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William Leschen

Water mimosa production using waste water Hanoi

# Urban Aquatic Production

**The cultivation of fish and aquatic plants/vegetables [1] is widespread throughout many cities in Southeast Asia and to a lesser extent in Africa and Latin America. Aquatic production is intrinsically linked with the livelihoods of a significant number of the lower-income urban households. It includes a wide array of activities, from extensive to intensive cultivation of both fish and aquatic vegetables. However, the production systems involved are generally semi-intensive often utilising wastewater from the city as a source of nutrients and fertiliser for increasing production.**

*Editorial*

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Despite the growing importance and attention given to urban agriculture, the importance and potential of growing fish and edible aquatic plants/vegetables in and around cities remains largely unknown to the wider development audience. The term "urban aquaculture" captures a broad array of activities. Fish farming in or around cities varies from the relatively large-scale semi-extensive culture of fish in the Kolkata wastewater-fed wetlands and lagoons to the high-tech, intensive culture of tilapia in tanks in North America and Europe. Aquaculture also includes the considerable, unrecorded cultivation of edible aquatic plants/vegetables, often using wastewater, in and on the periphery of a number of cities throughout southern Asia, providing income and employment for a significant proportion of urban households. It produces fresh green foodstuffs which are consumed daily by millions of city dwellers as a regular and nutritious part of their diet. The benefits of this valuable "hidden green harvest" remain largely unrecorded. They are, for example, not listed in FAO statistics for aquaculture. The multitude of stakeholders involved in the production, harvesting and sale of aquatic vegetables thus remain largely unrepresented and unrecognised by both city planners and developmental agriculturalists.

This issue of UA Magazine draws on preliminary research findings from the PAPUSSA (Periurban Aquatic Production Systems in South-East Asia) project, which aims to give an overview of the status and impact of periurban aquatic production systems in four cities (Bangkok, Phnom Penh, Ho Chi Minh City and Hanoi). Production, livelihoods, markets and institutional aspects affecting a wide range of the stakeholders involved are discussed within the context of increasing urban migration, future sustainability and development in the sub-region; similarities and differences between the four cities are highlighted. This issue also contains a number of articles on the cultivation of fish and aquatic vegetables in other cities in Southern Asia, Africa and South America, which the reader can use as a basis for comparison.

The EU-funded PAPUSSA (Production in Aquatic Periurban Systems in SE Asia) project is a collaborative research project of European organisations and Asian partners in Hanoi and Ho Chi Minh City in Vietnam, Phnom Penh in Cambodia and Bangkok in Thailand. (see www.ruaf.org/papussa/index.html). PAPUSSA is in its second year and has the overall objective of providing a detailed, holistic situation analysis of periurban aquatic food production in these four cities. It uses a cross-disciplinary research approach, involving a range of partners from aquaculture systems, social sciences and health-related backgrounds.

## PERIURBAN AQUATIC PRODUCTION

There is no universally accepted definition of the term periurban. Periurban environments and communities share many facets with those defined as urban (or intra-urban). Usually the transition or interface from rural to periurban to urban is regarded as a continuum. Due to changes in the factors that determine aquatic production systems, eg the availability of land, in general one can state that in the urban setting relatively smaller and more intensively managed aquatic production systems are more common.

In the PAPUSSA-related articles and also the other contributions to this issue, the aquatic production systems referred to are largely found in periurban areas. These periurban areas are in a state of constant change and are often characterised by having only a basic infrastructure (roads, schools, medical centres) and poor service provision, e.g. unreliable sources of water and limited access to sanitation. There are often conflicts over land and water use, and urban industries often move into these areas to escape restrictions and regulations. Periurban communities are often heterogeneous with respect to ethnicity, income levels, language and social norms and are characterised by increasing population density through migration, caused not just by rural people coming in from outside the cities, but also by the movement of urban people radiating outwards from the urban core.

## TYPES OF URBAN AQUACULTURE

The classification of aquaculture systems by Coche (1982), which is based on production intensity and management demands, indicates the degree of control and surveillance operators are able to exercise, both practically and in terms of the assets upon which they have to draw. This might be particularly helpful in discussing the periurban situation.
In the case of periurban aquaculture production, the transition from extensive to semi-intensive aquatic production systems may be attributed to various factors. However, greater demand from markets combined with improved marketing channels often constitutes a particularly important driver for intensification. Control of resources and more access to production-enhancing inputs such as waste resources, food processing by-products and credit to purchase additional seed, feed and labour can also stimulate intensification. This transition from semi-intensive to intensive production appears to be driven largely by financial considerations and increased competition for resources, in particular land, but also solid organic and wastewater resources, labour, credit and markets. Intensification also appears to offer producers greater control, enabling them to better safeguard and enhance the quality of products, and also address concerns expressed by consumers regarding possible health hazards. Despite the competitive advantage associated with intensification, several barriers to such a transition and thus the sustainability of the production systems can be identified: transaction costs may be high, whilst limited access to knowledge, training, credit, markets and institutional support limit the options and opportunities available to producers.


William Leschen

Cultivation of water Morning Glory in Beung Cheung Ek Lake, Phnom Penh, Cambodia

There are of course also examples of successful semi-extensive periurban aquatic systems, such as those described in this issue, particularly in the case of aquatic vegetables. Therefore from a future planning perspective it should not always be assumed that intensification of periurban production systems is inevitable and also, perhaps more to the point, always most desirable. This drive for more intensive systems also raises questions about their long-term future. The increasingly intensive large-scale cultivation of water spinach (*Ipomea aquatica*), also commonly known as water morning glory, in and around Bangkok, involves the use of increasing amounts of chemicals in order to boost production, which has resulted in the increasing contamination of surface and groundwater supplies and degradation of the surrounding environment.

Periurban aquaculture has a number of benefits and constraints, as demonstrated with detailed findings in all of the contributions to this issue. Some of these main findings are summarised below.

## BENEFITS

The cultivation of fish and aquatic vegetables in cities provides food, income and employment, particularly to lower-income urban households. These benefits aren't just limited to those who actually farm the fish and aquatic vegetables but radiate out to a network of other individuals who are involved in the marketing chain, including those who process, transport and then market the products. This chain generates income and employment at as many as six levels between the farmer and the consumer. Also, as these aquatic production systems become more intensive they utilise more inputs, e.g. brewery and chicken-farming wastes, thus adding value to, and at the same time creating market demand and generating income for such waste products. The contribution from Ghana on page 39-40 describes the potential for urban aquaculture, describing semi-intensive aquaculture production in ponds close to Kumasi, Ghana using poultry manure to fertilise ponds. Aquaculture practices that utilise food processing and agricultural by-products, such as poultry manure, are widespread and diverse, and aquaculture has an important role in recycling organic wastes from industrial and urban activities. For example, in Thailand, by-products from chicken processing plants are used to feed catfish (*Clarias gariepinus x Clarias macrocephalus*) grown in urban aquaculture systems stocked at high densities. In Peru (see page 32, treated wastewater from stabilisation ponds is used to produce tilapia (*O. niloticus*). Environmental and social benefits were mentioned in earlier issues of UA Magazine (numbers 3 and 8 for instance) and are also discussed in the articles in this issue. Low-cost wastewater treatment on a city-wide level is described in the East Kolkatta wetlands article (page 24), but also on a more communal basis in the article on Lima, where both small and large-scale systems produce valuable foodstuffs and thus income and food security for the people working within them. From an environmental perspective, growing aquatic vegetables and fish in and around cities can fit in with the concept of cleaner and greener cities, which encourage a healthier environment for their citizens and visitors. The authorities in Hanoi are increasingly aware of the "City of Lakes'" potential for tourism and thus are now looking more closely into using the urban environment in a more sustainable and promotional way. The quality of the urban environment is also very much linked to the overall health and well-being of its citizens, and it is perhaps here that sustainably managed periurban aquaculture can act as "bio-indicators" of environmental health within communities, whilst also offering ownership and pride to a wide range of its ordinary citizens.

**CONSTRAINTS**

The process of urbanisation has had a negative overall effect on food production and thus aquaculture in cities. The limited access to land for the increasing numbers of people migrating to cities restricts their options. For both urban agriculture and aquaculture access to land is one of the main requirements for producing crops, fish or livestock. The attributes of the land required by the urban farmer are considerably less stringent than for the person cultivating fish or aquatic vegetables. Growing crops and even livestock can often be carried out very successfully within cities utilising relatively small areas of marginal land, which can be enhanced using chemical or organic fertilisers. However, the prospective fish or aquatic vegetable farmer has to not only find and retain access to the necessary area of land, but also obtain a source of water that is reliable both in terms of seasonal availability and quality (it does not deteriorate due to effluents from surrounding factories or other detrimental human activities). These factors can restrict and pre-determine to a large extent where more permanent periurban aquatic systems are located.

This constraint is now beginning to be addressed by the development of closed or recirculation aquatic production systems in a growing number of cities, although they exclude many potential fish farmers due to the high capital investments required to start up. These systems are still very much in their infancy in terms of food production and tend to be more commonly used for high-value species and also increasingly for ornamental fish production, as illustrated by Rana's article describing the emergence of Clarias (catfish) culture in recirculation systems in urban Lagos, and Hung's article describing the growing ornamental fish sector in Ho Chi Minh City.

Deteriorating surface and groundwater quality and also rising agrochemical use increasingly threaten the future of farming fish and aquatic vegetables in most developing cities. For urban aquaculture there is a conflict here, since increasingly intensive periurban production systems require more chemicals, pesticides and fertilisers to grow their aquatic vegetables and fish. If this trend continues and there is little effective monitoring and regulation, the resultant decline in urban water quality could bring about the eventual disappearance of these systems altogether.

Increasing contamination of domestic wastewater with industrial effluents is reducing production levels in a number of periurban aquatic systems. This also manifests itself in a reduction in quality of the product sold, e.g. water spinach produced using wastewater in the dry season in Phnom Penh is increasingly vulnerable to disease. As a result a significant proportion of this dry season crop is now sold as livestock feed.

The terms of access to land can also restrict the long-term sustainability of these systems. In Hanoi many of the city's fish farmers can obtain at most a 5-year lease for the ponds or wastewater-fed lakes they stock and harvest. These leases are often allocated through a closed auction system. Therefore these periurban fish farmers have no long-term security of tenure and as a result are less likely to invest capital in developing or even maintaining their own systems. Similarly, as illustrated in the case study from Phnom Penh, women renting plots for the cultivation of water spinach in the wastewater-fed Beung Cheung Ek Lake can be forced to move from their plots after a warning period of only two weeks.

Availability of another essential input resource, namely labour, was also found to be a considerable constraint for fish farmers in both Hanoi and HCMC (described on page 20)), especially around the time of harvesting when certain periurban communities had to import labour from other areas on the periphery of the cities to fulfill their needs. This is a good illustration of how labour markets develop through competition with urbanisation: the younger generations are more attracted to the increasingly varied and lucrative job market that a growing city offers and thus leave the cultivation of fish and aquatic vegetables to the older family members, many of whom were involved in farming during their formative years. This process tends to limit the level of innovation and subsequent uptake of new technologies, which could, if utilised, further increase yields and production of fish and aquatic vegetables.

## In this issue

William Leschen

**Harvesting tilapia in a wastewater fed lake in Yen So, Hanoi**

## PAPUSSA EXPERIENCES

The overall findings thus far from the PAPUSSA project have been qualified by both the considerable differences and some similarities between the four target cities. This allows us to comparatively analyse periurban aquatic systems in these cities and the communities involved in them.

Bangkok could be seen as the "model for development" for the other three, with HCMC and Hanoi already beginning to show similarities. The evolution and translocation of aquatic production systems from the inner metropolitan area to the expanding peripheries, in the case of Bangkok to its surrounding provinces, is already underway in HCMC and Hanoi, with the gradual upgrading of the cities' respective transport and road networks as well as the growing ownership of motor vehicles amongst its citizens allowing more flexible access to markets. This is illustrated by Edwards' article (page 27) and the article on Hanoi (page 10), which at first might appear contradictory. It is likely that land areas utilised for aquatic production systems have declined within Hanoi over the last five years, however there have been corresponding increases in aquaculture on the outskirts of the city. In the case of fish culture, more intensive, higher input systems are producing larger sizes of higher-value species (e.g. red tilapia), which the urban consumer is increasingly partial to.

Of the four PAPUSSA cities, Phnom Penh has the least developed infrastructure, making it much more dependent on local production of fresh foods. Other vegetables are scarcely available and the traditional livestock sector thus relies on aquatic vegetables produced using wastewater in Beung Cheung Ek Lake to be used as feed. The city's fish farming industry is well positioned to supply the growing markets in the area because plentiful feed is available (trash fish) from the Great Lake, as well as seed (fingerlings) from nearby Vietnam. The future of the considerable water spinach production in Beung Cheung Ek Lake and its associated treatment of the city's wastewater is uncertain due to many factors including deteriorating water quality in the lake caused by pollution and growing pressures from population growth in Phnom Penh.  The "illegal settler" status of most of those living around the lake can in the future allow the government to move them and redevelop this area for further industrial or residential development. To do this, however, the government would have to provide alternative methods for treatment of the city's wastewater which are both practical and comparable in cost to the present essentially low-cost biological filtration and treatment carried out by the lake.

The characterisations and delivery mechanisms of **wastewater** vary considerably among the cities studied. In Ho Chi Minh City the diffuse, tidal nature of the city's main wastewater canals differs from the more defined wastewater canals running north to south in Hanoi. Furthermore, in Hanoi fish and aquatic vegetable growers actively pump wastewater from the canals into their fishponds or fields. In Phnom Penh a large proportion (80%) of the city's wastewater is pumped into Beung Chueng Ek Lake. A number of communities located on the fringes of the lake make their living from culturing water spinach, which is a very popular edible aquatic vegetable. Water used in periurban Bangkok is derived from a series of irrigation canals, which contain both domestic and industrial wastes. Agrochemicals are now used quite intensively in many of Bangkok's aquatic vegetable production systems with studies showing that the resulting residues constitute a potential problem.

Initial **market surveys** were carried out in each of the cities in order to identify the major actors and channels for fish and aquatic vegetables. Some key findings are summarised in table 1. Bangkok has the most developed urban markets and related transport systems, with the increasing influence of supermarkets now also becoming apparent in Ho Chi Minh City and Hanoi. Adding value through packaging, presentation and certification, as well as food safety issues for aquatic products are becoming increasingly important for the urban consumer and as a consequence increasingly for those who produce them. There is also a premium associated with selling live fish and this remains the most common approach to selling fish at wholesale and many retail markets in all of the cities.

In all four of the cities the considerable demand for aquatic vegetables is met almost entirely by production in periurban areas. With the exception of Bangkok, these aquatic vegetables are being grown almost entirely using wastewater. Aquatic vegetables, particularly water spinach, can be commonly found as a daily constituent of urban people's diets in each of the four cities. Consumer surveys found that very few people have negative perceptions regarding the consumption of such aquatic vegetables produced using urban wastewater, whereas the situation regarding the consumption of fish within the cities was quite different, with most urban consumers interviewed in markets preferring to eat either marine or freshwater fish imported from outside areas. Periurban-produced fish, often cultured in wastewater, are generally consumed by lower-income urban consumers and sold directly to households or at street markets. This is probably due more to price and size considerations than preferences or availability.  Results from a survey conducted in Hanoi, which are backed up by Edward's article, showed that a significant percentage of periurban wastewater-produced fish were actually transported outside the city to nearby provinces. Although the rationale behind this is not entirely clear, urban consumers appear to have concerns about eating the relatively smaller fish produced in cities due to the use of wastewater and possible health risks associated with contamination in such systems This role of wastewater-cultured fish in feeding more distant populations reflects the increasing connectedness of urban and rural production.

Within all four PAPUSSA cities the relative success and value of the marketing of periurban wastewater-cultured vegetables compared to their fish counterparts can appear confusing, particularly if the same health and food safety perceptions are considered. We believe one reason for this difference is that the periurban farmers who produce large volumes of attractive, good-quality, fresh water spinach and other edible aquatic vegetables have little competition from provincial producers. Also the products themselves have a very short "shelf life" with freshness and quality being foremost in the minds and choices of urban consumers. Therefore distance and delivery time from production site to market is very important. Conversely, the increasing infrastructure of refrigerated, iced and oxygenated transport/ truck delivery of live or fresh fish ensures that the supply, variety and quality of fish entering urban markets is far more competitive. It is interesting to compare this with the situation in sub-Saharan Africa, as portrayed on page 36, where current market forces also very much restrict the growth of fish culture in the cities. The importation and subsequent popularity of plentiful supplies of frozen herring and mackerel at very low prices (US$ 0.40-0.60 /kg) make it very difficult for prospective periurban fish farmers to compete. As Rana explains, this price level may well influence the cost ceiling of any fish farming activity, and certainly those aiming at mass markets, making it necessary for prospective fish farmers to concentrate on more niche markets for either larger or live/fresh fish. Market forces in the PAPUSSA cities are also restricting periurban fish farmers since they are competing with not just the variety of marine and freshwater wild-caught fish but also growing production from the expanding fish farming sector in their provinces.

### Aquatic Vegetable (AV) Growers

- Lacking in formal or non-formal extension/training/technology transfer compared to periurban fish farmers
- Almost nonexistent voice in the urban planning process – uncertainty as to which government ministry or department is responsible for them
- Few signs of group/association formation to protect their own interests
- Some positive urban development plans (e.g. HCMC) have set aside areas on the periphery of the city for agriculture and aquatic plants

### Local Planners and District/ Commune Officials

- Some form of de-centralised administration in Bangkok metropolis, however this still doesn't give local officials much influence in planning process
- Most local officials have limited role of informing and providing statistics for higher centralised urban policy makers
- Increasing role of larger construction and real estate development in Hanoi and Phnom Penh – to a large extent this has already happened in Bangkok and HCMC
- Little planned integration of aquaculture into other urban water users' activities, e.g. leisure, city park lakes, angling

### Fish Farmers

- Extension and training better than for aquatic plant growers but they still suffer from Govt/NGO's greater interest and involvement in more commercially related aquaculture development in provincial areas
- Better representation at urban planning table through Fisheries Departments but overall still little influence
- Again poor group/trade association formation to protect interests or help in marketing – some positive signs of this in Bangkok

### Centralised Planners Policy Makers

- Lack information about the relative importance and benefits of urban-produced fish and aquatic vegetables to these communities, for job and income creation, for providing a localised food supply, creating a "greener" more attractive city whilst also recycling urban waste
- Limited provision for future development or even maintenance of urban fish and aquatic vegetable cultivation in previous City Development Plans. Policy of "zoning" being developed in periurban HCMC and to a lesser extent Hanoi
- Communication between main players in the urban planning process is demand driven from other more influential government ministries and outside stakeholders – political influences, construction/industry and real estate

Institutional analysis was carried out in each city to identify those institutions which were involved or related to periurban aquatic production systems. Understanding and being aware of these institutional characteristics, relationships and associated strengths and weaknesses is one step towards making a positive impact on the future of and potential for growing fish and aquatic vegetables in these cities. Findings from our institutional analyses in the four cities are summarised in the box on this page for the different stakeholder groups involved.

## FUTURE PERSPECTIVES

A number of aquatic producers were found to be exhibiting risk-aversion strategies in response to the changing environments in which they were living. In Bangkok and HCMC certain fish farmers have begun to produce ornamental fish, whilst hatchery producers in HCMC have also begun cultivating ornamental (house) plants for the growing market of urban consumers. In Hanoi seasonal rotation of different aquatic vegetable species have provided farmers with higher incomes and security from seasonal fluctuations in prices of the main crop (water spinach). Other successful aquatic vegetable producers in Hanoi have set up small-scale "backyard" electro-plating workshops producing kitchen utensils. Similarly in Phnom Penh, many women cultivating water spinach also run shops and stalls where they sell food and household items. For these farmers minimization of risk will ultimately affect their future livelihoods and also the future of the aquatic production systems they currently work in.

Perhaps here a case can be made for the relative advantage of aquatic vegetable production over fish in the periurban environment. Aquatic vegetables are far less vulnerable to theft and chemical contamination; generally more land efficient, involve lower entry costs and normally require lower value inputs. Cropping cycles are also shorter than for fish culture, eg water spinach farmers can harvest three full cropping cycles throughout the year. Fish cultured in periurban areas, as illustrated in Edwards' article, are highly vulnerable to contamination from polluted water, leading to fish kills and therefore subsequent loss of the farmers' investments.

Based on preliminary findings we could conclude that the disappearance of some systems in the four cities studied is inevitable due to urbanisation, a process which also involves the gradual shift of aquatic production systems to more geographically peripheral periurban areas. This conclusion mirrors experiences in other cities around the world, where agricultural production has been displaced in a similar way. However, this process should not be seen as inevitable. There is currently huge demand for aquatic vegetables within these cities, especially water spinach, which is virtually all produced in periurban areas often using wastewater as its main nutrient input. This relatively cheap input combined with the climatic/temperature regimes of these four cities (Hanoi to a lesser extent) and their proximity to ever-increasing markets give them a considerable comparative advantage in producing and selling large volumes of fish and aquatic vegetables all year round. Also these cities have the advantage of year-round availability of commercially important waste products (e.g. brewery and canteen wastes), which are currently used as lower-cost feed inputs for periurban fish production. The availability and use of these types of inputs is likely to increase as wastewater quality continues to deteriorate.

The future potential for growing both aquatic vegetables and fish using urban wastewater will depend on city planners' ability to coordinate and develop strategies for the effective separation of industrial waste effluents from domestic sewage. This separation is also desirable for other lower-income periurban households that rely on the cultivation of land vegetables, cut-flowers and crops using wastewater as their main, often only, source of water and nutrients. Implementing such strategies of wastewater management could prove quite problematic for larger cities where the existing infrastructure appears to be more inflexible to these changes. However, there are already encouraging examples in Hanoi and HCMC of relocation and zoning of urban industries into industrial parks which allow more effective treatment and monitoring of effluents. Perhaps this perceived constraint would have fewer implications for smaller, provincial cities which still have the flexibility and potential within their infrastructure to incorporate cost-effective, longer-term aquatic production systems into their development plans.

In the first year of PAPUSSA (2003) the project partners in each of the four cities produced an overview of the status of peri-urban Aquatic Food Production Systems (AFPS) in their city based on sources of data and information from:
1. an institutional analysis relating to AFPS at city, district and commune levels
2. a marketing survey carried out throughout fish and aquatic vegetable markets
3. participatory community appraisals (PCA) in different communes indicative for AFPS
4. a state of the systems (SOS) meeting to gather and validate opinions from stakeholder systems concerned.

The articles from Nigeria, Peru and Cuba illustrate the potential for the small-scale production of fish on a community, or even household level. The uptake of these systems in these areas is perhaps related mostly to differences in cultures and availability and access to water and land compared to the Asian cities studied. Small-scale systems such as those described by Afolabi, could be appropriate and cost effective for the citizens of certain southern Asian cities who have the initial capital to construct and maintain them. Perhaps more feasible and exciting is the potential for transferring the considerable knowledge, expertise and benefits in the large scale production of aquatic vegetables using wastewater from the four SE Asian study cities to their geographically and climactically similar sub-Saharan African and South/Central American counterpart cities. Whether this would be applicable would depend on a number of factors, most notably the nature and flexibility of their existing domestic wastewater removal systems to adapt, and the willingness of citizens to accept the production process and the crop itself.

Food safety for the consumer and occupational health risks for those working with wastewater also affects the future potential of growing fish and aquatic vegetables in cities. Studies on food safety/health carried out in urban communities in Phnom Penh are described by Van de Hoek, with particular reference to chronic skin problems observed amongst water spinach farmers working in the wastewater-fed Beung Cheung Ek Lake. The PAPUSSA project will also be assessing the risks to both consumers and those who work with wastewater, including an ongoing water sampling programme of inlets and outlets of different periurban aquatic production systems, which will also provide indications of the capacity of these systems for cost-effective wastewater treatment.

New guidelines from the World Health Organisation (WHO) for the safe use of domestic wastewater and excreta in aquaculture are due to be published shortly. Their main objective is the prevention of transmission of wastewater and excreta-related diseases (both from infectious agents and toxic chemicals) to farmers and their families, to local communities and to product consumers. These guidelines will be based on the development of "health-based targets" for certain levels of health protection in an exposed population. This level of health can be achieved by using a combination of management approaches, e.g. good aquaculture practice (GAP), produce restriction, human exposure control and microbial water quality targets. This approach is intended to lead to national standards and regulations that can readily be implemented and enforced, and that protect public health. More on these guidelines will be published in future issues of this magazine.

Although research studies on the future of urban agriculture have been far more numerous, recently there have been a number of publications on the potential of growing fish and aquatic vegetables in and on the outskirts of cities. It is important to ask why we are studying or projecting the future sustainability of periurban aquatic production. Is it as an aim or objective in itself? Or do we see it as a way to fulfill the growing requirement of food to feed the rapidly expanding urban populations as well as a system to re-use and treat the cities' wastewater? Our PAPUSSA studies and also evidence from markets in sub-Saharan Africa appear to indicate that marketing periurban-produced fish is not the only answer, as market forces are differentiating in favour of other outside sources of fish. It is also pertinent to ask who will be the periurban fish and aquatic vegetable farmers of the future if periurban aquaculture is to survive and fulfill an important role? Is it our objective to help (perhaps on more a community-based level) remove constraints for , lower-income city dwellers so that aquaculture can become or remain a significant income-earning activity for their families? Or should we be promoting periurban aquaculture on a more commercial basis, by encouraging entrepreneurs to farm fish or aquatic vegetables using the readily available inputs of wastewater supplemented with waste products such as brewery wastes or agrochemicals where appropriate? These farmers could gradually intensify their systems to maintain or increase profits whilst also modifying their production in order to sell an attractive product to the consumer which is healthy to eat. These are two quite different approaches with the drivers and research bases needed to develop them being radically opposed. In reality both of the scenarios are unfolding in the periurban environment, as demonstrated by our PAPUSSA household baseline survey. If one looks at comparisons between Bangkok and the other cities it can be seen how overall market forces, affecting not just aquatic products but equally importantly also urban land itself, develop and change the location and focus of periurban aquaculture as well as the livelihoods of the people living in the communities and those who have moved away, either by necessity or choice. Therefore being too focused on one particular group of stakeholders, e.g. the urban poor or conversely potential entrepreneurs who have the capital to develop such systems, is not a realistic approach in looking to the future. If one's objective for the future of periurban aquaculture is to include both groups then we should be looking more constructively into possible complementarities between the two groups rather than concentrating on their differences.

**Table 1. Key findings from market surveys relating to the marketing of fish and aquatic plants**
PAPUSSA Markey survey reports

| | Bangkok | HCMC | Hanoi | Phnom Penh |
|---|---|---|---|---|
| **Market transport** | Well developed, good transport network. Motorised- trucks and pick-ups. Well developed road network. | Aquatic vegetables/plants (AV) now transported more by smaller trucks. Fish bymotorbikes and trucks. | AV still largely transported bybicycle/motorbike. Fish mainly by motorbike and increasingly by smaller trucks. | Motorbike and bicycle. For aquatic plants, mainly by motorbike.For fish by some smaller trucks. Poorer road system outside city. |
| **Market infrastructure** | Large centralised wholesale markets supplying retailers. Increasing growth in supermarkets. | Well developed fish wholesale sector. Increasing supermarkets. | Construction of new wholesale markets. Urban street/retail markets causing increasing traffic congestion. | Distinction between wholesale and retail less clear |
| **Adding value/ packaging processing** | AV increasingly sold packaged. Fish still sold live. Also processing + packaging for supermarkets | Beginning to change with packaging for AV + influence of supermarketsector. | Fish markets still based on selling live fish. Aquatic vegetables sold fresh and unpackaged. | No packaging for AV – sold fresh. Some sold for livestock food. Some smoking of catfish but small market. Fish sold live/fresh. |

Finally, this century is already seeing increasing pressures on the availability of freshwater in many countries. The United Nations World Water Development Report (2003) estimated that by 2050 at worst 7 billion people in 60 countries will be considered water scarce, or at best 2 billion people in 48 countries. The Population Council predicts that world population will grow to 7.8 billion over the next 25 years, with most of this increase occurring in urban areas. The urban population will roughly double, to approximately 4.5 billion people within this time. After 2020, all population growth—and most poverty—in the developing world will be concentrated in urban areas, as rural populations decline.

Universal water supply and sanitation coverage by 2025—a now widely acknowledged goal—will mean that in urban areas an additional 1.9 billion people will need water and an additional 2.1 billion will need sanitation services. This projected urban water scarcity will inevitably increase competition and even conflict for all available water sources in cities. This future prospect demands that we develop sustainable systems which can re-use water more effectively whilst also producing safe, healthy food, providing income and employment and developing green and environmentally friendly cities.

This issue of UA Magazine presents PAPUSSA findings in conjunction with articles on periurban aquaculture from other cities and other continents to a broader non-aquaculture audience. Our findings show that more effort needs to be focused on those who are directly involved in the urban planning and development process, wastewater management, health care, marketing, food safety, environmental protection and the media. By presenting a multi-focal overview of the current and past situation in these four cities our aim is for these stakeholders to be better informed of the many diverse benefits as well as the associated problems of growing fish and aquatic vegetables in cities.

The main aquatic production systems referred to in this issue are the production of Chinese water spinach (Ipomoea aquatica Forsskal), also known as water morning glory, water convolvulus, swamp cabbage, swamp morning glory, and tropical spinach; water mimosa (Neptunia oleracea Lour.); water dropwort (Oenanthe stolonifera); water cress (Rorippa nasturtium-aquaticum); water lotus (Nelumbo nucifera) and different types of farmed fish including, among others, tilapia (Oreochromis niloticus), hybrid catfish (Clarias macrocephalus), pangasius (Pangasius bocourti/P. macrocephalus ), walking catfish (Clarias batrachus), common carp (Cyprinus carpio), giant guorami (Osphromenus gourami), grass carp (Ctenopharyngodon idellus), kissing gourami (Helostoma temmincki), silver barb (Puntius gonionotus), and snakeskin gourami (Trichogaster pectoralis). Since morning glory is sometimes used to describe a very different plant species, we think Ipomoea aquatica should be referred to wherever possible as water spinach.

Notes
1) The term aquatic vegetable is used throughout this issue to describe the edible green plants water spinach (*Ipomoea aquatica*) – commonly known as water morning glory –, water mimosa (*Neptunia oleracea*), watercress (*Rorippa nasturtium-aquaticum*) and water dropwort (*Oenanthe stolonifera*), which are grown in water.

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