Dynamics of Vegetables in Asia: A Synthesis

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Introduction

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

Supply of Vegetables

Production

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

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

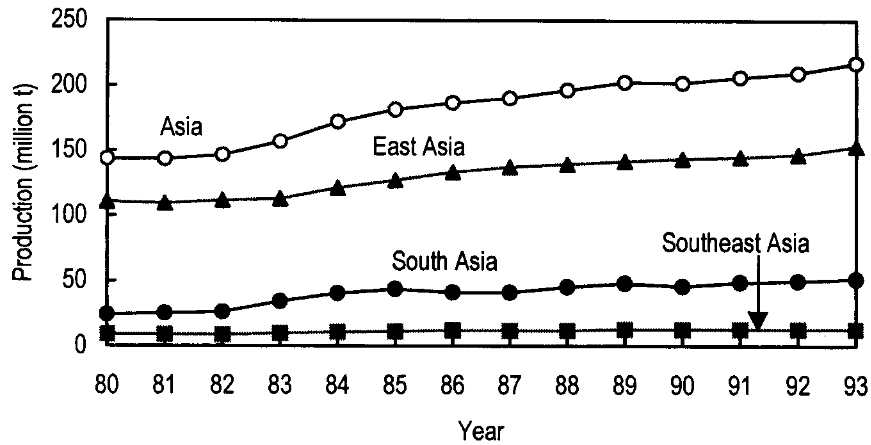


Fig. 1. Regional trends in production in Asia

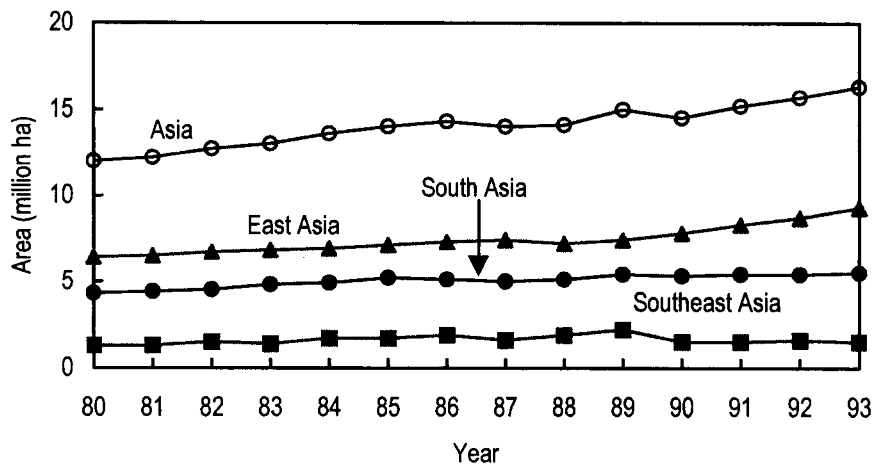


Fig. 2. Regional trends in area in Asia

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

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

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

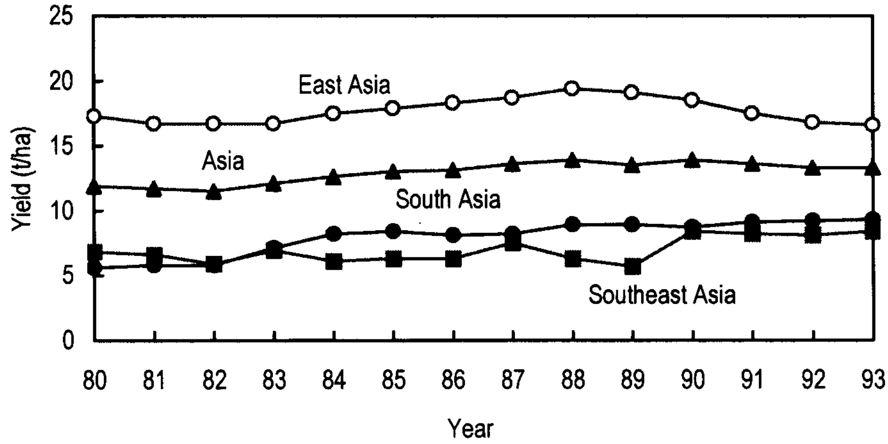


Fig. 3. Regional trends in yield in Asia

Availability

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

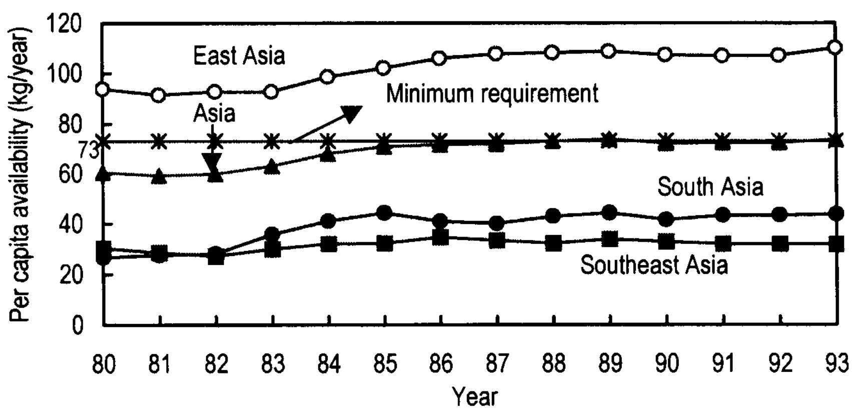


Fig. 4. Regional trends in per capita availability in Asia, 1981-93

Irregularity in Supply

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

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

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

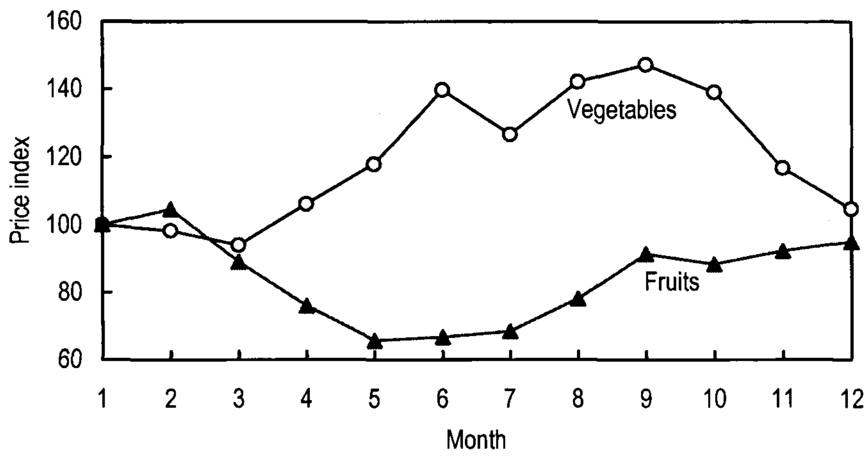
Region	Detrended CV in vegetables (%)			Detrended CV in cereals (%)		
	Area	Yield	Production	Area	Yield	Production
South Asia	9.69	10.40	8.17	2.08	3.73	3.82
Southeast Asia	14.51	11.09	5.37	2.35	2.46	2.86
East Asia	4.05	5.37	4.43	1.89	3.90	4.17
Asia	2.83	2.35	3.05	1.46	1.59	2.85

Seasonality in Supply

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

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

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



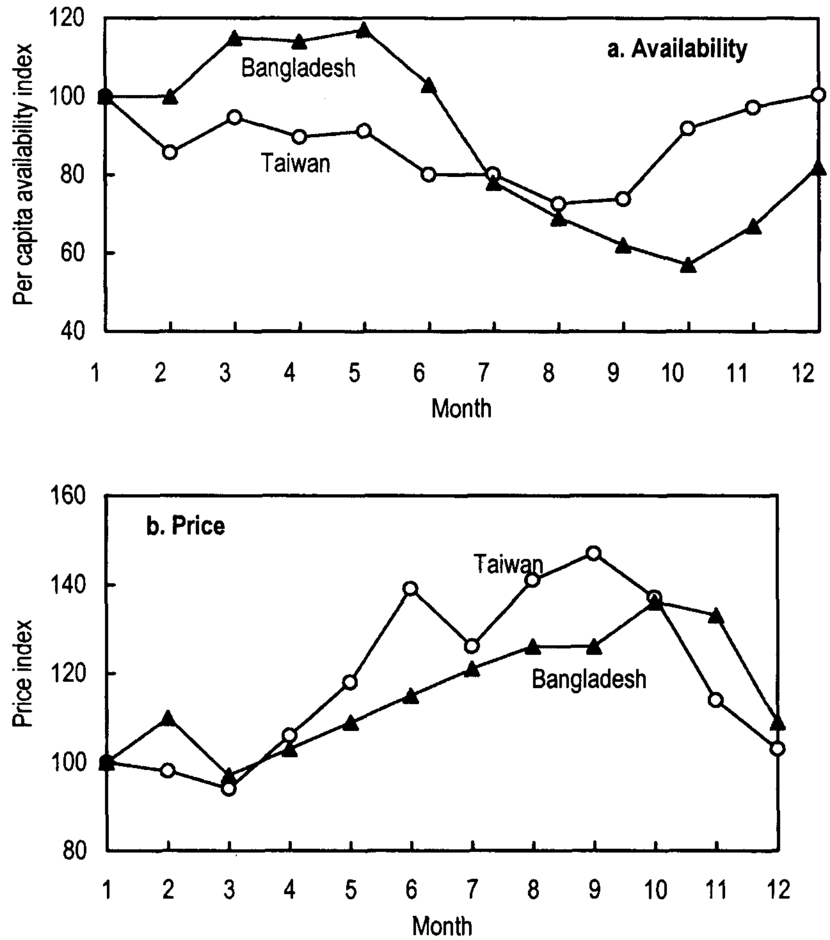
Source: Official data from Taipei Municipal Government

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

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

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

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



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

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

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

Introduction of modern vegetable technologies along with government policy support for summer vegetable production has proven to be a sustainable way to reduce seasonally in most vegetables. A pertinent example is Taiwan where such policy has improved summer vegetable supply (Wann et al. 2000). A more particular example is tomato in Taiwan, where introduction of summer tomato varieties from the Asian Vegetable Research and Development Center (AVRDC) has reduced seasonality in prices, especially during the months of August-November (Fig. 7).

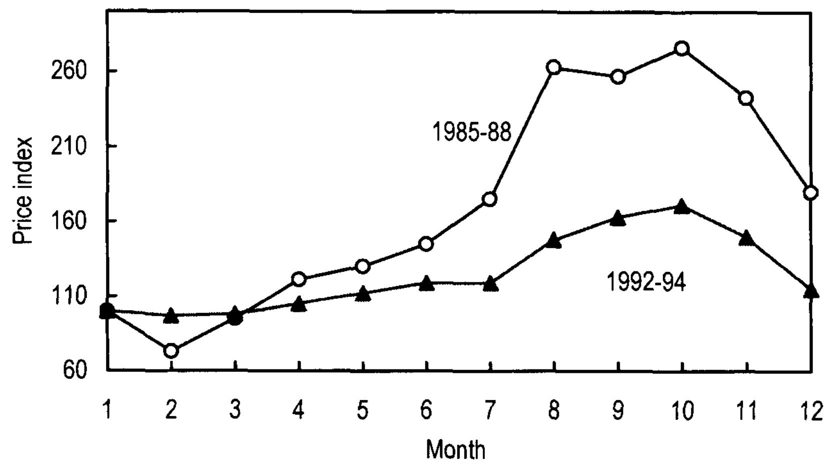


Fig. 7. Reduction in seasonal tomato prices at the retail level in Taiwan

Vegetable Demand

Consumption

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

Table 2. Vegetable share in diet in selected Asian countries

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

- implies that the information is not available.

Factors Affecting Demand

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

Income Effect

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

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

Price and Technology Effect

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

Regional Effect

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

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

Supply and Demand Gap

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

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

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

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

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

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

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

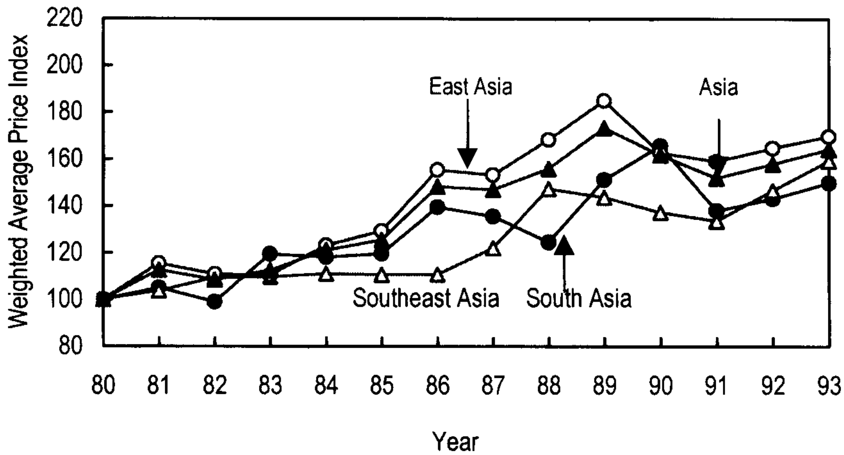


Fig. 8. Regional trend in the deflated or real vegetable prices in Asia

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

Implications for Micronutrient Malnutrition

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

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

Diversification and Vegetables

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

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

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

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

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

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

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

Contd. Table 4.

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

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

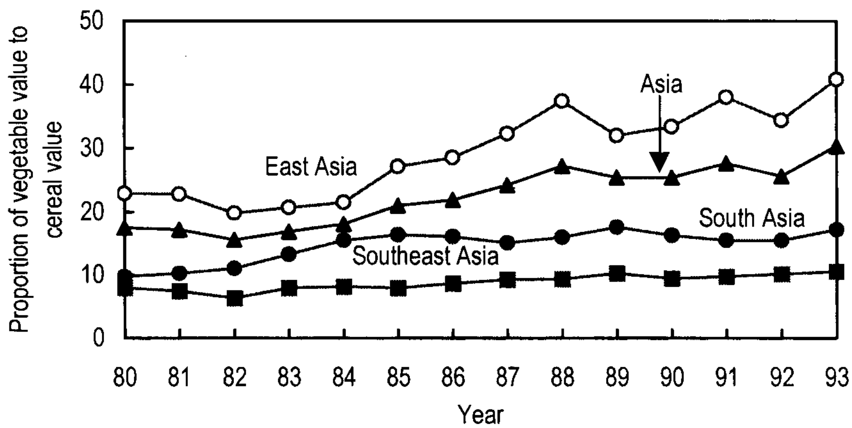


Fig. 9. Regional trends in the value of vegetable production as a proportion of cereal production value

Constraints and Possibilities

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

However, technologies that help overcome these environmental stresses are available, and depending upon vegetable prices and physical factors, harsh environments can be ameliorated. For example, vegetable farmers on the periphery of Bangkok build and maintain ditches and dikes (called *sorjan* systems) to manage flooding in vegetable fields. Similar systems are used to grow year-round vegetables in China (Plucknett et al. 1981) and in Indonesia (Pingali 1992). Technologies, such as hydroponics for the tropics, are also available (AVRDC 1995). Planting chili on raised (40cm versus 20cm) and narrow (1.0m versus 1.5m) beds can improve plant survival and total fruit yield in the rainy season (AVRDC 1992). Grafting of tomato on eggplant rootstocks improves flood survival and enhances yield many-fold; combining raised beds, fruit set hormones, and simple plastic rain shelters increases tomato yield three-fold (AVRDC 1993). Some of these technologies are discussed in the country reports. These technologies are expensive to install, operate, and maintain, and require high management skills. Thus, they are economically viable only when vegetable supplies are limited and prices are high. Modifying these technological solutions so that they become economically viable for a wider range of environments is a continuos challenge for vegetable researchers.

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

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

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

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

Vegetable Production Systems

Vegetable types

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

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

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

Agroecological Zone, Cropping and Cultivation Systems, and Markets

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

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

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

Source: TAC (1992).

Classification Based on Proximity to Consumption Centers

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

Peri-urban production, when situated in an unfavorable ecoregion (such as the hot-wet tropics), is a response to the market's failure to supply vegetables efficiently from distant but more favorable ecoregions (such as temperate regions and highlands) and failure to absorb unemployed urban labor. When market efficiency improves, the advantages of peri-urban production fade. The declining contribution from peri-urban production in Thailand, Vietnam, and China can be taken as evidence. These changes, however, are exerting pressure on transportation systems.

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

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

Classification Based on Intensity

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

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

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

Table 6. Characteristics of intensive and extensive systems

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

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

Component Technologies

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

From the evidence provided in this book, it is certain that more advanced technologies, as reflected by higher fertilizer, pesticide, and management labor, are used in vegetables than in cereals. Once farmers learn how to manage advanced production technologies in vegetable cultivation, they start to use these in cereal cultivation. Thus, vegetable farmers are found to produce more productive rice crops than do non-vegetable farmers (AVRDC 1999). In this way, vegetables become a stepping stone for overall agricultural development.

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

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

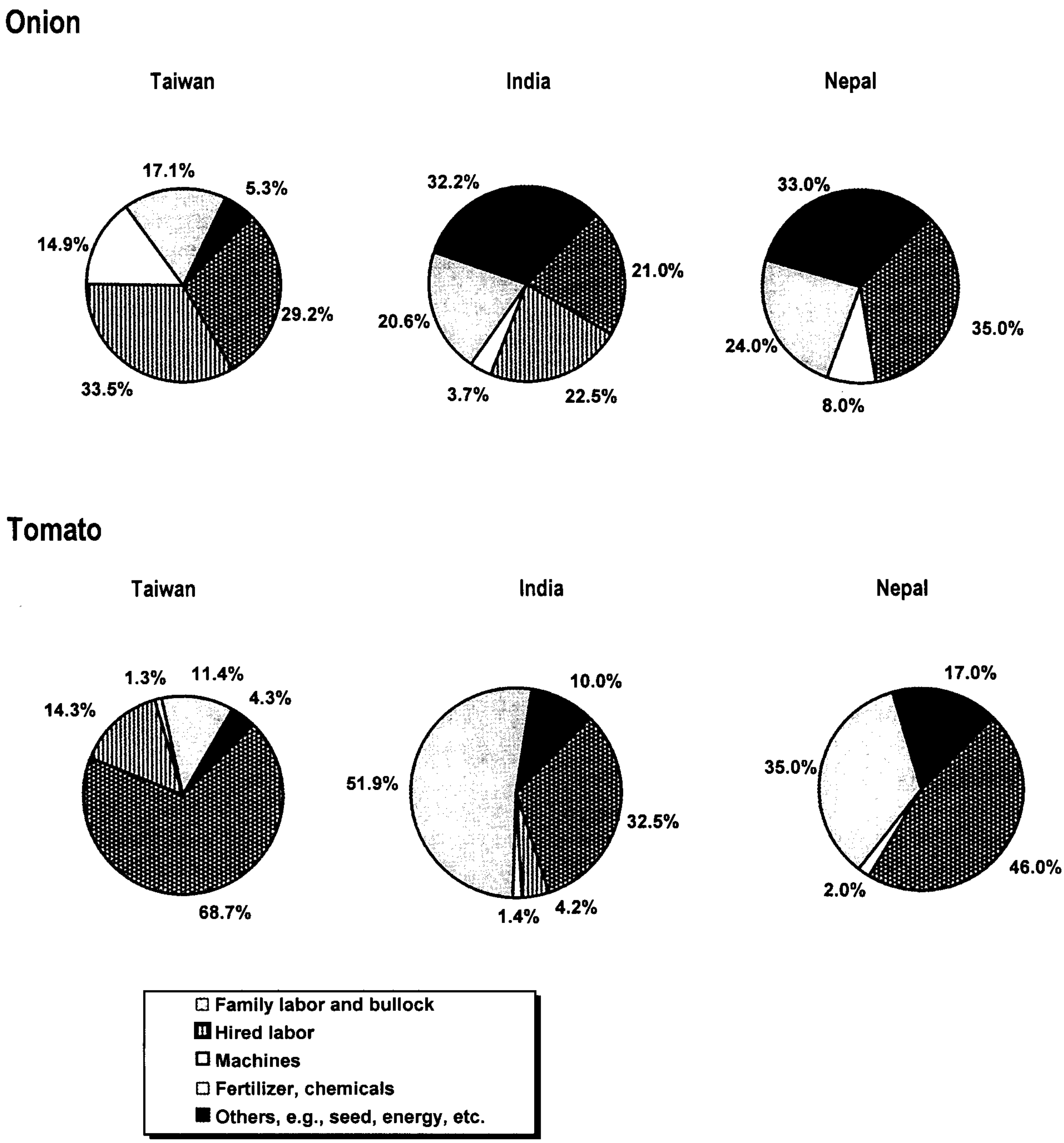
Marketing

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

Marketing Systems

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

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



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

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

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

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

Marketing Margins

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

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

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

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

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

International Trade

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

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

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

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

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

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

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

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

Research Needs

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

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

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

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

A related issue, almost unexplored until now, is the characterization of vegetable farmers. We know that vegetable farmers usually operate on a small scale, but what type of training, education, and attitude do they possess? What prompts a farmer to include vegetables in a cropping system, or specialize exclusively in vegetables? Why is vegetable cultivation not expanding on other small farms, despite high rate of return? What role does risk play? Why do vegetable farmers use high amounts of chemicals despite little or no crop response? Why do some farmers manage their fields very well while others do not? Is this due to lack of inputs, marketing constraints, or differential access to input supply, especially credit, extension, and education? The review of literature on various issues in this book suggests that these questions have yet to be answered. Therefore, it is suggested that a project be initiated in selected countries to characterize vegetable farmers, and to determine the yield and profit sensitivity under various management practices and socioeconomic and biophysical environments. Among other things, learning more about vegetable farmers will help in planning effective training courses for them.

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

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

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

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

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

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

Conclusions

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

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

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

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

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

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

The new macroeconomic environment has altered relative factor costs—the costs of labor (especially hired labor) and machinery are increasing, while material costs are decreasing. Therefore, demand for mechanical technologies to offset high labor costs, along with uniform-maturing vegetable varieties suitable for mechanical harvesting, will remain high in Asia. However, such a trend might aggravate already high seasonality in vegetable supply, as most of the output will be ready to harvest at the same time. This adds a dimension to vegetable varietal research: to spread supply, the new vegetable varieties should also be photo insensitive, so that they can be grown at any time of the year.

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

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

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

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Appendix 1 (Estimation Procedures)

Trend Analysis

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

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

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

Risk in Vegetable Cultivation

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

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

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

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

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

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

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

Seasonality

Seasonality in vegetable supplies was estimated from average monthly data on prices and availability. It should be noted that seasonality estimated from daily data would be much higher than that estimated from monthly average data, but such data are much more difficult to get and will have more noise. Monthly data for several years were first converted into a monthly index using January as base month in every year. This partially removed over-time trend in the data, if there was any. Monthly averages over the years were taken, and then seasonality was estimated as follows:

$$S_i = [(I_h - I_l) / I_l] * 100 \qquad (5)$$

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

Marketing Margins

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

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

Cropping Intensity

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

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

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