Pergamon

Food Policy 28 (2003) 13–27

FOOD POLICY

www.elsevier.com/locate/foodpol

Supplying vegetables to Asian cities: is there a case for peri-urban production?

D.J. Midmore [a,*], H.G.P. Jansen [b,c,d]

[a] *School of Biological and Environmental Sciences, Central Queensland University, Rockhampton, Queensland 4702, Australia*

[b] *Agricultural Economics Research Institute (LEI), The Hague, The Netherlands*

[c] *Wageningen University (WU), Wageningen, The Netherlands*

[d] *International Food Policy Research Institute (IFPRI), 2033 K Street, NW, Washington, DC 20006-1002, USA*

Abstract

In this paper, we analyse the dynamic interplay between peri-urban vegetable producers and their changing production and marketing environments in Asia, using examples from urban conglomerates in South, Southeast and East Asia. We discuss income generation, labour use, management of land and water resources, use of urban and market waste materials and health and food safety aspects. We conclude that peri-urban vegetable production, even though currently economically viable, is unlikely to be able to compete in the long run for scarce land and labour resources, unless alternative production technologies become available and the positive externalities generated by peri-urban agriculture become internalised. There is thus an urgent need for interdisciplinary research aimed at developing such technologies as well as for integrated economic and environmental analyses that take explicit account of interactions between peri-urban producers, the urban waste management sector, municipal planners and consumers.

Keywords: Vegetables; Peri-urban; Asia; Urban waste; Food safety

* Corresponding author. Tel.: +61-7-4930-9770; fax: +61-7-4930-9255.
E-mail addresses: d.midmore@cqu.edu.au (D.J. Midmore); h.jansen@cgiar.org (H.G.P. Jansen).

0306-9192/03/$ - see front matter
doi:10.1016/S0306-9192(02)00067-2

Introduction

Worldwide, the urban population is growing at twice the rate of total population growth (World Bank, 2000), creating unprecedented demands for goods and services as well as increasing pressure on the environment. Urban population growth is particularly high in Asian countries as illustrated by Vietnam (Jansen et al., 1996) and Nepal (Jansen et al., 1995) where it is up to three times the country means of about 2%. Per capita income growth in urban areas also typically exceeds that in rural areas.

The importance, characteristics and potential of urban and peri-urban agriculture in developing countries has received due recognition only recently (see, for example, the CGIAR Strategic Initiative on Urban and Peri-Urban Agriculture (http://www.cipotato.org/siupa/index.htm) and FAO's recent work in this area (http://www.fao.org/urbanag). Vegetable commodities in particular have received increasing attention since they are highly perishable, and when cool chains are rare or incomplete as in much of the developing world, are often produced close to where they will be consumed. Vegetable production in much of Asia has thus become concentrated in peri-urban zones where there exist large urban populations and high income elasticities of demand (Jansen, 1992).

In this paper, we define the peri-urban agricultural sector as agricultural production systems together with pre- and post-production support services within the immediate surrounding of cities. We focus on commercial peri-urban vegetable production in peripheral zones near major urban conglomerates that are influenced by relatively long-term major changes such as industrial or new municipal development plans. These zones form a belt of varying radius with market-oriented intensive vegetable production often affected by, or causing, environmental hazards (Richter et al., 1995). We will largely ignore urban agriculture and gardening activities that generally do not cause significant environmental hazards.

While world-wide some 800 million persons are believed to be involved in some form of urban and peri-urban agriculture (Smit et al., 1996), separate figures for Asia, peri-urban agriculture or for vegetable producers alone are not available. It is often assumed that the profitability and sustainability of peri-urban agriculture in general, and that of vegetable production in particular, is virtually guaranteed by the nearby existence of large populations, relatively low transportation and packaging costs and low post-harvest losses. Enhanced peri-urban farm income would provide the base for investment in value-adding and other high return activities in peri-urban areas while contributing to overall economic growth (Boncodin, 2000; Goletti et al., 1999).

In this paper we analyse the validity of some of these assumptions, drawing from case studies in Asia. We argue that most peri-urban agricultural operations in general, and peri-urban vegetable production in particular, face rather poor prospects in the long run unless promotive policies and improved technologies become available and farmers get compensated for the positive externalities generated by their production activities. The latter suggests that public investment in peri-urban agriculture would result in a public good of a greater magnitude. In this context, we pay special attention to the links between the peri-urban vegetable sector and the urban waste sector.

Using an example from China we demonstrate that dramatic shifts in occupations and incomes of peri-urban communities can take place. On the other hand examples from Vietnam, Nepal and Thailand demonstrate that higher income and employment opportunities amongst peri-urban producers of vegetables than their rice-producing counterparts have not been sufficient to compete with urban demands for labour. The argument that peri-urban vegetable production systems can absorb significant quantities of city waste is supported by experiences from Vietnam, the Philippines and (to a lesser extent) Nepal and India. We also synthesise the evidence regarding the potential negative impacts of peri-urban vegetables and their production systems, particularly on health of the consumer. Finally, we outline implications for research, development and public policy regarding peri-urban vegetable production in Asia.

Effects of peri-urban vegetable production on income and labour use

Examples of intentional linkages maximising the interplay between rural and urban settlements are rare, and almost entirely confined to countries with centrally planned economies. Great success has been recorded by Wang (1997) for the Shenyang-Dalian extended metropolitan region in the province of Liaoning in China. Over a 15-year period, a complete shift of land use has taken place away from rice cultivation to a predominately vegetable production system and from an agricultural to a non-agricultural dominated work force (Table 1).

Case studies from Vietnam (Jansen et al., 1996), Nepal (Jansen et al., 1995), Thailand (Kieft, 1994) and Malaysia (Midmore et al., 1996) clearly establish the private profitability of peri-urban vegetable production but are less specific about its communal benefits. This was largely due to the limited access to historical data for comparative purposes. On average financial returns were greater than for cereal production but also much more variable: weather risk, price risk and capital investment were also considerably higher, making some farmers barely solvent. Off-farm income was important in enabling farmers to invest in yield-increasing technologies or management practices.

Financial solvency of peri-urban farms is not only an issue to developing countries, but in developed countries too. Commitment to farming, and anticipated succession of the farm across generations was closely related to the value of output per working

Table 1
Labour occupation (%) in Hunhebu village in 1978 and 1991

Year	Agricultural labourers	Village enterprise workers	Managers of village enterprises	Business owners/partners	Others
1978	84	13	3	0	0
1991	21	49	6	14	10

Source: Wang, 1997.

day and to the financial viability of farms in the horticultural periphery of Attica, Greece (Moissidis and Duquenne, 1997). Similar research in The Netherlands (Van den Hoek, 1994) showed that the percentage of Dutch farm operations with a guaranteed successor is decreasing, and that farm continuity is largely determined by farm size, income level and future outlook.

Nugent (2000) argues that intensive peri-urban vegetable production can utilise an under-employed work force, but this is not so where less arduous and better paid employment is available in industry or commerce. In Ho Chi Minh City (HCMC), while returns to labour working on vegetable crops were 2–5 times the prevailing wage rate for hired agricultural labour, the need for 2.5–6 times more labour per hectare than for rice limited the extension of land that could be brought into vegetable cultivation by one family, as highlighted by the inverse relationship between cropping intensity and arable land area per farm (Fig. 1). The same phenomenon was observed in the peri-urban zones of Kathmandu (Jansen et al., 1995) and Bangkok (Kieft, 1994). On the boundaries between peri-urban and rural zones, temporal competition for labour may occur between rice harvest and sowing and transplanting for autumn vegetable production. Such is the case around Kathmandu, for example (Jansen et al., 1996). Increasing costs for hired labour (Rosegrant and Hazell, 2000) could result in production of some peri-urban vegetable crops becoming less competitive than those rurally grown.

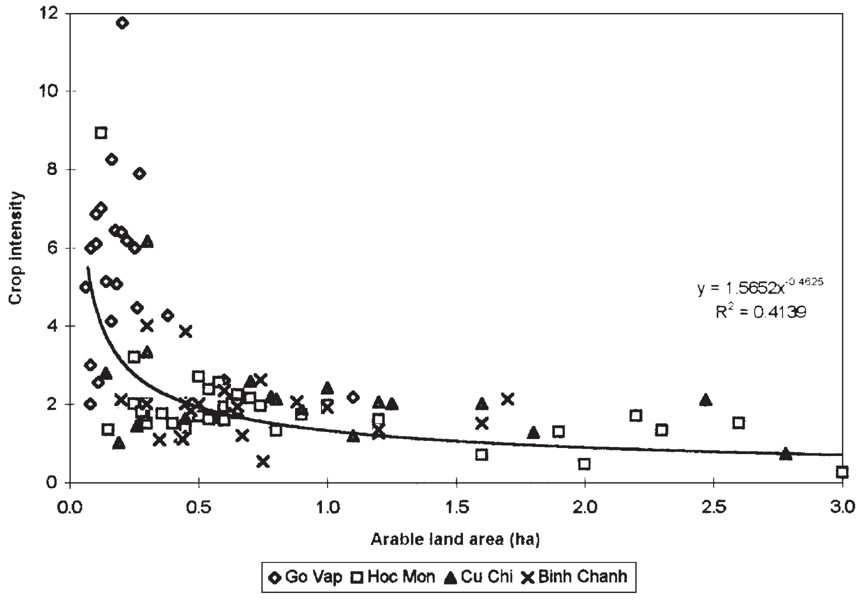

Fig. 1. Relationship between cropping intensity (= ratio on an annual basis of cultivated and arable land area) and arable land area, for surveyed farms in four districts supplying HCMC with vegetables, showing tendency for higher crop intensity with smaller farm size. Source: Jansen et al. (1996).

Waste management

Peri-urban vegetable production systems offer potential solutions to municipal governments faced with insurmountable issues of waste[1] management and disposal, despite the presence of potentially harmful pathogens, bulkiness and variation in nutrient content. Experience in developed countries has demonstrated that most of these shortcomings can be overcome by composting[2] (Midmore, 1995). In developing countries however, the use of 'true' composted urban wastes is scarce and instead urban organic wastes are frequently used as a 'compost' input (a euphemism for city waste, not including sewage) to peri-urban horticulture, as are dubious sources of waste (sewage) water for irrigation (Allison and Harris, 1996). Unlike chemical fertiliser, the use of the various forms of urban waste has the potential to help prevent soil degradation and erosion by adding organic matter to the soil, and closes the mineral nutrient cycle (Midmore, 1995). Finally, composting urban waste will contribute to solving the waste disposal problem and increase the lifetime of landfills. For example, Perla (1997) estimates that 75% of the 25 000 m^3 solid municipal waste that Jakarta produces daily, is organic. Even though 80% is collected, disposal presents a significant problem that could partially be solved by recycling.

The experience of HCMC is illustrative for some of the difficulties associated with the use of urban waste in peri-urban agriculture. Separation of primary wastes is costly and therefore minimal, and the use of 'raw' urban waste instead of composted waste complicates tillage and other field-based activities. Even though a government scheme to commercially produce compost from city waste became uneconomic after global increases in oil-based energy costs,[3] Jansen et al. (1996) estimate that peri-urban vegetable production around HCMC could assimilate 665 000 t of organic wastes per year. Average waste production per capita in low-income countries is consistently estimated at 150 kg $year^{-1}$ (Medina, 1993; Simpson, 1993) hence the wastes from 4.5 million people in HCMC could be recycled to peri-urban agriculture. The cost of centrally collecting, sorting and processing these wastes deserves closer attention and analysis, before embarking on large-scale projects such as the one in the city of Hanoi. Here, despite the fact that some 60% of total household waste is collected, less than 5% undergoes treatment in the URENCO (Hanoi Urban Environment Company) plant (Peters, personal communication). The importance of

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[1] A common distinction is between solid and liquid waste. Solid waste may come from households, markets and agro-industrial enterprises and can be turned into fertiliser, animal or fish feed or soil conditioner after composting. Liquid waste includes waste water from small household processing enterprises or from urban households that flows through integrated urban drainage and sewage systems.

[2] Composting refers to the process of biological breakdown of solid organic matter to produce a humic substance that may be valuable as a fertiliser and soil conditioner.

[3] The cost price issue is not unique to developing countries. At today's prices, compost made from city waste in New Zealand can only be purchased by the urban elite for non-commercial gardening (http://www.ccc.govt.nz/waste/envy/Envy.asp). An economic analysis of the use of urban waste-based compost in Canadian agriculture by Alder (1997) shows zero private economic returns even though social returns may be positive.

adequate policy incentives to stimulate the use of alternative fertiliser sources is addressed later in this section.

In the Philippines, there are at least two examples of use of urban household or market waste-based true compost in peri-urban agriculture. Marilao in the municipality of Bulacan near Manila segregates urban waste into biodegradable and non-biodegradable components, with the former being recycled into compost, which enhances yield when combined with inorganic fertiliser. The second example relates to the use of market waste-based compost in a peri-urban vegetable project in Cagayan de Oro. Even though here a much more scientific approach is being taken (even involving a PhD study), no attempt thus far has been made at commercialisation.

In contrast to Southeast Asia, lesser use of composted materials for vegetable production is documented for South Asia. Organic inputs to vegetable fields are not voluminous around Kathmandu (3–20 t ha^{-1} $year^{-1}$ vs. 70 t around HCMC), and largely comprise home-produced farm-yard manure and purchased chicken manure (Jansen et al., 1995). On the other hand in Calcutta, small cooperatives farm many hectares on refuse dumps, providing one-fifth of the city's fresh vegetables (Smit et al., 1996). Another Indian example mentioned by Eaton et al. (2000) concerns the municipality of Titagarh where some 110 peri-urban vegetable farmers use composted solid wastes and treated sewage sludge (the latter representing a virtually unique example for developing countries). In the Hubli–Dharwad city-region of Karnataka, urban waste is utilised by relatively few peri-urban farmers due to high labour requirements involved with the application of large quantities of organic material (compared to those for chemical fertiliser application) and stiff labour competition from the industrial and service sectors in urban areas (http://www.cityfarmer.org/indiawaste.html). Similarly for China, Gardner (1997) mentions rising opportunity costs of labour as the primary reason for the dramatic decrease in the use of organic fertiliser in favour of inorganic sources of nutrients over the past 50 years.

Notwithstanding the scattered experiences mentioned earlier, generally there exist few data on the amounts, quality and availability of the different organic wastes available to recommend location-specific composting technologies that match peri-urban farmers' requirements and ability to pay. This points to the need for an analysis of (latent) demand and supply as well as the long-term sustainability of composting. Such an analysis would have to consider all costs and benefits (financial, social and environmental) of using waste-based compost relative to costs and benefits of providing chemical fertiliser, both in the short-term as well as the long-term. This should include the opportunity or avoided costs involved when recovering organic solid wastes instead of landfilling or incineration. Since reusing urban waste has benefits that cannot be captured in the price of waste products, the role of government regulation needs to be an integral part of the analysis. In HCMC, for example, prohibition of off-loading of raw urban wastes to field perimeters would help to create a market for centrally-composted wastes, and prices set to cover costs would curb the over-application of nutrients already noted for peri-urban vegetable production systems (Jansen et al., 1996). In the Netherlands, the treatment and recovery of solid and liquid waste is on the rise mainly due to increasing disposal costs and growing environmental awareness, both of which are internalised in municipal taxation systems. In Shanghai on the other hand, subsidies on chemical fertilisers in the 1980s negatively influenced the market for compost made from the city's organic waste, despite the city government's official policy to stimulate the use of compost (Eaton et al., 2000). Payment for provision of peri-urban environmental services (as in the example of waste minimisation) through vegetable production to reduce a city's ecological footprint could offset the less competitive cost aspects of producing vegetables in peri-urban areas.

Water management

Demand for water by peri-urban vegetable production compounds already existing competition from residential and industrial users for limited supplies in an environment where the marginal value product of water is high, heightening potential conflict (Abernethy, 1997). Increased construction in Asian cities leads to reduced infiltration, increased runoff, less underground water storage and greater flooding risk, especially during the monsoon season. To some degree the retention of vegetable fields near cities, whether intentional or serendipitous (e.g. empty lots awaiting construction), offset these issues and certainly should be encouraged. An excellent example is the retention in Taiwan of the intensive horticultural region of Chang Hua county in an area of rapid industrial development.

Besides quantity, quality of metropolitan water as affected by industrialisation, urbanisation, sewage/effluent disposal and agricultural practices, has important impacts on vegetable quality and sanitation. In order to 'price water right', nominal trade in pure water and grey water and even effluent rights merits serious consideration by municipal water management authorities. Grey water can be used in power stations and for other industrial applications, treated effluent can be used in peri-urban agriculture, and potable water for domestic purposes. Taxing the use of water resources offers a potential solution to further regulate its allocation, as in the Netherlands where peri-urban farmers not only are liable to a tax on their use of groundwater resources but also subject to a compulsory registration system regarding the quantities of ground water used and drain water produced. A simpler system is in place in India: farmers irrigating with sewage water in the Hubli–Dharwad twin city should pay a nominal annual charge to the twin city corporation, but this is not enforced (Nunan, 2000). Only with enforcement could water treatment and distribution be improved.

Health and food safety

In view of their generally high vitamin and micro-nutrient content, vegetables are commonly valued as an essential component of the human diet (Ali and Tsou, 1997) and peri-urban vegetable production contributes substantially to the sum total consumed within cities (e.g. 75% of annual consumption in HCMC (Jansen et al., 1996) and 80% in Hanoi (Tran, 2000)).

Although largely unquantified, peri-urban vegetable production contributes to the aesthetic properties of the urban–rural divide (FAO, 1999a). Wang (1997) writes of the shift in population away from city centres to peri-urban zones, presumably for an improved lifestyle. Smardon (1988) discusses the impact of green vegetation on general human health and wellbeing. Pfeffer (2000) points to urban people's increased appreciation for goods and services other than primary products provided by agriculture in the US.

On the other hand, peri-urban vegetables may exert a negative impact on the health of the urban populace via induced infections/toxicities attributed to the consumption of contaminated vegetables, even though the risks of human infection do not seem to be more serious than through consumption of vegetables produced in rural areas (Albrecht et al., 1995; Senouci et al., 1993). Even though health risks from the reuse of organic urban wastes in peri-urban agriculture are often considered minimal (Furedy, 1996), human toxicity due to high concentration of heavy metals sometimes can occur in produce from peri-urban sources, e.g. in Hanoi (Tran, 2000). In addition, where peri-urban farmers in Hanoi use fresh human manure in peri-urban vegetable farming, virtually all children suffer from helminthiasis (Dang, 2000). Finally, as in HCMC (Jansen et al., 1996) and Bangkok (Waibel and Schmidt, 2000), the widespread overuse of both inorganic fertilisers and pesticides by peri-urban vegetable growers is a potential danger to environmental health.

Fortunately however, the degree of microbial contamination is amenable to both production and post-harvest management. Judicious management and use of sewage effluent can reduce exposure to coliform bacteria, e.g. by covering the soil with plastic sheeting (Sadovski et al., 1978). Rinsing of contaminated vegetables causes measurable differences in bacterial counts and a chlorine wash solution reduced coliform population on broccoli by one log unit (Rosas et al., 1984). Objective inoculation with selected lactic acid bacteria (*Lactobacillus casei* strains) is effective in reducing or eliminating populations of coliforms and enterococci after the third day of refrigerated storage (Vescovo et al., 1995).

From a policy point of view, WHO guidelines exist for the safe use of wastewater and excreta in agriculture (Mara and Cairncross, 1989) and for acceptable concentrations of various organic and inorganic compounds in soils treated with reclaimed water and sewage sludge (e.g. Chang et al., 1995). Given the current and likely increase in use of sewage and effluent for peri-urban vegetable production, attention to the possible impacts of heavy metals on the safety of vegetable consumption is appropriate even though the evidence regarding their potential harm is mixed. No significant difference in heavy metal content was observed in a comparison between vegetable plants irrigated with well water or treated municipal waste water (Burau et al., 1987), and preliminary evidence from West Africa (Bamako in Mali and Ougadougou in Burkina Faso) suggests that heavy metals, even though present in organic waste material, are not currently an issue of immediate concern (Derek Eaton, personal communication). On the other hand, one study has found positive correlations between plant lead (Pb) concentrations in lettuce and the lead concentration in the urban garden soils, and showed the benefits of applying limed sewage compost sludge to lower the concentration of Pb (Sterrett et al., 1996).

The concern with lead appears to be confined to production in urban areas: lead was found in high concentrations in urban soils at twice the values of rural or forest soils of Hong Kong, and studies of urban soils in Baltimore (USA) also showed high average lead concentrations (Sterrett et al., 1996), attributable to automotive Pb emissions, aerosol emissions and Pb-based paints. The major current concern with Pb is the surface deposition of Pb-enriched dust on vegetables that will then be ingested, as is so in the highly urbanised Hong Kong area (Chan et al., 1989). As might be expected, distancing vegetable production from streets minimises atmospheric deposition of Pb particles (Smit et al., 1996). Approximately 50% of surface-deposited Pb is removed by surface washing.

Finally, there is the issue of nitrate content in the edible part of vegetables. Vegetables (particularly the leafy types) that are harvested during their major growth stage are still actively accumulating nitrogen and tend to have high nitrate concentrations. However, the overall effect on nitrate concentration is similar in vegetables harvested from peri-urban and rural sources (Cerutti et al., 1996; Yin et al., 1993), and this, together with the reported levels of heavy metals in peri-urban-produced vegetables (with exceptions for lead in urban situations) should not give cause for serious concern amongst consumers of peri-urban vegetables (FAO, 1999b).

Peri-urban versus highland production of vegetables

The ever-increasing urban demand for vegetables in Asia has traditionally been met with supplies from peri-urban zones as well as more distant highland regions such as Dalat (Vietnam), Chiangmai (Thailand) and Mindanao (Philippines). Despite their generally favourable climate, many highlands are ecologically fragile and production of vegetables, if not accompanied by appropriate land clearing and production practices, can cause significant environmental degradation (Midmore et al., 1996). In addition, the sheer geographical distance of many highland areas from the urban centres of demand may lead to higher transportation costs than from peri-urban zones, and deteriorated (especially visual) quality. The latter is now a major issue in Asian cities as increasing proportions of vegetables are currently marketed through supermarkets catering to a fast growing quality-conscious affluent class (ATO, 1998).

Relative to highland production, peri-urban vegetable production has a number of advantages including proximity to their markets reducing the need for cool-chains and demands on energy; increased financial resources for capital investment needed to raise production efficiency (due to off-farm employment opportunities) resulting in lower unit production costs and retail prices of vegetables, making them more readily available for the urban poor; and increased scope for value-adding through washing, grading and even preparing mixes according to use before marketing. Greater demand for locally produced vegetables may also result, as the demand for premium-priced pesticide-free produce, a trend that is beginning in Asian cities is satisfied from local produce. Additional environmental and human health benefits include solid and liquid city waste dissipation, provision of combustion-free zones and soothing green spaces.

On the other hand, the inclement off-season (summer) weather in most lowland Asian cities, particularly high temperatures and typhoons, stimulates protected peri-urban vegetable production, often involving substantial investments. Such intensification may be stimulated by the government insofar as the necessary investments are beyond the financial means of farmers. For example, 40% of investment for greenhouse construction close to Taipei for the summer supply of vegetables was covered by government grants (Cheng, 1995) as was 50% of capital costs for protective structures used in peri-urban vegetable production around Beijing (Anon., 1995). A complementary area of government support concerns research investment aimed at increasing the off-season supply of vegetables, flattening price and species seasonality. In Taiwan, for example, the institutionally supported combination of more input- and knowledge-intensive cultivation of advanced cultivars, selected for tolerance to off-season biotic and abiotic constraints, led to increased production volume that favoured producers while lowering prices that favoured consumers (Wann et al., 2000).

Government-supported research into labour-saving opportunities for the traditional seasons, would also contribute towards stabilising vegetable prices throughout the year. As an example, near HCMC in Vietnam peri-urban farmers with limited land area have multiple cropping indices above that of larger farms (Fig. 1), if labour availability is not limiting. Labour for irrigation comprises the single most time-consuming field operation for peri-urban vegetable crops in HCMC and only labour-saving devices and greater input-use-efficiency can raise the economic returns to those farmers (Jansen et al., 1996). Government-assisted investment in research and development for suitable alternative irrigation technologies would, as mentioned earlier, favour the producer and consumer, and the environment through lessened externalities.

Ellis and Sumberg (1998) have argued against government support for peri-urban agriculture and suggest that scarce resources better be invested in the rural economy. However, low food prices are especially important to urban dwellers who buy most of their food and depend to a significant extent on efficient (peri-)urban food production, marketing, distribution and information systems, all of which require substantial public investments (Garrett and Ruel, 1999). In addition, since peri-urban vegetable production presents the opportunity to convert urban wastes into nutritionally beneficial foods, governments should take the ‘ecological’ contribution of peri-urban vegetable production into account in their investment decisions. Public investments in peri-urban agriculture in terms of infrastructure, processing facilities (relevant not so much for vegetables as for livestock products) and marketing institutions can be considered as a kind of risk premium that city authorities pay as part of an insurance strategy to avoid social disruptions. Fewer stages in the marketing chain, and greater cost–benefit ratios for peri-urban vegetables favour peri-urban over rural producers of vegetables (Moustier, 1998).

Even though land prices are invariably higher in city and peri-urban areas than in rural areas, government can mitigate their negative effects on peri-urban agriculture, e.g. through the introduction of a land sales tax as in Vietnam and through secure tenure legislation. Indeed, farmers near HCMC were de facto owners while farmers close to Kathmandu were essentially owner-producers (Jansen et al., 1995, 1996). Around Bangkok, even though farmers rented, the land tenure systems still permitted significant ditch and dyke construction to take place for vegetable production (Midmore, 1995). However, experience elsewhere shows that in combination with insecure tenure, the advance of urbanisation may inhibit development of peri-urban agriculture (Ciparisse, 1997).

Implications for research, development and policies

Even though currently economically viable, peri-urban production of vegetables is dynamic and will face increasing constraints in the future. Continuing metropolitan expansion, while creating market opportunities, also leads to ever-increasing production costs (given current production technologies) as competition for resources (in particular land, water and labour) intensifies with that by the cities themselves. As demand for vegetables increases in cities, peri-urban production is unlikely to be able to keep pace as industry and commerce compete for labour and land. Labour-saving production practices will be necessary for peri-urban production systems to remain competitive with rural systems where labour is expected to remain cheaper as evidenced by increasing urban/rural gaps in wage and land prices (Rosegrant and Hazell, 2000). New developments in modified atmosphere packaging of vegetables now allows for longer storage without cool chains (Feng, 2001) and will increase the price competitiveness of distant production zones. Increasingly strict environmental legislation will not only limit the extent of pesticide, waste water and nutrient application to acceptable levels but is also likely to raise operating costs. This will force many farmers to abandon production if adequate research and extension do not provide them with alternative production technologies. Such technologies should have sustainable natural resource management as their departure point and may include approaches to integrated pest management and simple nutrient-balances, to heavy metal sequestration, and to simple water treatment and delivery systems. Moreover, development of effective linkages between the peri-urban agricultural and urban waste sectors is needed, with particular attention to the cost of separation, adequate quality control and logistic issues. In this context, it is necessary to go beyond vegetables and to identify environmentally friendly and economically profitable ways of improving the various types of interactions between peri-urban farmers, livestock farmers (especially pig farmers), the urban waste management sector, and agro-processing enterprises. With the exception of the urban waste management sector, these components are often managed within single peri-urban households. Whereas cropping activities have generally received more attention from researchers and donors (much less so livestock and processing industries), information on their interactions is virtually absent.

To ensure that Asian countries continue to benefit from the multiple advantages of peri-urban agriculture, investment in both research and development will be essential. Research should focus on all-encompassing analyses comparing the short-term economic gains and the long-term environmental consequences, for vegetable production in peri-urban zones with that in the rural uplands of Asia. Such research should be highly interdisciplinary combining technical (including a certain amount of experimentation at the local level) with socio-economic, marketing, livestock and nutritional research. Development efforts should focus on designing and implementing 'win–win' situations in which both a pressing environmental problem (created by various forms of waste from different sources), an agricultural problem (supply and management of plant nutrients) and a human problem (insufficient nutritional status of large segments of the urban population) could be relieved, with due attention to the economic aspects (income generation, employment and nutrition), including poverty alleviation.

Improving land tenure security, and strengthening public investment in research and development towards health and environmental aspects of peri-urban vegetable production, especially those that backstop legislation and implementation of least-risk socially acceptable reuse of wastes, are essential for sustained success of peri-urban vegetable production systems. The high demand on institutional capacity to implement the directives will also have to be addressed. Embracing of the total system perspective, where inputs and environmental services are appropriately priced and paid for is necessary to achieve a win–win outcome. Investments in improved marketing facilities may foster a closer link between consumer and producer and strengthen the moral and legal requirements binding on the producer. This may lead the way for entrepreneurial middlemen to capitalise on consistency in quantity and quality, and peri-urban producers will tend to specialise in a few commodities as they become integrated into new markets, with scale economies likely to follow. While small markets will always exist for cheaper, poorer quality vegetables, peri-urban producers should aim to satisfy the demands for vegetables by the discerning middle class as it expands. Unless governments recognise that peri-urban agriculture takes the pressure off unsustainable highland vegetable production (Midmore, 1995), and consumers are willing to pay premium prices for vegetables produced in peri-urban areas that cover the full costs of production and environmental services provided by local agriculture (including the provision of clean air and green space, water storage, and use of urban waste), peri-urban farm operations are unlikely to survive in the long run.

Acknowledgements

The authors thank Joost Moonen and two anonymous reviewers for their constructive comments on an earlier version of this paper. Remaining errors are our own.

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