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Horticulture for Poverty Alleviation

The Unfunded Revolution

Katinka Weinberger and Thomas A. Lumpkin

AVRDC
The World Vegetable Center

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AVRDC – The World Vegetable Center

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Horticulture for Poverty Alleviation—The Unfunded Revolution

by Katinka Weinberger and Thomas A. Lumpkin
AVRDC – The World Vegetable Center

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Acronyms and Abbreviations

AVRDC	AVRDC – The World Vegetable Center
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
EU	European Union
g	gram
GIS	geographic information system
ha	hectare
INIBAP	International Network for Improvement of Banana and Plantain
IRRI	International Rice Research Institute
kg	kilogram
LAC	Latin America and Caribbean
Lao PDR	Lao People's Democratic Republic
MT	metric ton
NAFTA	North American Free Trade Agreement
R&D	research and development
SPS	Sanitary and Phytosanitary Agreement
SSA	Sub-Saharan Africa
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
US$	United States dollar
WARDA	Africa Rice Center
WHO	World Health Organization
WTO	World Trade Organization

Executive summary

Since the 'Green Revolution' was initiated in the 1950s, vastly more resources have been channeled into the development and improvement of cereal grains compared to horticultural crops. As a result, productivity increases in horticultural crops have been much smaller as compared to rice, wheat or maize. Yet, farmers all over the world find it profitable to diversify into horticultural crops, and worldwide production of horticultural crops has grown faster than that of cereal crops, albeit from a much lower base. Between 1960 and 2000, the area under horticultural crops worldwide has more than doubled. The increases in total volumes of fruits and vegetables traded worldwide have been dramatic and the total value of horticultural crops traded at present is more than double that of cereal crops.

Although the supply of fruits and vegetables has increased continuously on a global scale, much of this growth has been concentrated in Latin America and China. Other regions of the world have been less fortunate. Per capita supply is inadequate in Sub-Saharan Africa and has seen virtually no increase over the past 40 years. Such low levels of fruit and vegetable consumption in some parts of the world have devastating health effects. It is estimated that insufficient fruit and vegetable intake causes some 2.7 million deaths each year, making it one of the top ten risk factors contributing to mortality.

Due to the limited attention that public research institutions have given to horticultural crops, yield increases in cereals have outstripped yield increases in horticultural crops. Nevertheless, the expansion of horticultural crops has exceeded that of rice, wheat and maize throughout the world. The share of area under horticultural production is increasing in all regions and globally now stands at 6.7%. The expansion of horticultural production has been most impressive in China, where nearly 20% of all arable land is currently under fruit and vegetable production. China produces nearly half (47%) of the world's vegetable supply. Notwithstanding the relatively small share in arable land, the value that horticultural production adds to total agriculture is impressive. In many countries the value of horticultural production equals or even surpasses the value of cereal production.

There are several reasons for the global increase in production and trade of fruit and vegetable crops. Horticultural production is profitable. Farmers involved in horticultural production usually earn much higher farm incomes as compared to cereal producers. Cultivation of fruits and vegetables allows for productive employment where the labor/ land ratio is high, since horticultural production is usually labor intensive. Increasing horticultural production contributes to commercialization of the rural economy and creates many off-farm jobs. However, expanding the scale of horticultural production is often hindered by lack of market access, market information, and many biological factors.

Demand for horticultural produce is rising, both in domestic and international markets. In developed countries, a desire for year-round availability and increased diversity of foods, as well as a growing awareness of the relationship between diet and health, all contribute to the increased consumption of these commodities. Many consumers today purchase a broad range of relatively expensive commodities such as off-season produce, exotic fruits and vegetables, and organic produce. Increasing participation of women in the labor market of developed economies has created demand for processed, ready-to-eat convenience products, including cut fruit and salad mixes. Developing countries are taking advantage of this trend, and over the past decade the increase of their processed food exports has exceeded that from the developed regions. Many work tasks, such as chopping, washing, labeling, and bar-coding, are being transferred to developing countries and are generating new jobs, especially for women.

But negative consequences of increasing trade have also been reported. Supermarkets increasingly influence the structure and conditions of the agri-food system and dictate the conditions and the potential for small farms and firms to sell agri-food products. Quality and reliability demands of supermarkets often act as barriers to participation in the trade chain by small-scale exporters and producers. The participation of small-scale producers in global fruit and vegetable trade is also affected by the increasing attention that food quality and safety are receiving in food trade, coupled with an expansion in the number of non-tariff measures that developed countries apply to agricultural products. Fruits and vegetables belong to the class of food items most frequently affected by sanitary and phytosanitary measures. Evidence exists that small-scale producers and processing firms are being pushed out of markets.

Demand for horticultural produce is expected to rise further, fueled both by affluent urban consumers in developing countries and consumers in developed countries. To ensure that small-scale and resource-poor farmers stand a chance to participate in these expanding markets, policy makers and researchers have to place greater attention toward their needs. In particular, more research efforts have to be undertaken in Africa. Yield levels there are extremely low compared to other regions of the world and need to be increased. More emphasis will have to be placed on the diversification of crops and products, development of hybrid varieties, and on increasing stability and productivity of yields by making use of modern technologies such as molecular tools. More research is also needed to analyze for functional properties of fruits and vegetables from a health perspective, leading to biofortifications that add value for poor, malnourished populations.

Another area of research that needs increased attention relates to the provision of safe horticultural produce. Fruits and vegetables together account for the major share of the global pesticide market, and farmers have been reported to apply pesticides every few days, often just before harvesting, and many of the pesticides are unapproved for these crops. Effective production technologies such as biopesticides, pheromones and other bio-intensive integrated pest management technologies must be developed and farmers and exporters from less developed countries must be provided training opportunities and access to information on how to produce and supply safe products for both regional and international markets.

Improving horticultural seed distribution chains and market information systems and facilitating farmers' access to credit are all essential components of a strategy that seeks to develop horticultural systems. In addition, increasing urbanization and the needs of growing cities to feed their population will require more attention toward urban and peri-urban horticultural production.

Today, 1.1 billion people continue to live in extreme poverty on less than US$1 a day. Another 1.6 billion live on between US1–2 per day. The productivity of agriculture must increase to enable these people to live in dignity. The expansion of markets and the liberalization of trade policies are providing new opportunities for rural people to escape poverty through production and exchange of nonstaple crops. However, the research agenda for agriculture must be broadened from cereal crops and must put more emphasis on horticulture. Only then will the growing importance of horticulture benefit a significant portion of the world's poor nations, farmers and landless laborers.

1 Neglect of horticultural research

Historically, the attention of development policymakers is and has been focused on staple grains. Since the 'Green Revolution' was initiated in the 1950s, vastly more resources have been channeled into the improvement of staple grains compared to horticulture crops. Between 1968 and 1996, the United States Agency for International Development (USAID) was one of the largest donors to the international agricultural research centers dealing with the staple crops rice, wheat and maize (IRRI, WARDA and CIMMYT). Over this 29-year period, USAID provided US$213.58 million to these three centers (27% of all USAID core contributions), while centers focusing on tropical fruits and vegetables (INIBAP and AVRDC) received US$18.80 million (2.4%), less than one-tenth as much (Alex, 1997).

Recently, the Consultative Group on International Agricultural Research (CGIAR) has expressed more interest in horticulture research, and research on high value crops has been identified as a system priority (CGIAR, 2004)[1]. Still, research investment into horticultural research remains woefully inadequate. In 2002, the CGIAR system invested US$118 million on research for cereals, 37% of all CGIAR expenditures (CGIAR, 2003). In contrast, during that same year CIAT[2], INIBAP, and AVRDC together invested US$15.7 million for fruit and vegetable research (CIAT, 2003; INIBAP, 2003; AVRDC, 2003), roughly 13% of what was invested into cereal crops.

These research investments do not adequately represent the value of horticultural crops. The world's five largest producers of rice, wheat and maize are China, USA, India, Indonesia and Brazil. Even in these five large cereal producing countries, the value of fruit and vegetable production as compared to all cereal production is 85%, 105%, 55%, 59% and 91%, respectively. On a global level, the value of all fruits and vegetables traded is more than double of the value of all cereals traded.

Despite this neglect, we argue in this paper that a silent horticultural revolution is taking place. Albeit from a much smaller base, average annual production growth in horticultural crops has been larger than in cereal crops. All over the world, the area under food grains is under pressure from more profitable horticultural crops. The increases in total volumes of fruits and vegetables traded worldwide have been dramatic.

But while trend lines are impressive, the magnitudes are inadequate to supply minimally nutritious diets and to have a major impact on poverty alleviation in the developing world. Much more political and financial attention must be given to research in horticultural systems if increasing numbers of poor farmers are to benefit from the potential of this silent revolution.

2 Global trends in fruit and vegetable production

The worldwide supply of fruits and vegetables per capita has increased continuously since 1961. In 2002, the global per capita supply of fruits and vegetables was 173 kg, i.e. 112 kg of vegetables and 61 kg of fruit.

But the availability of fruit and vegetables is unevenly distributed (Figure 1). Only a small minority of the world's population consumes fruits and vegetables equal to or greater than the recommended intake of 400 g per day (146 kg per year).

Availability is highest in the developed world at around 200 kg per capita. Asia, which had lower fruit and vegetable supplies per capita than Africa throughout the 1960s to 1980s, has recently enjoyed high production growth rates. In 2002, approximately 180 kg per capita per annum were available. In vegetables, the developing countries of Asia now have similar supply rates as developed countries.

The lowest levels of supply are recorded for de-

[1] Consider the opening address that Dr. Ismail Serageldin, former Chair to the CGIAR, gave during the International Congress of Horticulture in Toronto, 2002, Nurturing and Nourishing the World's Poor: Important Roles for Horticulture in Sustainable Development (Serageldin, 2003), which emphasized the need to place more research efforts on horticultural crops.

[2] Tropical fruits are only one among several mandate crop groups and constituted only 0.6% of all research expeditures at CIAT in 2002.

veloping countries in Africa. There, only 106 kg of fruit and vegetable produce is available per capita, half of the developed world rate.

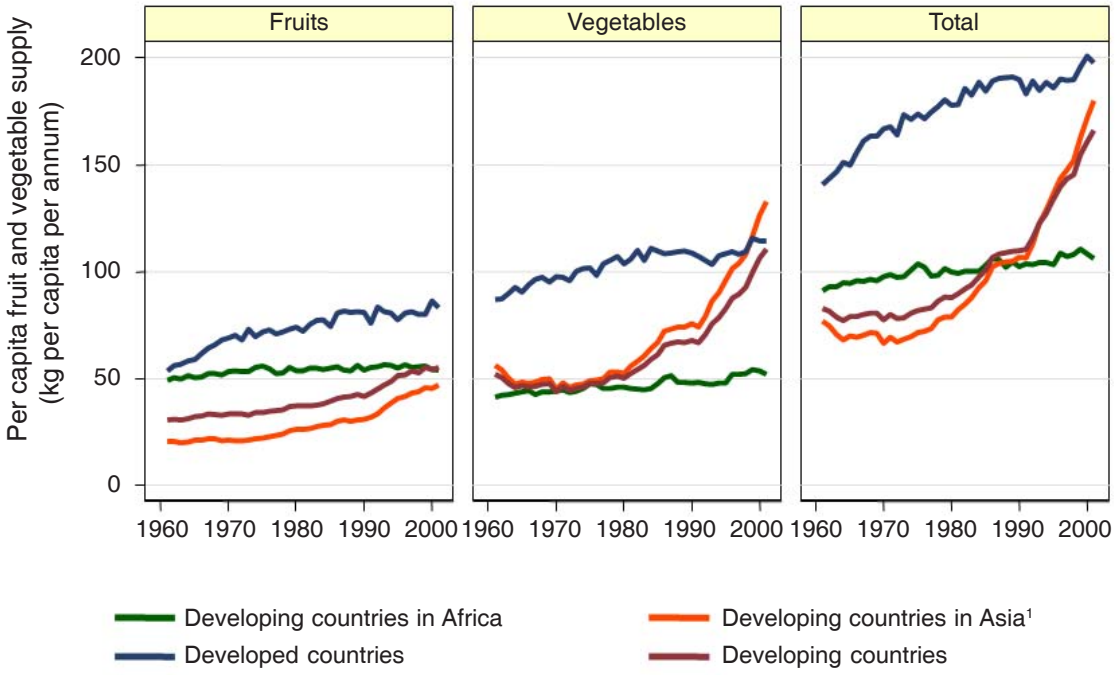
Such aggregated supply figures do not adequately reflect the large disparities that exist within regions and within countries. A study by Pomerleau et al. (2004) indicates that wide variations in intake exist between gender and different age groups. For example, estimated intake levels are lowest for women in the age group 15–29 in certain countries of Latin America (Argentina and Mexico), Europe (Estonia, Lithuania and Russian Federation) and South Asia (India and Bangladesh) at 54 kg, 72 kg and 73 kg, respectively.

Such low levels of fruit and vegetable consumption in some parts of the world have devastating health effects. It is estimated that insufficient fruit and vegetable intake causes some 2.7 million deaths each year, and belong to the top 10 risk factors contributing to mortality (Ezzati et al., 2002). In order to stimulate fruit and vegetable consumption, the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) jointly announced a fruit and vegetable promotion initiative in 2003.

With the exception of Sub-Saharan Africa (SSA), where average annual growth in per capita supply of horticultural produce was negative between 1971 and 2000, all other regions experienced growth in per capita fruit and vegetable supply at rates outstripping growth in per capita cereal supply. Average annual growth rates have been increasing over decades, and have been particularly rapid in the last decade, 1990 to 2000 (Table 1)[3]. The growth of worldwide per capita vegetable supply has been somewhat faster than that of fruit, with a growth rate of 1.8% against 1.2% for fruit.

Increases in production have been achieved both because of area expansion and productivity enhancement; but in general, for fruits and vegetables

Figure 1. Per capita fruit and vegetable supply



[1]Upward trend of vegetables largely influenced by changes in China
Source: FAOSTAT data, 2004

[3]Here and in the following, estimates of growth rates are based on the least square growth rate. The regression equation takes the form log Xt = a + bt. In these equations, X is the variable and t is time. If b* is the least-squares estimate of b, then the average annual growth rate is obtained as [antilog (b*)-1] and multiplied by 100 to express as a percentage.

Table 1. Average annual growth rates (%) in fruit and vegetable and cereal supply (per capita)

	Fruits and Vegetables			Fruits and Vegs.	Cereals
	1971–1980	1981–1990	1991–2000	1971–2000	1971–2000
China	1.5	7.5	9.0	6.2	0.8
South Asia	0.7	0.8	2.5	1.2	0.5
East and Southeast Asia	3.4	0.5	1.1	1.2	0.5
Latin America and Caribbean	0.2	1.6	1.4	0.9	0.2
Sub-Saharan Africa	–0.6	–0.4	–0.1	–0.3	0.4
World	0.9	1.6	3.0	1.6	0.4

Source: FAOSTAT data, 2004

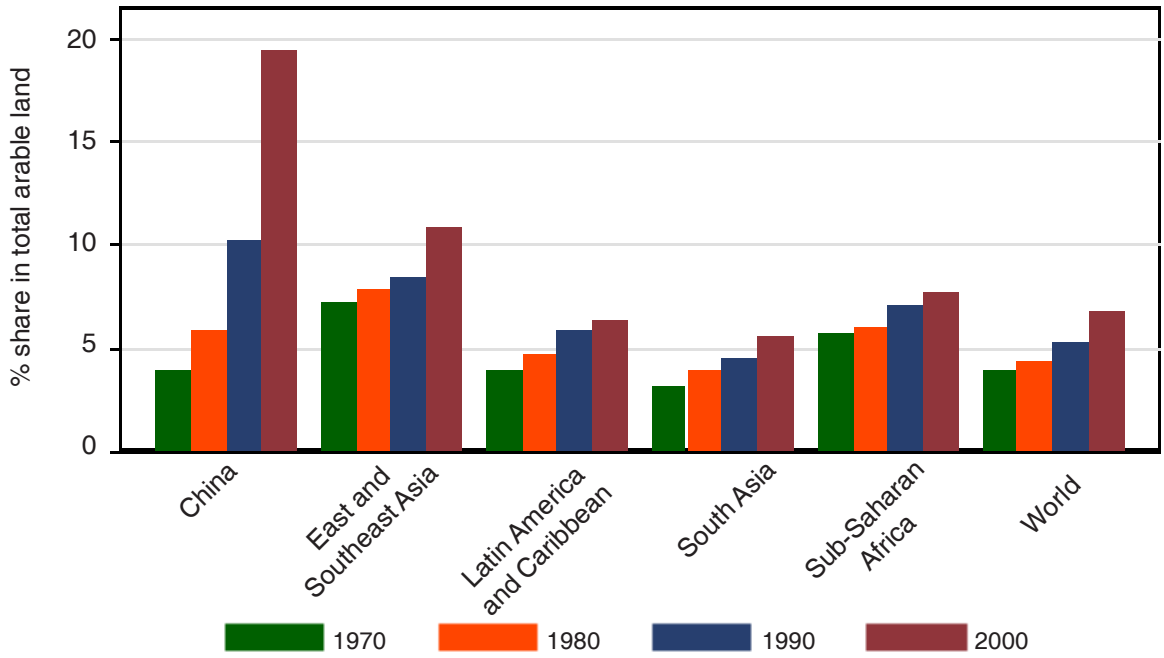
the expansion of area has been larger than yield increases, in contrast to cereals, where growth in yields has usually been larger than area expansion. The average growth in area has been larger for fruits and vegetables as compared to cereals in all regions, except for developed countries, where all area growth was negative (Figure 2).

While in 1970 only 3.9% of world arable land was under fruit and vegetable production, by 2000 this share had risen to 6.7%. The share of area under horticultural production has increased in all regions, but is strongest in China, where nearly 20% of all arable land is currently under fruit and vegetable production (Figure 3). Yields have increased more consistently for vegetables than for fruits (Figure 4). Between 1970 and 2000, annual growth rates in vegetable yields have been impressive in South Asia (1.8%), Latin America and the Caribbean (1.7%) and East and Southeast Asia (1.6%). In fruits, only

Figure 2. Average annual growth rates (%) in area and yield of food crops by region between 1961 and 2004

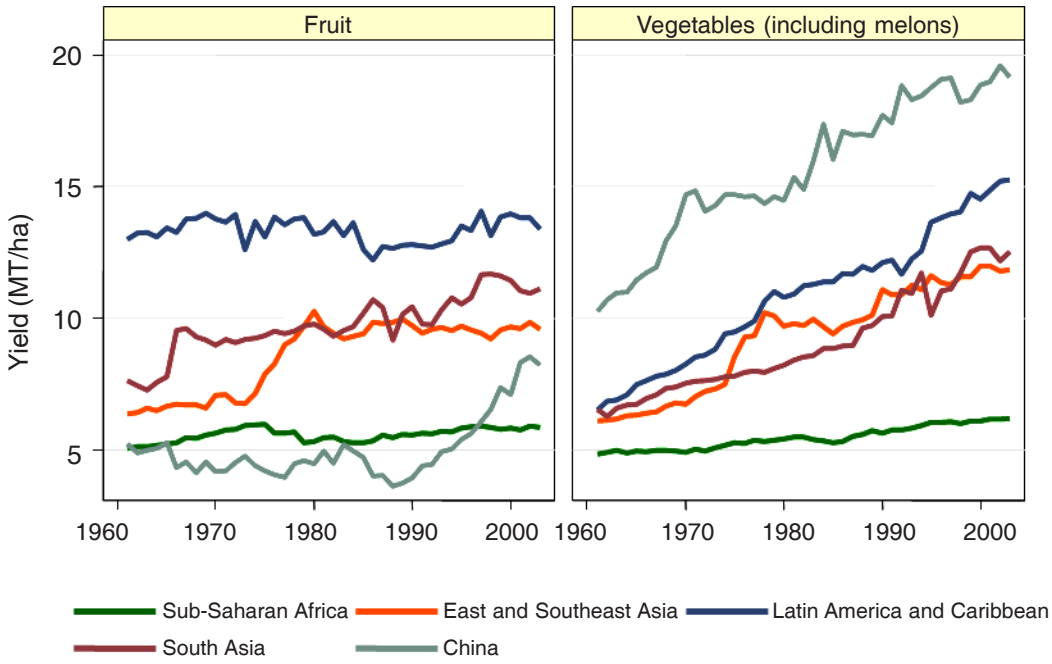
C: Cereals; F: Fruits; V: Vegetables
Data for China are plotted on a different y-axis scale
Source: FAOSTAT data, 2004

Figure 3. Percent of fruit and vegetable area in total arable land



Source: FAOSTAT data, 2004

Figure 4. Yield development in fruit and vegetables



Source: FAOSTAT data, 2004

the East and Southeast Asia region has achieved annual yield growth above 1% (1.2%).

The production increases of horticultural products in China are especially remarkable. These increases began in the 1980s after the government allocated land on a family basis and eliminated fixed procurement and retail prices for fruits, vegetables and some other agricultural products. As a result of the elimination of low procurement prices, farm profits for these products rose. Fruits and vegetables, which have higher labor requirements than grains, have a comparative advantage in China because of the low ratio of arable land per capita (Lu, 1998). China also has a traditional preference for vegetables. Vegetables make up about 35% of per capita food consumption in China, a much higher share than the world average (Gale, 2002). China has always been a large contributor to world vegetable production, and currently produces nearly half of world supply (47%), up from 26% in 1961 (FAOSTAT data, 2004).

China's liberalization of trade practices has also contributed to the increasing importance of horticultural products, which have subsequently emerged as a leading class of food export products (Lu, 1998). For example, China now produces more than 40% of the world's apples and more than 70% of the world's garlic. Large areas in Shandong province have been converted from grain to vegetable production to supply inexpensive vegetables and other nongrain agricultural goods for consumers in nearby Japan. As a result, China has replaced the USA as the number one supplier of fresh and frozen vegetables to Japan (USDA, 2002). Rising imports of inexpensive produce from China has forced Japan to impose temporary import protection against some Chinese agricultural products (Hsu and Gale, 2001).

Although area expansion has been largest in China, farmers in other regions of the world have also found it profitable to expand production of horticultural produce at the expense of the cereal area, although, as pointed out above, yield increases in horticultural produce have been smaller than in cereal grains. This increase in produce area is due both to increasing domestic and international demand. However, the miniscule or negative response in yields of horticultural produce indicates a need for R&D investment.

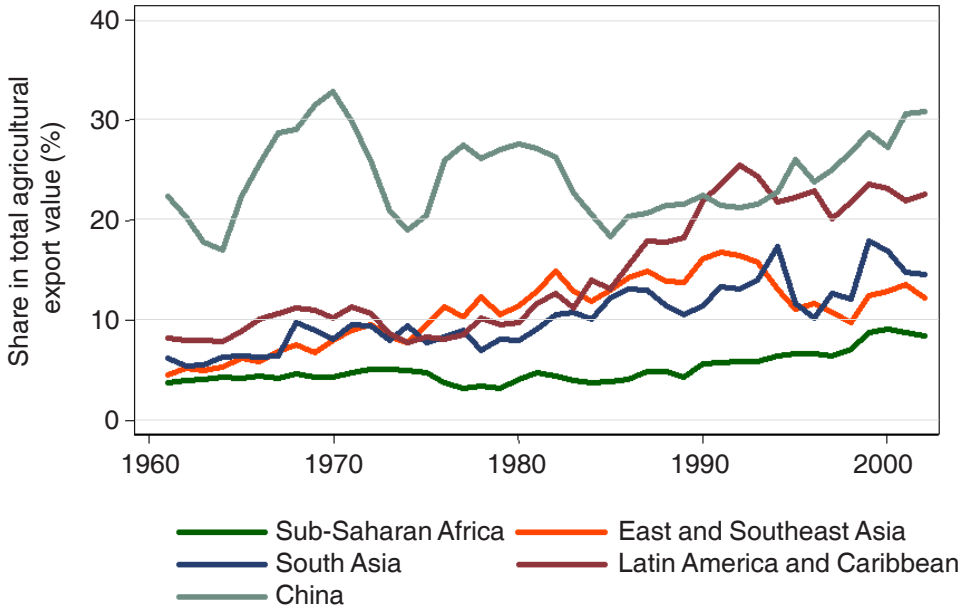
3 International trade in fruits and vegetables

Compared to overall exports of agricultural products, the importance of fruit and vegetable exports remains minor, comprising 17% of the total value (Figure 5). However, the share has been rising and is projected to continue to rise faster than other agricultural products. During the 1990s, the value of fresh and processed vegetables imported by the EU surpassed all other categories (Dolan et al., 1999). In contrast, the terms of trade for several traditional agricultural commodities have declined significantly from the early 1970s to the 1990s. In 2002, the seven major tropical agrocommodities (coffee, tobacco, cotton, sugar, rubber, tea, and cocoa) accounted for 23.1% of the total agricultural exports of Africa, Asia, and South America combined, down from 40.1% in 1980 (FAOSTAT data, 2004). This decline gives considerable scope for exploiting the potential of non-traditional export crops, such as horticultural produce, since it could motivate diversification from traditional low-profit commodities.

The total volume traded in fruits and vegetables has increased fivefold between 1961 and 2001, from 24 million MT to 125 million MT (FAOSTAT data, 2004). A large share of this comes from Latin America and the Caribbean (LAC) and from China, each contributing roughly one-tenth to overall vegetable exports. In SSA, Kenya and Côte d'Ivoire are two of the most important nations producing horticultural crops for export. While many other agricultural commodities face stagnation and declining world prices, non-traditional horticultural exports grow dramatically. *"In many African countries, export horticulture (principally cut flowers and fresh vegetables) has become a bright spot in an otherwise dim agrarian landscape"* (Dolan et al., 1999). For instance, Kenya's exportation of vegetables has increased in value by 78% since the early 1990s and has surpassed coffee (Dolan, 2001). The horticultural sector now is responsible for 13% of the value of Kenya's exports and is one of the top four foreign exchange earning industries in that country (McCulloch and Ota, 2002).

Latin American produce is mainly exported to the USA, while most European imports come from Africa. The USA is the single largest importer of fruits and vegetables worldwide, worth US$10.8 billion in 2001. It imports 65% of its fresh vegetables from Mexico. As a block, the European Union (EU) domi-

Figure 5. The share of fruit and vegetables in all agricultural exports



Source: FAOSTAT data, 2004

nates horticultural trade, importing fruits and vegetables worth $36.2 billion in 2001. Germany has long been the most important import market within the EU, accounting for 12% of world fruit and vegetable imports in 2001, worth US$9.2 billion. Japan is the third most important market, receiving 8% of world imports in 2001, worth US$5.9 billion (Cook, forthcoming).

The overall share in fruit and vegetable exports and growth rates of exports do not reflect the net trade positions. These are very different for SSA, LAC, and the three Asian regions (Table 2). LAC, China and, albeit at a lower level, East and Southeast Asia are clearly net exporters of fruits and vegetables, with increasing trends. Exports from SSA and South Asia however just barely equal import levels. Developed countries incur a large and growing trade deficit in fruits and vegetables every year, which is now larger than the trade deficit for all food products taken together. This indicates the growing demand in developed countries for fruits and vegetables, and the growing opportunities for exporters in developing countries.

Table 2. Net trade in fruit and vegetable and food products (billion US$)

Year	China	South Asia	East and SE Asia	Latin Amer. and Caribbean	Sub-Saharan Africa	Developed countries
Fruit and vegetables						
1970	0.38	0.04	0.10	0.51	0.05	–2.54
1980	1.04	0.20	1.04	1.82	0.07	–8.19
1990	1.97	0.05	1.60	5.68	-0.01	–18.67
2000	2.56	-0.03	1.24	8.30	0.32	–20.04
All food products						
1970	0.52	0.03	–0.49	4.27	1.52	–7.65
1980	–1.07	1.35	–0.24	15.26	1.96	–16.26
1990	1.84	0.92	0.58	15.27	0.76	–24.38
2000	3.11	1.93	–3.21	16.08	–0.44	–12.85

Source: (FAOSTAT data, 2004). Three year averages.

There are several reasons for the rapid increase in fruit and vegetable trade over the past decade. In the 1990s, many countries, particularly in Africa and Latin America, changed their trade policies from protectionist to more openness. This opened the way for several new trade agreements that facilitated trade in high-value agriculture. For example, liberalization under the North American Free Trade Agreement (NAFTA) underpinned the rapid growth in the agricultural imports of the USA from Canada and Mexico (Putnam and Allshouse, 2001). In the EU, horticulture products have also benefited from preferential trade access. For instance, imports of fresh vegetables into the EU rose by 150% between 1989 and 1997 with almost three-quarters of the value of these exports coming from SSA. The majority of exports come from countries with preferred trade status under the Lomé Convention. For instance, in 2000 Kenya was the single largest supplier of green beans to the EU, followed by Switzerland, Ethiopia and South Africa. Kenya captured 53% of all the total traded value. Cote d'Ivoire was the second largest supplier of green onions and shallots to the EU, after New Zealand, capturing 16% of the total traded value (FAOSTAT data, 2004).

Growth in these commodities is also linked to changing trends in consumer and food retailing in developed economies. Desire for year-round availability and increased diversity, as well as a growing awareness on the importance of healthy diets, have been important reasons for increased consumption of high-value commodities. For example, the dietary benefit of fresh produce is the major reason for the 25% increase in fresh fruit and vegetable consumption in the USA between 1977 and 1999 (Regmi and Gehlar, 2001). Rapid growth in mean per capita incomes in developed countries during the 1990s enabled consumers to purchase a broader range of relatively expensive commodities such as off-season produce, exotic fruit and vegetables, and organic produce. Higher incomes have also raised the demand for other "quality attributes." Increasingly, consumers are concerned about quality and safety of their food, as well as the social and environmental conditions under which it is produced. This trend, in turn, has led to the increased importance of organic food and labeled brands (Reardon, et al., 1999; Yussefi and Willer, 2003). Organic trade from developing to developed countries is currently growing at over 20% per year (Raynolds, 2004).

Factors such as increased participation by women in the labor market of developed economies have created demand for processed, ready-to-eat convenience products. The food processing industry has improved dramatically over the past 30 years, including transportation technology, sanitation packaging, storing, and product appeal. Taken together, these changes have sharply increased the value-added share of processing and distribution within agribusiness, and of nonstaple subsectors relative to staples, opening up new marketing opportunities for developing countries (Reardon and Barrett, 2000). The share of processed food in the value of total global agricultural trade has increased steadily over the past decades to over 60% by 1995. Exporters in developing countries are taking advantage of this trend, and over the past decade the increase of their processed food exports has exceeded that from developed regions (Rae and Josling, 2003).

Generally, the horticulture export industry provides an important source of foreign exchange, generates substantial employment and has contributed to the upgrading of agricultural production skills. Many work tasks, such as chopping, washing, labeling and bar-coding are increasingly being transferred to Africa and are generating many new jobs (Dolan et al., 1999). Employment is generated on farms owned by the major exporters and on independent large farms producing for these exporters under contract. Often these workers are landless women who have few other opportunities for earning an income (McCulloch and Ota, 2002). Women in particular have been able to capitalize on these new labor market opportunities. In Africa, Asia, and Latin America, high-value crop exports are female intensive industries, with women dominating most aspects of production and processing. In Chile, Ecuador, Guatemala, Kenya, Mexico, South Africa, and Zimbabwe, evidence suggests that women occupy at least 50% or more of the employment in these industries (Dolan and Sorby, 2003).

Negative consequences of increasing trade have also been reported. The quality and reliability demands of supermarket corporations in the EU, which comprise most of the market for imported fresh vegetables, often act as effective barriers to participation in the trade chain by small exporters and producers. Supermarkets increasingly influence the structure and conditions of the agri-food system in Africa and determine the conditions and the potential for small farms and firms to sell agri-food products (Dolan and Humphrey, 2000). As a consequence, many producers and exporters fail. Dolan and Humphrey report that by 1998 the share of small-

scale production in export vegetables from Kenya dropped to less than 30%, and recent research by Bawden et al. (2002) indicates that fewer than 2% of smallholders in Kenya are directly engaged in the subsector. However, for those companies and firms that are able to participate, the benefits have been lucrative (Dolan et al., 1999).

The participation of small-scale producers in the global fruit and vegetable trade is also affected by the increasing attention that food quality and safety are receiving in food trade, coupled with an expansion in the number of non-tariff measures that developed countries apply to agricultural products (Henson and Loader, 2001). Fruits and vegetables belong to the class of food items most frequently affected by sanitary and phytosanitary measures[4] (Unnevehr, 2000). Traceability, phytosanitary standards, market infrastructure, and crop productivity issues will continue to be barriers for participation in the fruit and vegetable trade for most of the developing world. The application of agricultural chemicals is often poorly regulated and industrial pollutants are common hazards in the soil, water, and air of developing countries. In the future, the inability of developed countries to meet increasing strict phytosanitary and traceability requirements for food products will increasingly constrict exports to developed countries. Growers and processors in developing countries will thus have to learn to supply safe products with traceable labels if their participation in global trade shall continue and expand.

4 High-value crops for small-scale farmers

Fruit and vegetable production is usually lucrative compared to staple crops. Horticultural produce has high value-added and income generation potential, and due to a relative lack of economies of scale (compared to grain production and livestock) their production is attractive especially for small-scale farmers. The production of fruits and vegetables has a comparative advantage particularly under conditions where arable land is scarce, labor is abundant and markets are accessible. This is the prevailing situation in many countries of South and Southeast Asia, where the average size of landholding is among the lowest in the world and transportation infrastructure has seen dramatic improvements.

4.1 High profitability of horticultural crops

Farmers engaged in the production of fruits and vegetables often earn higher net farm incomes than farmers that are engaged in the production of cereal crops alone (Table 3). Studies from developing countries frequently show higher average net farm incomes per household member among horticultural producers. A study in Kenya that sampled smallholder farmers who produced for export found that net farm incomes were five times higher per family member compared to smallholder farmers who did not grow horticultural products.

Table 3. Net farm income per family member of horticultural versus non-horticultural smallholder farms

Country	Difference in farm income (%)
Kenya	497
Bangladesh	29
Cambodia	117
Lao PDR	380
Vietnam (northern)	20
Vietnam (southern)	189

Sources: Kenya: McCulloch and Ota (2002); Bangladesh: Ali and Hau (2001); Cambodia: Abedullah et al. (2002); Lao PDR: Siphandouang et al.; (2002), Vietnam (northern): Thuy et al. (2002); and Vietnam (southern): Hau et al. (2002).

The relative profitability of horticultural crops compared to cereals has been shown to be a determining factor for crop diversification into horticultural production in India (Joshi et al., 2003). Table 4 collates the results of several studies in Asia and Africa. Profitability of vegetables and cereals is expressed as the net return on different input measures (area, labor, and days field is occupied). In these studies total labor cost is included, while land cost is excluded. Profitability of vegetables (as a group) compared to cereals (rice) is expressed as

[4] Phytosanitary issues concern the protection of domestic crops from imported pests and diseases while sanitary issues refer to ensuring a safe food supply for consumers.

the ratio of vegetables to cereals. Thus, an index of 1 would indicate that the profitability for the specific measure is the same for vegetables and cereals, whereas an index greater than 1 indicates a greater profitability of vegetables, and an index smaller than 1 indicates a greater profitability for cereals. While the absolute value of the index varies greatly, certain trends can be observed. Apparently, vegetable production is more profitable than rice production in terms of cropping days—since the growing period of vegetables is usually less than rice—and in terms of cropped area. On the other hand, the profitability of vegetables compared to rice is much lower on a labor input basis. Thus, the production of vegetables has a comparative advantage under conditions where arable land is scarce and labor abundant. Vegetables have a lower comparative advantage than staple foods when labor and access to inputs are the limiting factors.

Table 4. Profitability indicators of vegetable production as a ratio to rice

	Output values per		
Country	ha	labor day	cropping day
Niger	3.3	1.6	na
Bangladesh	13.8	2.1	na
Cambodia	9.4	1.9	13.8
Lao PDR	8.7	3.7	12.5
Philippines	1.3	0.7	1.6
Vietnam (northern)	14.2	2.3	16.7
Vietnam (southern)	9.6	1.9	10.6

Sources: Niger: Chohin-Kupera et al. (1999); Bangladesh: Ali and Hau (2001); Cambodia: Abedullah et al. (2002); Lao PDR: Siphandouang et al. (2002), Philippines: Francisco (2004); Vietnam (northern): Thuy et al. (2002); and Vietnam (southern): Hau et al. (2002).

4.2 Creation of employment

The generation of additional employment opportunities in rural areas where labor is abundant is critical for achieving widespread and equitable growth. The production of horticultural products offers opportunities for poverty alleviation, because it is usually more labor intensive than the production of staple crops. Often, horticultural production requires twice as much, sometimes up to four times as much labor than the production of cereal crops. See for example Table 5, which compares average labor use in vegetable production with average labor use in cereal production for several South and Southeast Asian countries.

Table 5. Average number of labor days per ha for production of cereals and vegetables in Asia

	Cereals	Vegetables
Bangladesh	133	338
Cambodia	81	437
India	80	124
Lao PDR	101	227
Philippines	93	185
Vietnam (northern)	216	468
Vietnam (southern)	111	297

Sources: Bangladesh: Ali and Hau (2001); Cambodia: Abedullah et al. (2002); India: Joshi, et al. (2003); Lao PDR: Siphandouang et al. (2002), Philippines: Francisco (2004); Vietnam (northern): Thuy et al. (2002); and Vietnam (southern): Hau et al. (2002).

In Kenya, the production of snow peas and French beans, the two most widely grown horticultural export crops, require 600 and 500 labor days per ha, respectively (Dolan, 2002). In Mexico, the horticultural sector accounts for more than 20% of the total labor days within the agricultural sector. In comparison, only 6.7% of arable land is under fruit and vegetable production (Barron and Rello, 2000). Shifting from cereal production to horticultural production generates additional employment. Joshi et al. (2003) estimate that in India, a shift of production from coarse cereals to high-value vegetables, such as cauliflower, eggplant and tomato, would on average generate additional employment of 70 person-days per hectare. Often, additional labor requirements are met through hired labor, benefiting small farmers and landless laborers (McCulloch and Ota, 2002, Weinberger and Genova, 2005). Greater employment opportunities result in greater incomes for poor households. In Bangladesh, total value added in wages is approximately US$400 per ha, 7.5 times higher than valued added through hired labor in rice (Weinberger and Genova, 2005). But where labor is scarce, availability of hired labor may actually be a limiting factor to vegetable production as a study of determinants of horticultural production in Kenya has shown (McCulloch and Ota, 2002).

4.3 Commercialization of the rural sector

The market integration of producers of fruits and vegetables is usually higher than that of staple crop producers. For instance in Bangladesh, farmers on average sell 96% of their vegetable products but only 19% of their cereal output (Weinberger and Genova, 2005). The same pattern is reported for other countries in Southeast Asia and East Africa (Table 6).

Table 6. Percentage share of farmers selling vegetables and rice production on markets

Country	Vegetables	Rice
Bangladesh	96	19
Cambodia	99	11
Lao PDR	99	23
Tanzania	88	37

Sources: Bangladesh: Weinberger and Genova (2005); Cambodia: Abedullah et al. (2002); Lao PDR: Siphandouang et al. (2002); and Tanzania: Ellis and Mdoe (2003).

A study from Tanzania that analyzed the significance of traditional African vegetables in agricultural production showed that the degree of commercialization is high for fruits as well as traditional African vegetables (i.e. amaranth and African eggplant) and exotic vegetables (i.e. tomato and cabbage). In this study, 100% of farmers who grew fruits, 98% of farmers who grew exotic vegetables, and 88% of farmers who grew traditional African vegetables marketed their output. In comparison, only 49% of farmers who grew cereals marketed their output (Weinberger and Msuya, 2004)

This phenomenon is consistent across income groups, although wealthier farmers usually sell a larger share of their production. Minot (2002) found that both fruit and vegetable production in Vietnam is highly commercialized, with about 70% of fruit and vegetable farmers selling their output. Minot compared the degree of commercialization for wealthy and poor farmers. The market integration of the highest income quintile is higher at 75%, while in the poorest income quintile, only 56% sell their output to the market.

In the Tanzania study there is an interesting difference between exotic and indigenous vegetables. For exotic vegetables, 95% of farmers in the lowest income quintile sell at least some of their produce, compared to 100% of farmers in the highest income quintile; but the pattern is reversed for indigenous vegetables. Here, 95% of poor farmers sell their output, while only 87% of farmers in the highest income quintile sell their output of indigenous vegetables (Weinberger and Msuya, 2004).

Since horticultural producers are better integrated into markets, the production of horticultural crops contributes to commercialization of the rural economy, which is characterized by increased trade and marketing. Studies show that commercialization stimulates the rural economy and contributes to the growth and development process (Pingali and Rosegrant, 1995, von Braun, 1995). Commercialization benefits the poor both through generation of employment and increasing agricultural productivity. On the other hand, the production of horticultural crops is often more risky, because these crops are much more costly to produce per hectare than traditional crops, and because yields and prices are more variable than for staple crops (Key and Runsten, 1999). Resource-poor farmers must thus be supported by an enabling institutional environment, such as access to credit and capital, and must be provided with access to market price information.

5 Research needs

Worldwide demand for horticultural products, especially vegetables, is on the rise. Higher incomes and urbanization, changing lifestyles, international market integration and trade liberalization are all expected to fuel demand for horticultural products. However, this growth potential remains largely untapped. Policy makers and researchers have to increase their efforts to understand and empower poor farmers in developing countries to participate in the expanding market for horticultural products. In the following chapter, we discuss several areas of research and development that are of crucial importance to facilitate horticultural production for economic growth and poverty reduction.

5.1 Genetic improvement

Yield improvements in fruits and vegetables have been lower than in cereals. Productivity growth has been particularly low in SSA, where yields in vegetables have grown at an average annual rate of

0.6% against 0.7% for cereals and against the world average of 1.4% between 1961 and 2004. Concerted action is required to lift up average yields of horticultural produce on this poor continent. Yields will increase by focusing both on productivity and stability of yields. More emphasis will have to be placed on the development of hybrid varieties, using the natural vigor of hybrids to fight stresses of disease, heat and drought. Molecular tools will be useful in increasing yields, as recent experience has shown. In Southern India, molecular-based tools were used to identify strains of tomato leaf curl virus (ToLCV) and to select genes of resistance from wild tomatoes that were then bred into cultivated lines. After only a few years ToLCV-resistant lines were developed that produce twice the yield of the most popular varieties in the region (Hanson et al., 2000).

Nutritional content, product quality and safety are also important aspects of breeding efforts. Many fruits and vegetables are rich in functional properties such as lycopene, beta-carotene and other antioxidants. Orange fruits and dark green leafy vegetables, for example, are rich in concentrated provitamin A, a component of the vitamin A complex. Fruits and vegetables are rich in antioxidant compounds and it is proposed that these compounds reduce the risk of chronic disease by protecting against free-radical mediated damage (Southon, 2000). The interplay of the different micronutrients and antioxidants found in vegetables and fruits have important health impacts, explaining for instance the higher birth weight of children in India, when mothers consumed higher rates of green leafy vegetables and fruits during pregnancy (Rao et al., 2001). More research is needed to analyze for functional properties of fruits and vegetables, and to develop new varieties that add value for poor, malnourished populations.

Genetic improvement efforts must be targeted both toward exotic crops and traditional vegetables, the latter including African eggplant, amaranth, nightshades and the like. Traditional fruits and vegetables have largely been neglected by policy makers and researchers. But while their production often takes place under low-input conditions, they contribute substantially to household food and livelihood security, particularly for resource-poor farmers (Cavendish, 2000; Weinberger and Msuya, 2004). Traditional vegetables constitute an important source of micronutrients, contributing between 30% and 50% of iron and vitamin A consumed, respectively, in poor households (Gockowski, et al., 2003; Weinberger and Msuya, 2004).

5.2 Safe and environmentally friendly production

In the future, production of safe food products will become even more important than it is now. Food safety legislation in the EU and the USA will soon institute stricter standards. In general, fruit and vegetable production activities are the largest users of plant protection products per hectare, since some of these crops are more susceptible to pest and climatological hazards. Fruits and vegetables together account for the major share of the global pesticide market, in most years between 26–28% of total pesticide use, or around US$8.4 billion a year (Dinham, 2003). Almost 25 kg/ha of active pesticide substances are used on average in fruit and vegetable production in the EU (OECD, 1997). Fruit and vegetable production accounts for less than 2% of the USA crop area, but 14% of its total pesticide use (Osteen, 2003).

A study on pesticide levels in Brazilian fruits and vegetables found that the pesticide residues in 13.6% of fruits and 3.7% of vegetables exceeded tolerance limits (Mansour, 2004). Pesticide residues are often attributed to the failure of farmers to restrain application before harvesting and to the use of prohibited pesticides. Aside from the effects on farmer and consumer health and the environment, the presence of pesticide residues has significant trade implications as well.

Fruits and vegetables are also at risk of contamination from heavy metals and waste products. Several studies have reported high heavy metal contamination in fruits and vegetables, i.e. arsenic, lead and cadmium in Bangladesh (Alam et al., 2003) and lead in fruits, vegetables and medicinal herbs in Egypt (Mansour, 2004). Toxicity of fruit and vegetable produce also occurs due to human and animal waste used in crop production (Midmore and Jansen, 2003).

Because fruits and vegetables are often traded and consumed in fresh forms, biological contamination and pesticide residue are serious issues. The Sanitary and Phytosanitary Agreement (SPS) of the WTO defines that countries can pursue their own levels of food safety standards. SPS issues are sometimes used as a protectionist tool against imports since multilateral trade agreements have reduced the ability to protect domestic production with tariffs and quotas (Cerrex, 2003; Henson and Loader, 2001). SPS regulations are probably the

most important barrier to international trade in fresh fruits and vegetables (Unnevehr, 2000). Thus exporters from less developed countries must be provided with training opportunities and access to information on how to produce and supply safe products to developed economies.

5.3 Horticultural systems development

5.3.1 Enabling institutions

Capital and risk constraints are key factors that limit the adoption of high-value crops by small-scale farmers because these crops generally are much more costly to produce per hectare than traditional crops (Ali, 2002; Ali and Hau, 2001; Key and Runsten, 1999), and most growers require credit to finance their production. While staple crops are usually cultivated using a level of input intensity appropriate to the financial resources available within a household, horticultural crops often require an intensive input regime and necessitate large labor inputs for harvesting and planting that cannot be met with family labor alone (Weinberger and Genova, 2005). Horticultural crops also tend to be riskier than staple crops, since the higher costs associated with production impose a greater income risk. In addition, the profits of horticultural crops tend to be more variable because they have both more variable yields and more variable prices. From another perspective, prices for horticultural crops are more variable because the variability in yields increases the variability in market supply (Key and Runsten, 1999). In addition, governments usually do not regulate the price of horticultural crops or even provide market information unlike for staples crops. Improving market information systems for horticultural crops, and facilitating farmers' access to credit are essential components of a strategy that seeks to develop horticultural systems.

5.3.2 Seed sector development

A major limitation to fruit and vegetable production in many developing countries is the availability of good quality seeds. The public sector in developing countries frequently does not have sufficient capacity to supply adequate quantities of good quality seed and there are few private seed companies adapting varieties to local environments, especially in poorer countries. Farmers themselves often produce seeds of locally preferred or indigenous varieties, as the individual markets are too small to attract the interest of the private sector. Without proper seed production, processing technology, quality assurance, or management supervision, seeds are often contaminated by seed-transmitted pests and diseases, and are genetically diverse. The lack of proper storage facilities often lead to low or uncertain seed viability and vigor. Moreover, low capital resources and poor market information discourage development of seed-related agribusiness. Knowledge on constraints in the horticultural seed distribution chain remains limited in many countries, making it difficult to enter into target-oriented promotion of the vegetable and fruit seed and seedling sector. It is therefore necessary to gain a solid understanding of the issues within the fruit and vegetable seed sector, both private and public, in order to identify constraints that this sector faces and to formulate a strategy for its sustainable development.

5.3.3 Post-harvest facilities

Horticultural production, particularly in hot-wet tropical environments is severely constrained by post-harvest losses, which reduce profits to farmers and marketers. Horticultural crops are often highly perishable, restricting the ability of producers to store them to cope with price fluctuations. Available information indicates that post-harvest losses can be as high as 60% for cabbage and tomato, 50% for head lettuce and cauliflower, 30% for bell pepper and 17% for Chinese cabbage in South East Asia (Bhatti, et al., 1993). Reducing post-harvest losses would make diversification into vegetable production less risky and more attractive.

Post-harvest related quality losses also reduce opportunities for export revenues. Vietnam, for instance has experienced declining export revenues for fruits and vegetables—during the first quarter of 2004 the export revenue for fruits and vegetables was US$30 million, only 2/3 of the value for the same quarter in 2003. This decline was attributed to low quality of export goods, which was due to poor storage and outdated post-harvest technologies (Socialist Republic of Vietnam, 2004). Participation in international markets requires relatively sophisticated marketing, information and transportation networks. Successful competition requires quality control, product standardization, and to some future markets, traceabilities. The development of the post-harvest sector includes improving pre- and post-harvest processing technologies, as well as developing and improving market information systems that include information on prices, seasonality, handling constraints, and emerging technologies. International

supermarket chains and large processors are becoming the main buyers of fresh horticultural products (Reardon, et al., 2003) and small-scale farmers need to be trained and organized to meet the challenge of supplying these international players.

5.4 Horticultural production in the peri-urban environment

Increasing commercialization of the fruit and vegetable production sector is fueled not only by growing export markets, but also by increasing domestic demand. In a study comparing elasticities for different food commodities and across countries, Seale et al. (2003) showed that low-income countries have relatively high expenditure and own-price elasticities for fruits and vegetables, indicating that demand in developing countries for these products will change more than income increases or price reductions. Demand is expected to increase especially in urban areas, which are considered to be the most dynamic food markets in developing countries due to increasing urban populations and incomes (Weatherspoon and Reardon, 2003). Estimates indicate that about 800 million urban dwellers are actively engaged in urban agriculture and that about 200 million provide food for the market (FAO, 1999; Smit, et al., 1996). These urban farmers produce substantial amounts of food for urban consumers. An estimated 15–20% of the world's food (1993 data) is produced in urban areas (Armar-Klemesu, 2000). Peri-urban production, i.e. production in close proximity to urban centers, is attractive especially for highly perishable and delicate products such as fruits and vegetables.

Generally, urban and peri-urban agriculture plays an important role for household food security, albeit based on differing strategies. For some people, urban agriculture is a strategy adopted by households whose monetary incomes are not adequate to purchase sufficient food. For others, commercial urban farming is more highly developed, especially with regard to vegetable and perishable-food production, but some of this production is also for home consumption (Maxwell, 2001; Midmore and Jansen, 2003). Thus, poor urban farming families have been found to eat more fresh vegetables than other families in the same income category (Potutan et al., 2000). Within Kampala, Uganda, children aged five years or less in low-income farming households were found to be significantly better-off nutritionally than counterparts in non-farming households (Maxwell et al., 1998). Urban and peri-urban areas are the origin of 24% of fruit type vegetables, 50% of crucifers, and up to 100% of leafy vegetables in Hanoi (An et al., 2003); and 60% in Shanghai (Cai and Zhangen, 2000) and Dakar, Senegal (Mbaye and Moustier, 2000). In Havana, urban agriculture has emerged as a response to the food crisis. Over 26,000 small gardens cover 2,439 ha in Havana producing 25,000 tons of food each year (Gonzales Novo and Murphy, 2000).

Another aspect of peri-urban production that is often overlooked, particularly if the production is low input or organic production, is its contribution to the well being of urban areas by preserving open space and a serene landscape, often in the midst of abysmal squatter ghettos.

Although peri-urban horticultural production is important to nourishing cities, it faces opposition from local authorities in many places. The main reason is the various risks associated with production close to urban centers, which include contamination of crops through irrigation using polluted wastewater or fertilization using undecomposed organic solid wastes; human diseases associated with unsanitary post-harvest activities; contamination of crops and/or drinking water by residues of agrochemicals; and contamination of crops by uptake of heavy metals from contaminated soils, air or water (Lock and van Veenhuizen, 2001). Furthermore, an expansion of peri-urban agriculture could lead to increased competition for water resources, causing water shortages in arid and semi-arid areas. More site-specific research needs to be undertaken to assess the costs and benefits of peri-urban horticultural comprehensively, formulate low-impact peri-urban horticultural systems, integrate peri-urban agriculture and city planning, and organize producer/marketing cooperatives, all so that policy makers can undertake informed decisions.

6 Concluding remarks

Today, 1.1 billion people continue to live in extreme poverty on less than US$1 a day. Another 1.6 billion live on between US$1–2 per day. Coordinated action is required to accomplish the Millennium Development Goals and to enable more people to live in dignity. The first goal, to eradicate extreme poverty and hunger, in particular depends on raising the productivity of agriculture (von Braun et al., 2004). However, the research agenda for agriculture must be broadened from cereal crops and must put more emphasis on horticulture. Horticulture research must receive more attention from policy makers and donors alike.

This paper has highlighted the growing importance of fruit and vegetable production and how these crops can contribute to poverty alleviation and economic development. Horticultural produce and processed products are facing increasing domestic and international demand. The expansion of markets and the liberalization of trade policies are providing new opportunities for rural people to escape poverty through production and exchange of non-staple crops. We have highlighted that horticultural production can be highly profitable, increase employment opportunities and bring about increasing commercialization of the rural sector.

However, much more effort needs to be undertaken to bring resource-poor farmers and landless labors into this development. We have highlighted a sample of possible R&D efforts to support this goal. A major effort has to be undertaken to increase yield levels and the stability of yields, particularly in Africa. Enabling market institutions that provide farmers with timely price information and access to credit, post-harvest facilities and technologies, and a functioning seed market are important components of enhancing the domestic supply of horticultural produce. Growers must also be provided access to information and training to participate in increasingly competitive global markets that demand safe produce.

Increasing urbanization and the needs of growing cities to feed their population will require more attention toward urban and peri-urban horticultural production. Research has to be integrative and include natural and social sciences. Technologies such as GIS can be used, integrating ecological and economic information for identifying 'hot spots' of comparative advantage for horticultural production in the poorest developing countries.

Policy makers have to turn their attention to an enabling environment, allowing farmers to compete with their products on a world market increasingly determined by quality standards and phytosanitary concerns. Only then will the silent horticultural revolution currently underway benefit a significant portion of the world's poor nations, farmers and landless laborers.

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