The integration of chicken farms over large fish ponds benefits from the recycling of chicken droppings for fish pond fertilisation. In Myanmar, this system has been widely expanded and is delivering large amounts of freshwater fish (aside from chickens) to local consumers at affordable prices.
Photo: M. Prein

Can aquaculture help the hungry poor?

Aquaculture holds a big potential to satisfy the growing demand for aquatic food. Setting out from lessons learnt in past development projects, our author describes what fish farming systems must look like to fit the needs of smallholders and the environment.

Aquaculture, also known as fish farming, is the fastest growing sector in food production. In 2012, 66.6 million tons of fish was produced in aquaculture, which represents 42 per cent of total fish production world-wide. In the last three decades, farmed fish production, which can be either 'freshwater' or 'marine', has increased twelve times at an average annual growth of over eight per cent. With the levelling out of global wild fish catches, it is now widely agreed that the foreseeable future increase in demand for fish will have to be satisfied through aquaculture production. World aquaculture is heavily dominated by the Asia-Pacific region, which accounts for 89 per cent of production in terms of quantity and 77 per cent in terms of value. Today, in a number of countries in Asia, the supply of fish from aquaculture is larger than that from capture fisheries (e.g. over 80 per cent in the case of Bangladesh), with an increasing trend.

For developing countries, aside from wild-caught small pelagic marine fishes, freshwater fish play a major role for food security. The supply of the latter from inland water bodies, rivers and streams as well as floodplains is declining, while human populations are increasing. The resulting supply gap is partly being met by a growing aquaculture sector. But is farmed fish really the saviour of the hungry poor? Its contribution to global food security depends on where production occurs and what is being produced. The major species groups contributing to global production by aquaculture comprise marine fishes, at above five per cent, crustaceans at around 40 per cent, a majority of 60 to 80 per cent for diadromous fishes (e.g. salmon), molluscs and freshwater fishes, and aquatic plants (e.g. algae), in excess of 90 per cent. Obviously, small fisheries involving poorer people have hardly a role to play in many areas.

Pros and cons of the system

The development of aquaculture, particularly between 2000 and 2010, has resulted in lower fish prices. Aqua-

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culture has increased fish supply on the world market, while competition causes it to generally sell at lower prices than wild caught fish. For some species, e.g. tilapia, the production efficiencies and supply volumes have resulted in their prices being comparable to or even cheaper than chicken meat. Today, tilapia (originally of African origin) grown in large-scale aquaculture in China are available in remote markets in Africa (frozen, gutted, Hazard Analysis & Critical Control Points [HACCP] certified) at prices lower than those for local tilapias caught in rivers and lakes nearby.

While increasing fish availability at low price is beneficial for consumers, it can imply economic difficulties for fishers. Nevertheless, aquaculture has created an enormous labour market. Over the last 20 years, the global number of employees in aquaculture has been growing faster than average population growth. In 2013, aquaculture provided direct employment to 16 million people globally, compared to 38 million in capture fisheries.

Fish in aquaculture systems are very efficient converters of feed into protein and provide advantages over most terrestrial livestock systems. Aquaculture has a lower carbon footprint compared to other terrestrial animal production systems. Its contribution to global greenhouse gas emissions is rather insignificant, while agriculture contributes 10–12 per cent. Nitrogen and phosphorous emissions from aquaculture are much lower compared to beef and pork production systems, but slightly higher than those of poultry. Domestication is a major driver of rendering aquaculture production more efficient and lowering the sector's ecological footprint. The proportion of domesticated species will increase with improved efficiency and profitability.

There are two distinct sets of environmental concerns related to aquaculture, globally and locally. Globally, the increased demand for fishmeal and fish oil from so-called reduction fisheries as feed for aquaculture production has increased fishing pressure on wild stocks. Locally, discharges from farming sites, destruction of local habitat, and escapees and spreading of pathogens are causing more concern.

Making aquaculture work for small-scale producers – lessons learnt

Similar to the agricultural sector, for a long time, research in aquaculture with regard to development cooperation focused on developing more efficient systems in terms of costs, space, labour, hence to maximise outputs and revenues, e.g. fish per unit area (or volume). This development process started in the 1970s, including various steps of intensification: fertilisation of the water to enhance natural productivity, provision of feed, breeding varieties with better growth performance, improved disease control (e.g. biosecurity, vaccinations), moving from polycultures of several species to monocultures, managing water quality (e.g. bio-filters) and improved holding systems (e.g. net cages, closed recycling systems). However, all these innovations are highly complex. They demand a high level of technical skills and knowledge, investment and hence risks. As a result, their adoption by the usually poor small-scale farmers was impossible. However, aquaculture remained one of the best options to diversify smallholder production systems and to equally contribute to food security, particularly by providing protein and micronutrients.

Subsequent research revealed that targeting smallholders for the introduction of aquaculture requires the provision of production systems that are technically, operationally and financially feasible and are adapted to the current situation on the farm. Aquaculture must fit into the existing structure, e.g. a trench in a rice field, seasonally flooded crop production plains, or a small fish pond. It can also utilise fallow areas where floodplains used for rice cultivation are seasonally flooded. Traditional use of 'wild' fish that may occur can be significantly enhanced by introducing stocked fish resulting in more high-quality, nutrient-dense food fish production. The community based floodplain fish farming approach has been widely adopted and proved beneficial at the national level in Bangladesh, India and Myanmar.

Given the necessary preconditions (labour, land access, water supply, suitable soil and an appropriate topography), the aquaculture production system needs to be integrated according to the preferences, operational criteria as well as the social and economic context of the farmer. However, starting from the 1980s, only small numbers of such systems existed in Asia and practically none in Africa. In order to introduce such complex management to novices, a farmer-focused participatory approach and procedures were devised in the 1990s that promoted simple and robust aquaculture-specific operational rules and principles. As a result the aquaculture component started to succeed as an integrated component within existing farm environments and in compliance with the household's capabilities. Implementation of appropriate solutions usually began in small steps, following a gradual process of increasing productivity and building up of knowledge among farmers over several years. Scaling-up and incremental of successes were achieved by engaging novice aquafarmers in groups or clusters reinforcing each other, utilising elements of the Farmer Field School Approach for widespread aquaculture dissemination.

Benefits of this approach are the provision of fish to enrich the farmer family diet with animal protein and valuable micronutrients, as well as the fulfilment of social obligations such as providing meals to community labour (e.g. joint planting of rice fields, social events, etc.). Ponds and rice field trenches serve as "fish banks" for discretionary access, often far beyond the time that the fish attain their maximum size. Use is made according to market demand, price, customary or social situations.

Success factors: market access and certification

Initiatives in the introduction of aquaculture to subsistence smallholders in developing countries have a long history with mixed successes. These were limited to their introduction and promotion by NGOs and development initiatives, which in the end were costly per adopted farmer. Experience in both Africa and Asia led to the conclusion that a stronger market orientation leads to wider and faster growth and contribution of the sector to fish availability and income. Increased connectedness to and between markets is the major driver that either turned subsistence mixed farmers with a fish pond into market-oriented small aqua-farmers, or attracted outsiders to embark in aquaculture, e.g. 'aquapreneurs', particularly around urban areas (towns, cities). This change provides greater benefits to smallholder producers as well as poor consumers. For example, in Kenya, small and medium-sized farmers became such "aquapreneurs" by taking a market-oriented business approach. This was triggered by the doubling of fish prices from Lake Victoria as a result of a rise in local fish demand driven by population growth and the decline of fish catch from the lake. An on-going development cooperation project is focused on capacity development of farmer group leaders, farmer group formation, and training of trainers in fingerling and feed production as well as fish farm management.

The recognition of "Best Aquaculture Practice" and the introduction of environmental standards and certification (organic, Good Agricultural Practice [GlobalG.A.P.] and Aquaculture Stewardship Council [ASC]) promoted by government institutions or industry associations can lead to improved performance in terms of environmental, economic and food safety criteria at local and national levels. At the moment, these standards apply to species that are exported to markets notably in Europe and North America. Additionally, examples exist where aquaculture is also engaged in environmental (e.g. biodiversity) and climate change adaptation initiatives, such as in the mangrove areas along the Mekong Delta of Vietnam. Here, shrimp, crabs, molluscs and various fish species are cultivated in "silvi-aquaculture", i.e. integrated with mangrove conservation. This means aquaculture production sites are positioned seaward of the protection dikes for coastal zone management, enabling "wise use" of the resources, instead of entirely prohibiting human access and use.

While the process and requirements to meet sustainability standards ('Eco-labels') are more affordable by large export-oriented farms they can also be adapted to smallholder production systems under the "group certification" scheme. For this, the internal control system (ICS) is required such as that under the GlobalG.A.P. Type 2, or the Naturland organic aquaculture criteria. In the near future, the Aquaculture Stewardship Council (ASC) plans to release group certification criteria as a means to provide export opportunities to small aquaculture entrepreneurs otherwise oriented towards local markets. However, this scheme requires considerable efforts, including long-term support to succeed, usually from a company within the value chain. Group certification of smallholder organic aquaculture farmers has a history of just over ten years (see also article on page 18). The viability of the approach has been demonstrated, notably in shrimp farming (e.g. in Bangladesh, India and Vietnam). Experiences show that in some sectors, certified products can become a listed item in discounter shops (e.g. organic shrimp), whereas in others they may remain a niche item (e.g. organic pangasius from Vietnam).

Future challenges and potential

Aquaculture will intensify, diversify and expand. Production of all species groups (including seaweed) will increase. New species will appear in aquaculture, notably in those countries where wild catch of traditional species has declined and their cost to consumers has considerably increased. To achieve this, all environments will be increasingly utilised for aquaculture (e.g. water bodies, rivers, wetlands as well as all artificial impoundments and structures). For higher production volumes, more and more resources and inputs will be used in increasing quantities. However, improving efficiencies will also lead to reduced need for fish oil and fish meal as ingredients in formulated fish feed. More people will be involved in aquaculture production and value chains, providing employment and income,

Today, more than 80 per cent of fish consumed in Bangladesh comes from aquaculture, largely thanks to the wide availability of juvenile fish for stocking of ponds and enclosures from such small entrepreneurial operators of fish hatcheries and fish nurseries widely distributed in the rural areas.
Photo: M. Prein

but requiring capacity building, appropriate training for the required specialised and complex skills and experience. In this growing sector, more and more constraints will have to be faced too. Informed and responsible governance will need to steer these developments to ensure sustainability. New countries will become important producer nations, e.g. Myanmar and Brazil.

Development needs to be supported to supply growing markets, notably in Asia. Ninety per cent of this production growth will happen in developing countries through highly efficient and productive aquaculture production systems in a range of intensities that supply the growing and quickly urbanising Asian and also Western markets. In parallel, system development needs to continue targeting poorer small to medium-scale farmers contributing to food security and livelihood security in the rural context of developing countries.

Research is needed to enhance productivity as well as sustainability of aquaculture, both in small, medium and large-scale systems. Improvements are needed in health control and food safety, feed ingredients that do not directly compete with human foods, integration of aquaculture in agro-ecological models of production at farm and landscape levels and linkages with the food chain. Domestication allowing for genetic improvement of stocks in aquaculture will be a major driver of production efficiency, creating opportunities to lower the sector's ecological footprint.

The reliable supply of young fish "fingerlings" for stocking of fish ponds is the most important step in the establishment of an aquaculture "industry", followed by artificial feed supply.
Photo: M. Prein

Under the scenarios described above, the role for small – to medium-scale aquaculture producers will remain key to contributing to food and livelihood security in the context of developing countries. For instance, the Food and Agriculture Organization's Blue Growth Initiative (BGI) for Small Island Development States (SIDS) estimates that aquaculture can increase total fish production in the Caribbean island states by 30 per cent within ten years if essential investments are made, together with an enabling policy and legal frameworks and supported by applied research, capacity building and information provision.

Developing countries targeting export to industrialised countries will be increasingly faced with a growing range of demand criteria, i.e. certification or labels, price volatility and variability in quality standards in their supply chains. While the European market, driven by societal and economic values, continuously stipulates demanding criteria and standards, this trend may not yet be entirely replicated by other faster-growing markets, e.g. China, India, the Middle East, Russia, Mexico, Brazil, and South-East Asia, although there are trends to establish own national or regional labels and standards, e.g. ASEAN in Asia and the African Ecolabelling Mechanism in Africa.

Fish feeding – in competition with human consumption?

Up to 25 per cent of all wild-caught fish is processed into fishmeal and fish oil to feed carnivorous and omnivorous farmed fish and crustacean species (salmon, trout, tuna, shrimps and tilapia), poultry and other livestock. Fed aquaculture represents 69 per cent of global fish and crustacean aquaculture production. However, more strategic and efficient use, as well as the development and use of substitutes (vegetable protein and oil ingredients, waste from fish and animal production) caused global fish production used as fishmeal to decrease from an average 23 per cent (26 million tons/year) in the 1990s to 10 per cent in 2012 (16 million tons). Usage of fishmeal has switched from mainly pig and poultry feed to mainly aquafeed, and that of fish oil from mainly production of hydrogenated fats (for margarine) to aquafeed and direct human consumption as supplements (e.g. fish oil capsules). Low-trophic level species mostly farmed in developing countries use fewer supplementary feeds and fishmeal as compared to the higher trophic level species that are mainly supplying markets in industrialised countries. Continued technological improvement of formulated feeds utilising mainly non-fish protein and lipid sources is decreasing production costs. An impact on food security and nutrition would increasingly be achieved if small pelagic fish species caught for feed were sold on the local markets, particularly in Low-Income Food-Deficient Countries (LIFDC).

Why promote aquaculture?

Overall, reasons for development cooperation involvement in the introduction and spreading of aquaculture are that: (a) more fish is produced and supplied to markets at affordable prices, (b) leading to higher incomes of producers and to economic growth not only along the aquaculture value chain but also in ancillary sectors such as fingerling producers/hatcheries, feed producers, advisory services; (c) certification, at least initially, opens the door to premium-price markets, which helps improve the socioeconomic situation of the farmers; and (d) farmers can lead by successful examples to showcase that such an approach can be successful, earning them local appreciation and prestige. Additional benefits are that the ecosystem services of the natural system are maintained (i.e. non-disruption of ecosystem functions; reduction of external cost to a minimum) and that low input systems also equate to a low ecological footprint (carbon emission per product volume, low inputs for fertiliser, feed, etc.).