Peri-Urban Horticultural Systems and Household Gardens in Southeast Asia

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Background information

Peri-urban horticultural systems are mainly important as suppliers of vegetables to urban centres. Their proximity to markets makes it possible to produce vegetables that are perishable. Such proximity is especially important in lower-income countries where the lack of good roads and cold chain options make it challenging, if not impossible, to transport vegetables over longer distances.

Household gardens (or home gardens, kitchen gardens, backyard gardens) are an integral part of local food systems all over the world and make an essential, yet often little recognized, contribution to food and nutrition security. Gardening is an ancient practice and probably the oldest form of crop cultivation. Household gardens are typically mixed cropping systems that may include seasonal vegetables, fruit trees, herbs and spices and other useful plants and may be combined with livestock. Gardens are usually located close to a dwelling for easy care and convenience and their main purpose is to supply the household with food, although excess production may be sold or shared (Galhena et al 2013).

The role of peri-urban horticultural systems is the provision of food whereas the role of household gardens includes family needs, cultural and regulatory services alongside food production. Nutritional service towards the household includes the provision of much-needed vitamins and minerals (Schreinemachers et al 2018). Cultural services include the conservation of plant species diversity and indigenous knowledge of plants, making living spaces more liveable and more beautiful (e.g. providing shade, reducing dust), a place over which mostly women (and the elderly, and children) have control, and the

A woman harvesting ridge gourd from a garden in Nakhon Pathom Province, Thailand (photo: Sorawit Limsiriwat, World Vegetable Center)

supply of inputs to the local food culture (Galhena et al 2013). Regulatory services would include the recycling of organic household waste and grey water, but are hard to quantify because of the small scale and diversity of household gardens. There is probably the greater tendency to recycle grey water in the home gardens in remote areas where water is scarcer and may have to be transported some distance to the homestead, though the perceptions and acceptability of using grey water vary greatly (Radingoana et al 2020). However, with climate change and pressure from urbanization, providing local greywater treatment facilities is becoming a higher priority for providing safe irrigation water for small-scale horticultural operations in peri-urban situations in SE Asia and other tropical and subtropical areas. The valuable habit of recycling organic waste through composting or simple surface mulching may be declining with the rural youth loosing interest in agriculture/horticulture and migrating to the cities and towns for work leaving ever aging parents and grandparents to tend the home gardens.

Home garden in Son La, Vietnam (photo: P Schreinemachers, World Vegetable Center)

PlantSystems considered in this report

Across SE Asia a great diversity of vegetable, fruit and herb/spice crops are grown in the smallholder peri-urban commercial horticulture systems for sale in local markets and in some cases for transport to and sale in the larger cities. Among the vegetables in these systems, generally the most valuable in terms of provisioning and income generation will be one or more Solanaceous species, bean species (Fabaceae) and fast-growing leafy vegetables such as some of the leafy brassicas. Leafy salad vegetables, such as lettuce, that are eaten uncooked, only have become more commonly grown in peri urban systems in recent years in response to the increased demand for more “Western style” cuisine, and as drinkable water and simple treatments to decontaminate from microbiological hazards have become more affordable and available (Cheung et al 2021). However, the most important vegetable species differ from country to country and even from region to region within a country depending on local preferences and growing conditions. For this assessment we chose tomato (*Solanum lycopersicum*), yard-long bean (*Vigna unguiculata* ssp. *sesquipedalis*) and the leafy brassicas pak choy (*Brassica rapa* subsp. *chinensis*), Chinese leaf mustard (*Brassica juncea*) and Chinese kale (Mandarin: ”jie lan”; *Brassica oleracea*) as representative of some of the most important and ubiquitous for the peri-urban systems of SE Asia ecoregion (Jansen et al 1995). Tomato adds flavouring, colour and some nutrition to cooked dishes and sauces, and (particularly the cherry types) are increasingly being eaten raw as a salad vegetable/fruit. Yard-long beans are harvested at the almost full-grown, green-pod stage and eaten fresh and cooked for their relatively high protein (2.6%), vitamin, and fibre content. Similarly, the leafy brassicas are picked young when they are tender and require little cooking and so remain relatively nutrient dense.

Household gardens vary greatly in size and species diversity even within the same village so the species diversity they hold is huge considering the SE Asia ecoregion as a whole. Although most household gardens contain perennial trees and shrubs that are important both culturally and for their provisioning service, for this assessment we consider kang kong (*Ipomea aquatica*), chilli peppers (*Capsicum* spp.) and a Cucurbitaceous

species (pumpkin, bitter gourd, luffa, cucumber etc.) as being common to most household gardens across the region (Minh et al 2015). Kang kong is a very fast growing (provided there is enough water) leafy vegetable that is highly nutritious and easy to grow. Chilli peppers add spice and colour to meals and are often grown as a semi perennial in the home garden situation since they can have a long fruiting season. Households only harvest what is needed on that day. Excess ripe fruits can be harvested and dried in small batches for the off season. The cucurbits are very diverse; some are highly nutritious while others are less nutritious and are eaten primarily for their texture or flavour, some have to be eaten or cooked while still young and green (e.g. cucumbers, bitter gourds), while others are left to mature and then can be stored for several months (pumpkins).

Peri-urban vegetables near Hanoi, Vietnam (photo: P Schreinemachers, World Vegetable Center)

Although there is a great overlap in the vegetable species grown in the peri-urban commercial setting with those grown in the household garden, the cultivars grown are often very different. Since the commercial growers need to have more uniform crops growing more intensively and with synchronous harvesting, they are more likely to be purchasing seed of newer varieties and hybrids, whereas many household gardeners will save their own and exchange seeds of more traditional varieties and land races since these may be better adapted to their generally lower input/less intensive system where longer and less synchronous harvesting period is preferred.

Woman harvesting yardlong bean, near Hanoi, Vietnam (photo: P Schreinemachers, World Vegetable Center)

Keystone species	**Family**
Peri-urban commercial:	
Tomato (*Solanum lycopersicum*)	Solanaceae
Yard-long bean (*Vigna unguiculata* ssp. *sesquipedalis*)	Fabaceae
Leafy brassicas (pak choy (*Brassica rapa* subsp. *Chinensis;* Chinese leaf mustard (*Brassica juncea*); Chinese kale (Mandarin ”jie lan”; *Brassica oleracea*	Brassicaceae
Household gardens:	
Kang kong (*Ipomea aquatica*),	Convolvulaceae
Chilli peppers (*Capsicum* spp.)	Solanaceae
Cucurbitaceous species (pumpkin, bitter gourd, luffa, cucumber *etc*.)	Cucurbitaceae

Vegetables health in Southeast Asia

Assessment for keystone species:

Keystone species	Health
Peri-urban commercial:	
Tomato	
Yard-long bean	
Leafy brassicas	
Household gardens:	
Kang kong	
Chilli peppers	
Cucurbitaceous species	

State of vegetables health in the past 30 years

Peri-urban commercial systems, because of increased urbanization, generally have been squeezed into smaller plots and have had to intensify: closer spacing, year-round production, greater use of inorganic fertilizers or manure (where available), greater use of fungicides (almost absent 30 years ago), continuing use of excessive insecticide inputs, and use of higher yielding cultivars and F_1 hybrids. This in turn has probably lead to more favourable conditions for spread and increase in some pathogens - including the build-up of soil-borne pathogens and nematodes (Ali and Porciuncula 2001).

Commercial peri-urban tomatoes - Depending on the location, plant health has fluctuated as different pathogens have been introduced or emerged and new resistances or other control methods have been introduced;

Late blight (*Phytophthora infestans*) in cooler and wetter highland areas - emergence/introduction of new races/genotypes (including fungicide resistant races);

Tomato yellow leaf curl begomoviruses - increasingly rapid emergence of new species/genotypes perhaps associated with spread of more polyphagous and vectoring efficient *Bemisia* whiteflies - high disease level, mixed infections and recombinant types help virus to overcome plant disease resistance/tolerance (Kenyon et al 2014);

Tomato chlorosis virus (*Crinivirus*) - spreading across the region, no resistance commercialized yet though some genetic tolerance (stay green) genotypes have been identified;

Bacterial wilt (*Ralstonia solanacearum* species complex [RSSC]) - increasing importance especially where over intensification and lack of crop rotation is occurring. *Bwr6* and *Bwr12* starting to be commercialized more;

Other occasional or emerging problems: root-knot nematodes (*Meloidogyne* spp.), early blight (*Alternaria* spp), and bacterial spot (*Xanthomonas vesicatoria* species complex).

Commercial peri-urban yard-long-bean - Similar intensification of production as tomato has led to waves of disease and new resistance introductions; Anthracnose (*Colletotrichum lindemuthianum*), Rust (*Uromyces vignae*), mungbean yellow mosaic diseases (Begomoviruses), Cercospora leaf spot (*Pseudocercospora cruenta*), and aphid-transmitted potyviruses.

Commercial peri-urban leafy brassicas - Because of their very short production cycle these tend not to be affected by many pathogens except a few that are seed-borne and carry over from the seed crop (e.g., *Xanthomonas campestris*) or build up or are carried over in crop debris in the soil (*Pythium* spp.) and affect the germinating

seeds or seedlings. Note that leafy brassicas are much more susceptible to attack by leaf-feeding insects.

Household gardens are generally very diverse, each with a range of cultivated plants, spice, medicinal and ornamental species planted in small blocks or as just a few plants. Although, to our knowledge, there are no formal reports and historical accounts of the plant diseases in HGs, it may be assumed that the high diversity of species and the less intensive systems might be less conducive to diseases. Rural HGs in most countries tend to be more reliant on self-saved or exchanged seeds, whereas HG in or closer to growing urban centres are generally smaller and given over to the less common plant species/varieties that are not so readily bought in the local market. Alternatively, peri-urban HGs may be more intensive with a smaller range of crop species, growing some for home consumption and the excess for informal exchange/sale (early stage commercialization). These are more likely to use commercial seed or seedlings of similar varieties to, and purchased from similar suppliers as, the peri-urban commercial growers.

HG Kang kong - Fast growing and easily propagated. Although there are commercial sources of seed, most HGs use self-saved and/or rooted cuttings shared by friends of diverse/mixed land races. Kang kong is infected by few diseases (e.g. White rust/White blister [*Albugo ipomoeae-panduratae*], leaf spot [*Cercospora ipomoeae*]) and these rarely cause significant loss, especially in the HG setting.

HG Chilli peppers - The most ubiquitous species in HGs, and generally grown as just a few plants of diverse and often local/family heritage land races/cultivars grown from self-saved or locally exchanged seeds. This type of seed system may support the inadvertent selection of *Capsicum* genotypes/landraces better adapted to the local conditions - including tolerance to locally endemic diseases; HG growers can put up with a fair level of disease on their chilli plants and if the disease becomes too extensive, they simply destroy the plant(s) and try growing new plants in a different part of the garden. A problem may arise however when the HG is close to commercial chilli production where disease epidemics, particularly of pathogen races novel to the region, readily can occur (e.g. Anthracnose [*Colletotrichum* spp.](Vos and Duriat 1995), pepper yellow leaf curl begomoviruses (Kenyon et al 2014), *Phytophthora* blight, Bacterial spot [*Xanthomonas* species complex]) and act as a potent source of 'exotic disease' inoculum for the HG.

Home garden chilli pepper infected with severe pepper yellow leaf curl begomovirus, West Java, Indonesia (photo: L Kenyon)

HG cucurbits - These are often trained or allowed to scramble along fences and over trellises, and often as much for their aesthetic appeal and the shade they provide as for their provision of food. They are usually grown from self-saved seed or locally exchanged seedlings of locally adapted cultivars/landraces that may show some tolerance to the local disease races. However, as with the chilli peppers described above, commercial/intensive production of a narrow range of cucurbit varieties can lead to the rapid

build-up of pathogen populations (with selection for more virulent and aggressive strains/races) which generates more inoculum for the HG. Examples include the increasing occurrence of whitefly-transmitted squash leaf curl and other begomovirus diseases (especially in pumpkins, luffa, cucumber), aphid-borne poleroviruses (e.g. suakwa aphid-borne yellows virus in bitter gourd), whitefly-transmitted cucurbit yellows criniviruses, Fusarium wilt, Cercospora leaf spot, and Gummy stem blight (*Didymella* spp.)

Home Garden Bittergourd infected with a potyvirus and a littleleaf phytoplasma, Philippines (photo: L Kenyon)

Evolution of vegetables health over the recent 10 years

PU-Tomato - stable-declining; New species/strains of leaf curl begomovirus emerging which can overcome the current *Ty* resistance genes faster than new resistance can be identified and pyramided with older resistance. Tomato chlorosis virus (*Crinivirus*) is spreading rapidly across the region, perhaps because there are more vectoring-efficient whiteflies to transmit them, and there is no durable resistance identified. Thrips-transmitted tomato necrotic ringspot virus (*Orthotospovirus*) is an increasing problem in parts of Vietnam, Cambodia, Thailand, and China with no stable resistance identified yet. Bacterial wilt is an increasing problem in many areas and currently available resistances (*Bwr-6*, *Bwr-12*) do not provide complete control against all species/genotypes, especially where root knot nematode is also a problem (here grafting to resistant eggplant (*Solanum melongena*) rootstock may provide the most effective control but is also more expensive). New species/races of *Xanthomonas* bacterial spot are spreading across the region, some already resistant to copper-based bactericides, and able to overcome currently available host plant resistance.

PU-Yard-long bean - stable-improving; many commercial lines now carry Anthracnose and begomovirus resistance.

PU-Leafy brassicas - stable (good); short cropping cycle avoids disease build-up.

HG Kang kong - stable(good); still mainly locally adapted land races in most HGs.

HG Chilli peppers - stable-declining; spillover of new/more aggressive/virulent disease genotypes (e.g., leaf curl begomoviruses, Orthotospovirus (see tomato above) and bacterial spot from commercial plantings having a deleterious effect on HG where plants are kept for longer and there is little attention to virus-vector control or application of fungicides. No available resistance to many begomoviruses or criniviruses.

HG-Cucurbit spp. - stable-declining; spillover of pathogen inoculum from commercial production infecting HGs - whitefly-transmitted begomoviruses and aphid-transmitted poleroviruses.

Ecosystem services, as affected by plant disease

Provisioning

Peri-urban commercial

Provisioning

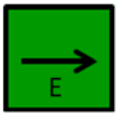
Household gardens

Regulating

Peri-urban commercial

Cultural

Household gardens



Level of ecosystem services generated by vegetables, as affected by plant disease, in the past 30 years

Peri-urban horticulture: The gradual introduction over the last 30 years of more disease resistance genes into commercial tomato and yard-long-bean cultivars, combined with greater use of a wider range of fungicides in the PU setting probably means that diseases now have less of a direct (negative) effect on the provisioning services that these crops provide. However, the higher planting densities of uniform stands of faster-growing and potentially higher yielding cultivars associated with intensification in PU areas means that the soils can be depleted/degraded much more quickly. There is a greater reliance on inorganic fertilizers, a demand for a more constant supply and more water for irrigation, and the crops are at greater risk from build-up of host resistance-adapting and/or pesticide resistant races of plant pathogens. Thus, diseases may have an indirect negative effect on ecosystem services *via* a greater use of pesticides (more pesticides in the environment, greater risk of pesticide residues on the produce, greater risk to the environment, to the growers and the consumers), diversion of water supplies from other uses and faster depletion of water reserves, and the faster depletion of fossil fuels for fertilizer production (Cheatham et al 2009). Some consumers might argue that intensively produced improved cultivars do not have as much flavour or nutrition ("goodness") to them as older, less intensively grown cultivars, and there is risk of higher pesticide residues on newer cultivars in intensive systems. As diseases have been relatively unimportant compared to insect pests in leafy brassica production in SE Asia, the diseases have had negligible effect on the ecosystem services, whereas hazardous insecticide residues above their MRLs frequently have been detected, for example in Chinese kale in Thailand (Wanwimolruk et al 2015).

Home gardens: Since most home gardens carry such a high diversity of plant species, poor health (disease) in a few species has minimal effect on the provisioning services provided by the garden and may be compensated for by growing more of another species, or including a new species not grown before. However, the different species/landraces in the home garden have different cultural significance (provide different levels of cultural service). Local land races of chilli and cucurbit have high cultural significance in some areas and so if a severe epidemic of an exotic strain/ disease of these crops is promoted by the local peri-urban or other agricultural system (e.g. Pepper yellow leaf curl), then few of the local land races of the crop may be resistant and there may be a significant decline in the provisioning service of home gardens, which may also affect its cultural service (e.g. inability to prepare culturally important meals [the right chillies and squashes], give culturally important food gifts [a large pumpkin, calabash], grow the most aesthetically pleasing and useful shade cover [luffa vines].

Evolution of the level of ecosystem services generated by vegetables, as affected by plant disease, over the recent 10 years

Peri-urban commercial: Faster plant breeding methods (e.g. marker assisted selection) means that new cultivars of tomato and yard-long-bean with different combinations of disease resistance have entered the market in recent years. However, because urban populations are perceived to seek clean, unblemished produce, many PU growers still apply pesticides prophylactically (Schreinemachers et al 2012). Thus, plant health has probably had a little positive or no effect on provisioning services, and no effect on cultural services.

Household gardens: In more rural and isolated areas where HGs are still very important, the level of disease is still relatively low and so the effect of plant health on provisioning and cultural services is minimal and stable. Nearer to large urban areas there is perhaps less interest and experience in maintaining HGs, and there may have been greater disease intensity, with spread from peri-urban commercial horticulture (though HGs could potentially also act as sources of infection for the PU systems). It seems likely that there is some loss in species diversity in these near-urban home gardens, including species with cultural/heritage importance (but it is difficult to attribute this directly to plant health problems).

Complementary information

Population growth, globalization (better communications and easier transport for travel and trade), urbanization, and climate change, have all been drivers of the changes in vegetable production systems in SE Asia over the last 50 years, including the rapid expansion in peri-urban commercial horticulture (and the decline in home gardens in the near-urban areas). These changes and the wide diversity of plant species, geographies/agroecologies and production systems encompassed by peri-urban horticulture and home gardens within SE Asia make it difficult to generalize about the changes (or not) in plant health and their effect on the associated ecosystem services over either the long or short term. Added to this, there has been considerable research and writing on the socioeconomic and other important aspects of different peri-urban horticulture settings. However, consideration of plant health has been restricted almost entirely to insects and the high rates of pesticides applied. Similarly, although there have been many studies about the nature and importance of home gardens in different parts of the world, remarkably little has been written about either the pests or diseases affecting them in SE Asia or elsewhere. However, the vegetable seed breeders and producers and the other input supply dealers to the peri-urban vegetable growers have much more intimate knowledge of the different pest and disease problems vegetable growers face in different locations. Thus, without empirical data, this assessment is based mainly on personal and expert opinions (in part built on interactions with vegetable seed and breeding companies) and extrapolation from knowledge of other crops and ecosystems in the region. As such, at best we can be only moderately confident that this is an accurate and reliable assessment.

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