticides. Such a database must consist of a time series of observations of a variety of factors. Examples of factors important in determining the use of pesticides include: prices of inputs; farmgate and marketplace prices of outputs; wage rates; transportation costs; and import and export data for agricultural inputs and outputs.

Recommendation 2. The Kenyan government and donor agencies should actively support and strengthen the data gathering and analysis capabilities of units such as the Central Bureau of Statistics.

6.2. Policy and regulatory environment

6.2.1. Donor commitment to effective pesticide management and environmental protection

For years, donors have urged that pesticide legislation and regulations be enacted and enforced in developing countries. Donors and international lending institutions have funded technical assistance projects to put such legislation and regulations in place and have made the formulation of NEAPs a condition of funding. Presumably, these NEAPs will address pesticide pollution and could play a constructive, complementary role in judicious pesticide management.

All these paper measures must be enforced, however, and this entails operational, staff, and infrastructure costs and the application of specialized expertise. Many African countries, including Kenya, do not yet have the means to implement such measures. Pesticide legislation and regulations have been "on the books" in Kenya for almost a decade, and a NEAP will be completed by the end of 1994. It appears, however, that Kenya may lack the financial and human resources and perhaps the political will to apply these policy instruments.

If pesticide legislation is to be enforced, therefore, and if pesticide pollution monitoring is to be conducted, donors and lending institutions must provide policy support as well as a significant portion of the resources required. This is the case not only with regard to bilateral arrangements, but also with regard to international agreements to assist developing countries. An example is the Interim Multilateral Ozone Fund, created to help phase out use of the ozone-depleting methyl bromide in the developing world.

Recommendation 3. International donors must make a major long-term commitment of policy support, funds, training resources, and expertise for the implementation of pesticide regulations and environmental measures in Kenya and other developing countries.

6.2.2. Eliminating subsidies for pesticide

As part of economic adjustment programs, donors are encouraging free markets in agrichemical inputs, including the elimination of subsidies and the privatization or dismantling of parastatals and government agencies that formerly procured, distributed, and marketed pesticides. If alternative pest-management technology is available and extended to farmers effectively, higher pesticide prices can act as an incentive for farmers to reduce their use of pesticides by adopting IPM practices or converting to organic farming.

In Kenya, policy reforms are making slow progress and are far from complete. Some pesticide subsidies are still in place. For example, the government is not planning to apply import tariffs or value-added taxes to agrichemicals, and distributes pesticide grants-in-aid to farmers at nominal prices through parastatal agencies. Such subsidization distorts the economic returns from using pesticides, encouraging farmers to use more and reducing the economic efficiency of pest management.

Recommendation 4. All forms of pesticide subsidies should be eliminated in Kenya. Further, international donors should stop making nonemergency pesticide donations to Kenya and other developing countries.

6.2.3. Reevaluation of USAID's environmental procedures

Project and nonproject assistance, agricultural policy reform, and trade and investment programs and projects undertaken in developing countries by donor agencies and international lending institutions can affect pesticide use both directly and indirectly. Programs to provide farmers with alternatives to dependence on pesticides should be funded concurrently with credit programs for agricultural inputs, the promotion of export crops, and other initiatives that might increase pesticide use even indirectly. This does not mean that programs in support of agricultural production should be curtailed. Rather, it is a recognition that environmental assessment of a project should highlight the necessity for applying alternative methods for managing pests. Developing these alternatives is a sound economic investment and should have positive health and environmental impacts.

The KEDS Project was granted a categorical exclusion from an environmental assessment of pesticide use on the assumption that the project's impact on the environment would be indirect. That is, although the project might increase pesticide use by increasing the cultivation of heavily treated export crops, the project was granted exemption from further environmental review because it would not include "specifically identifiable activities" involving pesticide application (USAID 1991b). In fact, however, data presented in the present report support a strong connection between export agriculture and pesticide use. Therefore, exempting the KEDS Project from the

environmental assessment process means that an opportunity was missed to highlight the need to invest in the research and development of appropriate alternative pest-management technologies.[8] This oversight may be corrected in the next few months when the KEDS project is evaluated (P. Guenette, personal communication, 1995).

Recommendation 5. USAID should require projects and programs to complete an environmental review of pesticide use even if related activities would affect pesticide use only indirectly.

6.2.4. Interagency and private-sector collaboration for better pesticide management

Pesticides are important not only to agriculture but also to public health and environmental protection. Yet in Kenya those sectors do not collaborate with regard to pesticide management. The Ministry of Health appears to be oblivious to, or uninterested in, KARI's monitoring of pesticide residues on foodstuffs. The private sector and NGOs both possesses resources and expertise that could support improved pesticide management. Better collaboration would mean better-informed, higher-quality decision making and program implementation and would also prevent wasteful duplication of effort and facilities (e.g., for pesticide analysis).

Recommendation 6. Good working collaboration should be established among government agencies, NGOs, and agribusinesses that deal with pesticides, cutting across the agricultural, health, environmental, and education sectors. Information regarding patterns of pesticide use in agriculture and public health should be used to develop environmental monitoring plans. Data on pesticide poisoning and residues should be shared among agencies, and they should collaborate in policy making, regulation, enforcement, research, training, and hazard mitigation.

6.2.5. Regional collaboration for pesticide management

At present, pesticide regulations (including registration requirements and import restrictions) differ in each country in East Africa. Their enforcement is attempted in isolation by each country, but there is much scope for sharing information, expertise, and regulatory facilities (e.g., pesticide laboratories), and harmonization of regulatory measures. Doing so would benefit both governments and pesticide companies.

Recommendation 7. The Kenyan government should initiate regional collaboration in pesticide management with neighboring countries that face similar problems.

[8] The World Bank requires environmental assessments in similar cases (A. Kiss, personal communication, 1994).

6.3. Projects and initiatives

6.3.1. Research and extension of alternatives to pesticides

At the moment, the intensive use of pesticides can be viewed as something of an insurance payment. Pesticides are applied intensively because most farmers are not aware of other alternatives for averting risk. When new pest-management methods become available that reduce the need for expensive pesticide applications, and farmers know enough about pests and crop ecology to understand and trust those methods, farmers can be expected to adopt them.

The Government of Kenya and its donors are currently supporting a number of IPM research initiatives that address key pest-management problems on important crops. These are salutary initiatives and should be sustained on the long term. It is equally important to ensure that new, less-toxic pest-management methods are rapidly and widely disseminated. Kenya is less fortunate in that regard. The Kenyan extension system appears to be inadequate for delivering the sort of comprehensive ecological and crop-management training that is needed to make farmers confident practitioners of IPM or organic farming. Experience in other parts of the world has led to modifications of extension systems and training methodology that facilitate the extension of IPM (e.g., Matteson, Gallagher, and Kenmore 1994). Technical workshops, supported by projects such as KEDS, and involving organizations such as ICIPE, FREAK, and KARI, might help to disseminate data on IPM techniques to specialized farming groups involved with export horticulture.

Recommendation 8. The Kenyan government and donors should continue to give high priority to IPM research. In addition, it is important that donors help the Government of Kenya strengthen its extension operations further. This assistance should include innovations in methodology and program design, as necessary for adequate farmer training in integrated crop management.

6.3.2. Evaluation and support of organic farming

At the moment, neither Kenyan government agricultural agencies nor international donors are explicitly encouraging organic agriculture. Yet organic production has many advantages: it has proven to be competitive economically in many parts of the world, notably in the United States; there is a growing specialized market for organically produced commodities; research in this area is useful for minimizing pesticide use by nonorganic growers as well; and methods applied in organic farming are sustainable while avoiding damage to human health and the environment. Despite initial studies indicating problems with transport costs and certification (P. Guenette, personal communication, 1995), the opportunities that organic produce present have probably not been explored fully.

Recommendation 9. International donors such as USAID and Kenyan research and extension agencies should collaborate with organic farmers to develop and evaluate nonchemical pest-management methods and to promote the use of those methods by all growers in situations

where such methods are effective and attractive economically. Projects such as KEDS and agencies such as the HCDA should continue to explore markets for organically grown produce and strive to meet organic farmers' needs for information and technical assistance.

6.3.3. Equity and the promotion of nontraditional export crops

Governments, donor projects, and international lending agencies are promoting export agriculture in developing countries where the information on IPM and pesticide management that is necessary for profitable production and compliance with maximum residue levels is not yet available to small- and medium-sized entrepreneurs. This situation compounds the managerial and financial advantage of large-scale operations run with European expertise and resources by international corporations and Kenyan citizens who are already wealthy. Unless this imbalance is redressed (in other management aspects as well as in pest management), donors will be fielding a program of "aid for the rich" and an undue proportion of profits will be expatriated (World Resources Institute 1993).

In Kenya, the KEDS Project and its collaborating agency, the HCDA, recognize the inequities described above and are targeting smallholder beneficiaries accordingly. Moreover, KEDS is monitoring the direct company beneficiaries of its Export Development Fund. Initial results indicate that small- and medium-sized companies are the primary beneficiaries of KEDS' programs.

Recommendation 10. Small- and medium-scale producers and exporters of nontraditional export crops should continue to be targeted for support and services. Donors and government agencies should continue to monitor project beneficiaries and try to maximize equitable distribution of program benefits.

6.4. Prioritizing the recommendations

For the short term (two to three years), the first two recommendations should be given a high priority. Without the resulting data, decision making for sound implementation of the other recommendations will be far less effective.

Recommendations 3 and 8, which address support for the development and extension of alternative pest-management technologies and for enforcing pesticide and environmental legislation, should be given the highest priority for the long term (ten to twenty years). Unless least-toxic pest-management methods are available to them, farmers will have no choice but to continue using pesticides unnecessarily. This is uneconomic for them and for the country as a whole, particularly when the negative health and environmental impacts of pesticide use are considered. The improvements in pesticide management and the environmental monitoring and protection measures proposed in the present report are not economically feasible without a long-term commitment on the part of government, donors, and international lending agencies.

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Appendix A: List of banned and restricted pesticides in Kenya

Dibromocholoropropane	Soil fumigant--banned 1986
Ethylene Dibromide	Soil fumigant--banned 1986
2,4,5,-T	herbicid--banned 1986
Chlordimeform	insecticide--banned 1986
Mixture of isomers of Hexachlorocyclohexane (HCH)	banned 1986
Lindane (pure gamma-BHC [HCH])	insecticide--restricted use for seed dressing only
Chlordane	insecticide--banned 1986
Heptachlor	insecticide--banned 1986
Endrin	insecticide--banned 1986
Aldrin	insecticide--restricted for termite control in building industry
Dieldrin	insecticide--restricted for termite control in building industry
Toxaphene (Camphechlor)	insecticide--banned 1986
DDT	–public health, mosquito control only--restricted for use in mosquito breeding grounds –agricultural use--banned 1986
Captafol	fungicide--banned 1989
Parathion (Methyl and Parathion Ethyl)	insecticide--banned 1988
Daminozide (Alar)	plant growth regulator for use on fruits--voluntarily withdrawn by company
Cyhexatin	acaricide--voluntarily withdrawn by company

Appendix B: Foodcrop production in Kenya

Year	Maize				Beans			Millets			Sorghum		
	Area	M.Prd	T.Prd	Yld	Area	Prd	Yld	Area	Prd	Yld	Area	Prd	Yld
1970–1971	975	206	835	0.9	151,972	64,512	0.42	19,480	8,545	0.4	116,994	44,526	0.4
1971–1972	1,043	257	943	0.9	163,914	86,647	0.53	39,611	20,721	0.5	107,954	38,513	0.3
1972–1973	1,212	373	1,051	0.9	188,334	120,352	0.64	47,346	24,146	0.5	85,513	41,783	0.5
1973–1974	1,151	441	1,159	1.0	178,567	125,399	0.70	41,898	22,487	0.5	35,332	13,958	0.4
1974–1975	1,162	365	1,267	1.1	206,753	120,611	0.58	40,697	28,444	0.7	49,785	16,496	0.3
1975–1976	1,191	488	1,375	1.2	245,532	110,188	0.45	54,227	30,280	0.6	57,230	19,714	0.3
1976–1977	1,216	563	1,597	1.3	243,625	124,754	0.51	57,972	30,473	0.5	54,931	29,110	0.5
1977–1978	1,247	424	1,671	1.3	282,983	199,247	0.70	48,357	29,678	0.6	79,510	74,565	0.9
1978–1979	1,282	236	1,620	1.3	243,843	184,463	0.76	63,377	48,984	0.8	84,914	88,386	1.0
1979–1980	1,323	242	1,607	1.2	245,633	166,227	0.68	45,951	34,906	0.8	66,624	54,141	0.8
1980–1981	1,365	218	1,888	1.4	342,829	195,854	0.57	47,546	37,126	0.8	81,914	61,314	0.7
1981–1982	1,120	473	2,560	2.3	412,907	325,102	0.79	52,040	35,113	0.7	84,617	61,702	0.7
1982–1983	1,208	571	2,450	2.0	467,797	333,489	0.71	48,246	32,357	0.7	104,999	58,744	0.5
1983–1984	1,236	637	2,215	1.8	467,395	308,776	0.66	48,141	32,273	0.7	79,858	71,291	0.9
1984–1985	1,230	561	1,500	1.2	423,423	225,117	0.53	63,207	31,597	0.5	109,640	80,389	0.7
1985–1986	1,370	583	2,440	1.8	472,345	314,613	0.67	52,243	30,505	0.6	116,940	79,215	0.8
1986–1987	1,430	670	2,870	2.0	525,749	435,769	0.83	44,319	32,343	0.7	97,756	81,196	0.8
1987–1988	1,440	652	2,400	1.7	547,796	325,798	0.59	39,747	29,061	0.7	103,968	53,258	0.5
1988–1989	1,420	485	3,140	2.2	596,671	359,030	0.60	85,327	62,386	0.7	143,902	101,149	0.7
1989–1990	1,460	626	3,030	2.1	668,670	426,500	0.64	107,310	79,760	0.7	156,040	139,430	0.9
1990–1991	1,300	509	2,890	2.2	501,130	424,277	0.85	96,933	69,762	0.7	117,960	100,962	0.9

Source: Gitu (1992).

Notes: M.Prd = Marketed production. T.Prd = Total Production. Units: maize--area in '000 per hectare, Prd in '000 tonnes, yield in tonnes per hectare; beans, millets, and sorghum--area in hectares, Prd. in tonnes, yield in tonnes per hectare.
Units; bananas, groundnuts, and potatoes; Area in ha; Prd. in tonnes; Yield in tonnes per hectare.

Appendix B: (continued)

Year	Bananas			Groundnuts			Potatoes		
	Area	Prd	Yld	Area	Prd	Yld	Area	Prd	Yld
1970–1971				18,830	8,894	0.5			
1971–1972				16,072	9,541	0.6			
1972–1973	53,494	303,843	5.7	15,904	14,153	0.9			
1973–1974	48,725	535,119	11.0	17,110	5,125	0.3	42,736	311,174	7.3
1974–1975	41,970	529,492	12.6	18,046	10,435	0.6	47,912	399,972	8.3
1975–1976	44,051	665,622	15.1	17,767	15,848	0.9	43,271	418,610	9.7
1976–1977	35,573	639,661	18.0	42,053	38,052	0.9	55,572	549,928	9.9
1977–1978	36,802	660,174	17.9	25,641	22,649	0.9	55,598	349,508	6.3
1978–1979	39,841	707,676	17.8	17,527	15,774	0.9	47,150	701,149	14.9
1979–1980	48,096	863,800	18.0	22,582	20,482	0.9	48,415	1,347,689	27.8
1980–1981	59,201	989,716	16.7	14,711	13,023	0.9	61,543	578,049	9.4
1981–1982	62,156	1,028,570	16.5	17,560	11,480	0.7	62,702	734,576	11.7
1982–1983	63,083	1,021,797	16.2	14,730	15,717	1.1	62,621	596,532	9.5
1983–1984	63,688	1,179,370	18.5	17,766	3,398	0.2	64,842	414,337	6.4
1984–1985	68,272	1,185,217	17.4	18,246	7,311	0.4	49,886	288,332	5.8
1985–1986	81,996	1,402,469	17.1	15,978	5,437	0.3	78,549	809,344	10.3
1986–1987	88,766	1,635,343	18.4	14,504	5,197	0.4	87,888	809,690	9.2
1987–1988	89,761	1,615,689	18.0	11,623	8,954	0.8	85,288	670,966	7.9
1988–1989				18,099	22,718	1.3	86,598	799,813	9.2
1989–1990				18,303	13,260	0.7	85,628	810,158	9.5
1990–1991				19,508	16,133	0.8	86,965	771,178	8.9

Source: Gitu (1992).
Notes: M.Prd = Marketed production. T.Prd = Total Production. Units: bananas, groundnuts, and potatoes; area in hectares; Prd. in tonnes; yield in tonnes per hectare.

Appendix C: Summary of Pesticide Hazards

This is an illustrative list of hazardous pesticides recommended or widely used in Kenya for the use patterns shown. Those cancelled or only for restricted use in the United States are marked with an asterisk (*).

Use Pattern	Pesticides	Main Hazards
General use	Organochlorine insecticides (e.g., aldrin*, DDT*, dieldrin, HCH*, lindane*)	Carcinogenicity. Bioaccumulation. Hazard to wildlife, other chronic effects. Acute toxicity (lindane).
Cattle dipping	Organophosphate acaricides (e.g., dioxathion/Delnav toxaphene/Coopertox*)	Acute toxicity and/or chronic health effects and/or hazard to nontarget species.
Maize, vegetables, flowers, coffee	Some organophosphate and carbamate pesticides (e.g., amitraz/Mitac* carbofuran/Furadan* dichlorvos/Nogos, DDVP* dicofol/Kelthane, Acarin* dimethoate/Rogor* disulfoton* fenitrothion methomyl/Lannate* omethoate/Folimat parathion* propoxur/Baygon*)	Acute and/or chronic toxicity and/or toxic to nontarget species.
Maize, vegetables, flowers	Synthetic pyrethroid insecticides (e.g., cypermethrin* esfenvalerate/Asana* fenvalerate/Sumicidin* flucythrinate/Cybolt* lambda-cyhalothrin/ Karate* permethrin/Ambush*)	Toxic to nontarget species. Acute toxicity (lambda-cyhalothrin).

Use Pattern	Pesticides	Main Hazards
Vegetables, flowers, coffee	Some fungicides (e.g., benomyl/Benlate* captan* captafol/ Orthodifolatan* dinocap/Karathane* EBDCs—mancozeb, maneb, propineb, zineb, etc.*)	Chronic health effects and/or hazardous to nontarget species.
Coffee, tea, maize, general use	Herbicides (e.g., alachlor/Lasso* atrazine/Atrazine, Primagram, Laddock* bromoxynil/Brominol* 2,4-D*)	Can leach to ground water (atrazine, bromoxynil). Can cause tumor growth or birth defects (alachlor, atrazine, 2,4-D).
	Paraquat herbicide	Irreversible lung damage or fatal if swallowed, skin irritation.
Flowers	Soil sterilants (e.g., aldicarb/Temik* chloropicrin* fenamiphos/Nemacur*)	Acute toxicity and/or chronic health effects. Hazardous to nontarget species. Can leach to groundwater (aldicarb).
Flowers, strawberries, storehouses	Fumigants (e.g., methyl bromide*)	Acute toxicity. Ozone depletion.

Sources: *Use patterns*: Moll and Lohding 1984; Saxena et al. 1989: Morzaria et al. 1988; Young et al. 1990; Malik and Njenga 1992; Partow 1992; Darling 1993; Kibata 1993; Malik 1993; Mwanthi and Kimani 1993; Malik 1994; *Daily Nation* 1994b; Mbakaya et al. 1994. *Registration information and hazards*: Jourdain et al. 1990; U.S. Environmental Protection Agency 1990, 1993, 1994; Iowa State University 1991; Meister Publishing Co. 1992.