Chapter 17

Barriers to aquaculture development as a pathway to poverty alleviation and food security

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Abstract

The importance of aquaculture production in developing countries is reviewed briefly. Two sets of barriers to realizing the potential of aquaculture to alleviate poverty and improve food security and nutrition are identified: those directly attributable to aquaculture development policies and those arising from a lack of policy coherence for development (PCD). The latter applies to a wide range of sectors, the most important from an aquaculture perspective being energy, environment, agriculture and food production, and trade and sanitary standards. Lack of PCD is apparent at many levels: within development cooperation policies, between aid and non-aid policies within a single donor and between donors, and donor-partner coherence to achieve shared development objectives.

We conclude that development agencies can play a greater role in fostering the emergence of aquaculture as a means of alleviating poverty and improving food security and nutrition. This requires broadening the focus beyond poor producers to include small and medium aquaculture enterprises, adopting a value chain perspective on aquaculture development that fosters a "whole industry" approach that delivers key human development goals, and pursuing greater internal coherence within and between development policies. We also propose that development agencies promote mechanisms and interventions that redress policy imbalances by raising awareness among policy makers and through more integrated approaches to development assistance.

Introduction

Aquaculture addresses poverty and food insecurity through a variety of routes and at various scales. It offers a means for smallholder farmers to diversify production, thereby providing nutritious food for their own families, and sometimes those of their neighbours, while also generating surpluses for sale. Aquaculture enterprises from micro to large scale, providing fish exclusively for sale, create farm income and employment opportunities throughout the value chain and provide affordable, highly nutritious food in response to market demand.

While the development benefits from aquaculture are increasingly understood in development circles, the key question remains: where and in what circumstances is aquaculture the most appropriate option to improve livelihoods, foster economic development and improve food security and nutrition? Equally there is uncertainty as to how aquaculture can minimize impact on the environment, and where other policy investments are needed to foster aquaculture output and optimize its development benefits.

The present paper considers these issues and explains the importance of the aquaculture sector in developing countries. We consider how aquaculture contributes to poverty alleviation and food security and nutrition and review the sector's consumption of, and contribution to, ecosystem services. We analyze how aquaculture affects vulnerability and consider how development policies that focus on smallholder producers limit the potential of the sector to alleviate poverty and improve food security. We examine the coherence of OECD policies on energy, environment, trade and sanitary and phytosanitary standards with those on development, and examine how they can compound external shocks to increase vulnerability of the global poor and the ecological services upon which they depend.

Aquaculture in the developing world

Introduction

Fish provides an important source of protein (>20% animal protein) for 2.6 billion people worldwide and is the dominant source of animal protein in many small island developing states, Bangladesh, Cambodia, Equatorial Guinea, French Guiana, the Gambia, Ghana, Indonesia and Sierra Leone (FAO, 2009). More importantly, it is a rich and highly bioavailable source of much-needed micronutrients and vitamins. Provisional FAO statistics for 2008 show that aquaculture now supplies almost half of all fish consumed. While capture fisheries production has stabilized at around 95 million tonnes for the past 20 years, aquaculture production has grown at an average rate of 7% per annum, ahead of world population growth. Preliminary data for 2008 from the FAO indicate that 53.3 million tonnes was produced, a 6% increase on production in 2007. Farm gate value is estimated at USD 81 billion, but two-three times this figure from a value chain perspective.

The developing world accounts for the vast majority of global aquaculture production and increasingly is a producer of fish for the developed world. Ninety percent of global aquaculture production is from Asia, 67% from China alone. An increasing proportion of

Asian aquaculture production is traded both regionally and internationally, especially with Europe and North America. Three commodities in particular are worthy of note: tropical penaeid shrimp (predominantly *Penaeus monodon* and *P. stylirostris*), Mekong catfish (*Pangasius* spp.) and tilapia (*Oreochromis* spp.). Annual shrimp sales alone are worth an estimated USD 18 billion at farm gate. The Vietnamese striped catfish (*Pangasionodon hypophthalmus*) industry is the fastest growing single species farmed commodity ever recorded and today produces close to 700 000 tonnes, generating an estimated USD 645 million at farm gate values (Phan *et al.*, 2010). Ninety percent of the fish is processed and, trading under a plethora of names, striped catfish has rapidly penetrated markets throughout the developed world, especially in Europe, as an affordable and acceptable substitute for the depleted stocks of marine white fish formally supplied by domestic fisheries.

In contrast, there is little aquaculture production in Africa (775 500 t), the bulk of which (635 000 t) comes from Egypt where the indigenous Nile tilapia is the most important species. Aquaculture production in Africa is, however, now growing rapidly, albeit from a very low baseline. Five of the ten countries with the most rapid rates of production increase are African: Uganda, Mozambique, Malawi, Togo and Nigeria (FAO, 2009). Domestic markets are strong, and negligible amounts of African aquaculture production are traded outside the region (Gordon 2009; Bené *et al.*, 2010). Nonetheless, per capita fish consumption in sub-Saharan Africa remains the World's lowest through a combination of population growth, stagnating capture fisheries supplies and slow regional growth in aquaculture production, compounded by increasing world fish prices that constrain imports.

The bulk of developing world aquaculture is of herbivores and omnivores, in contrast to the intensive production of carnivorous marine finfish that dominates developed world aquaculture (Tacon *et al*., 2010). There is also an enormous diversity of producer types in developing country aquaculture. Smallholder 'subsistence' type fish farmers raise crops of fish in ponds on their farms. Production volumes tend to be low, a result of both small pond size and low productivity, the latter arising through dependence on on-farm (farm wastes), sometimes augmented with off-farm (inorganic fertilizers, manures from intensive agriculture and feeds) resources. The term small and medium aquaculture enterprises (aquaculture SMEs) is applied to a wide range of producer types that produce fish and other aquatic products for sale. The smallest enterprises may generate income from aquaculture as one component of a household livelihood strategy, but many small and medium enterprises are characterized by livelihoods largely dependent on aquaculture. SME production is typically semi-intensive, reliant on fertilizer and/or feed, with production levels between 1 and 100 tonnes per farm per annum. Larger, commercial aquaculture operations, which may produce as much as several thousand tonnes per annum, remain relatively uncommon in developing countries, other than in the Mekong delta of Vietnam. They are generally multinational operations, often targeting multiples in regional and international markets.

The FAO estimates that there are some nine million fish farmers (FAO, 2009), a figure widely acknowledged as a considerable underestimate. The aquaculture value chain comprises producers, those who supply inputs (*e.g* seed, fertilizers and feed) to producers and those engaged in downstream processing, distribution, marketing and trade of aquaculture produce. Although data are scant the numbers employed throughout the aquaculture value chain often exceed those directly involved in production by a factor of two or three. Employment opportunities are provided for a wide variety of actors including many women, the landless and the socially and culturally marginalized.

Aquaculture, ecosystem services and poverty

Aquaculture and ecosystem services

Aquatic foods - plants, shellfish and fish - obtained via hunting (collecting, trapping, fishing) and farming (aquaculture) are one of the most important provisioning ecosystem services derived from aquatic ecosystems - coastal areas, estuaries, lakes, rivers and wetlands (Béné *et al.*, 2010b). While some forms of aquaculture, especially of seaweed and molluscs, provide both food and supporting ecosystem services through the removal of anthropogenically generated nutrients (Soto *et al.*, 2009), the farming of fish and shrimp is dependent upon use of a wide range of provisioning and regulating ecosystem services - land, water, seed, feed and the dispersion and assimilation of wastes, including escaped farmed organisms (Beveridge *et al.*, 1997; Soto, 2009; Béné *et al.*, 2010a). At the farm level, consumption of ecosystem services is largely determined by species, system and intensity of production methods. While land and water use per unit production decreases with intensity of production methods, demand for seed, feed, energy and the use of ecosystem services to disperse and assimilate wastes tends to increase. Attempts to address these issues include policies to promote 'integrated multi-trophic aquaculture', where seaweed, molluscs and occasionally echinoderms are farmed alongside finfish.

While aquaculture can thus make significant contributions to reducing poverty and improving food security and nutrition, it does so at the cost of the ecosystem services consumed. Certain types of aquaculture are particularly heavy users of ecosystem services and therefore need particular care in their planning, design and operation. For example, conversion of mangroves and sea grass beds for aquaculture use should be avoided as they provide a wide range of ecological services, including the sequestration of carbon (Beveridge *et al.*, 2010). Cage aquaculture depends on the use of common property resources – lakes and coastal areas - and, per quantity of fish production, makes greatest use of certain types of ecosystem services (food; waste dispersion and assimilation) (Beveridge, 2004). Good governance, appropriate legal frameworks, strong institutions with good institutional capacity and the adoption of adaptive management are all essential to the sustainable use of such services and the equitable share of benefits from this type of aquaculture. Intensification of production methods is essential to achieving more productive use of land and water (*e.g.* Verreth *et al.*, 2008) but will also increase consumption of other ecosystem services, both provisioning (notably aquaculture feeds) and supportive (the dispersion and assimilation of nutrients and other wastes). Analyses of various types of aquaculture show that energy consumption, and thus global warming potential, is most strongly associated with feed use, especially when feeds are from outside the production area, and with up-stream post-harvest processing and distribution (Tyedmers, 2009; Henrikksen, 2009). Nonetheless, the linkages between different types of aquaculture production systems, value chains, and ecosystem services remain poorly defined and understood, contributing to the lack of policy coherence.

Poverty, vulnerability and aquaculture

One of the most important dimensions of poverty is the ability of individuals and communities to respond effectively to external shocks such as climate change and globalisation of markets. Resilience in the face of external shocks is dependent on both the degree of exposure to such shocks and the adaptive capacity of individuals and

communities. A vulnerability framework is useful in examining both potential and realized vulnerability at a range of scales. Individuals whose livelihoods are most exposed to climate change, for example who live in low-lying coastal areas and work as aquaculture labourers, and who are particularly sensitive to impacts through their dependence on aquaculture, are potentially most vulnerable. However, if those who are potentially most impacted through exposure and sensitivity are also young, have had a reasonable education, belong to well-organized producer organizations and are supported by strong institutions with sound policies, then they are more likely to be able to adapt to the impacts of external shocks than those who lack such adaptive capacity (Beveridge *et al.*, 2010). Development investments – including in aquaculture - that reduce exposure to shocks, reduce sensitivity and build adaptive capacity are increasingly seen as key components in effective approaches to reducing poverty. This requires an approach to aquaculture that goes beyond investment in production to investments in better policies, institutional support and services necessary to build adaptive capacity, particularly when exposing producers to the increased risks associated with international markets.

Aquaculture and development

Introduction

For a decade the Millennium Development Goals (MDGs) have provided an agreed international focus for national governments, development agencies, NGOs and private philanthropic organizations in their efforts to reduce global poverty and hunger. There has been no consensus on how to achieve this, however, and some sectors have received less attention. The share of agriculture in overseas development assistance declined from a high of 18% in 1979 to 3.5% in 2004. It also declined in absolute terms, from a high of approximately $8 billion (2004 USD) to $3.4 billion in 2004 (World Bank 2007). Only relatively recently, spurred in particular by the World Development Report (World Bank 2007) and rapidly escalating fuel and food commodity prices during 2007-2009, has greater focus been placed on agriculture and food production.

Within this evolving development arena and only recent resurgence in attention to agriculture, aquaculture has had a particular history. This has differed between Africa and Asia. As reflected by the current levels of production, 53.3 million tonnes in Asia and 775 500 tonnes in Africa, aquaculture has been spectacularly successful in Asia, but not so in Africa. The poor performance of aquaculture in Africa has resulted in little investment in the sector in recent years. This is beginning to change, however, in response to the growing gap between fish demand and supply and emerging signs that many of the historical constraints to aquaculture development can be overcome. The following section examines the case for aquaculture development investment. We do so by first examining experiences from Africa, the continent that has so far faced the hardest challenges, but where potential is seen as being greatest. In doing so we compare the development case for investment in small-holder aquaculture with its direct impact on poor producers, and investment in SME where many fewer people are engaged in production but where the impact on food security and nutrition at national and regional levels are likely to be greater.

Aquaculture in Africa

Since the late 1980s there have been a variety of donor investments in smallholder aquaculture in sub-Saharan Africa. Notable among these are the investments made by GTZ/BMZ (Germany), USAID, CIRAD (France), DFID (UK), SIDA (Sweden) and NORAD (Norway). The WorldFish Center, among others, has used such investments to work with farmers and NGOs through farmer-scientist research partnerships to pursue the development of smallholder-based aquaculture in Cameroon, Ghana and Malawi as a primary focus of efforts to foster the emergence of African aquaculture as an approach to reducing poverty and hunger.

A central conclusion from these investments is that adoption of fish farming by smallholders has produced many benefits. The farm pond assumes a central importance in integrated smallholder systems generating not only crops of fish but also offering additional flexibility to farmers to use the water for alternative crops or for irrigation and household needs if rains are late or smaller than expected (Miller, 2009). *Ex-post* analysis of the development and dissemination of small-scale integrated aquaculture in Malawi (Brummett and Williams, 2000; Dey *et al.*, 2007, 2010; Poumogne and Pemsl, 2008; Russell *et al.*, 2008), for example has shown that:

- total farm productivity improved by 10%;
- per hectare farm income increased by 134%;
- total farm income increased by 61%;
- technical efficiency improved by 40%;
- per capita household consumption of fresh (208%) and dried fish (21%) increased.

There are also positive impacts on the environment: reduced nitrogen loss and improved nitrogen use efficiency (Dey *et al.*, 2007, 2010).

In sum, where input and output markets are weak, but environmental conditions and on-farm resources for aquaculture are adequate, the development of farm ponds as means of diversifying and improving farm productivity has proved successful. The numbers of smallholders practicing aquaculture in southern Malawi, for example, has risen from 300 to 7 000 over the past 25 years (Russell *et al.*, 2008). Because individual farm production is low, this type of subsistence oriented smallholder aquaculture has had little discernible impact on national food fish supplies, but it has had a substantial impact on food security and nutrition of participating smallholders and has helped build the resilience of farmers in times of drought.

There are thus substantial benefits for agriculture households to be gained from integrating fish ponds into agriculture farming systems. To contribute substantially to food supplies and nutrition, this form of aquaculture needs to be widely replicated among the farming population, or intensification is required. Intensification needs to be supported by the development and dissemination of improved pond production technologies, improved seed and feed and provision of effective extension. Smallholder farmers in Africa do not, however, have the resources to pay for these inputs and their sustained provision requires long-term subsidies, especially in terms of technical support (Brummett *et al.*, 2008, 2010). We believe, however, that this can be an appropriate development investment in support of small farm producers, complementing social

protection policies such as food for education that helps improve nutrition, protect people against risks and vulnerability, and mitigates against the impact of shocks and supports people with few alternative means of livelihood diversification.

Analysis of performance success in Egypt, Cameroon, Ghana, Nigeria and Uganda shows that fish production begins to significantly impact on food security where conditions support the emergence of small and medium-scale aquaculture enterprises with a more commercial market-led orientation (Brummett *et al.*, 2008, 2010). Where market demand is strong and accessible, such as near centres of high population density, and where the required technologies and expertise have been available entrepreneurial farmers have seized opportunities to specialize in fish production. For example, in the areas where WorldFish has been working in southern Cameroon the number of commercial farms has increased in peri-urban areas. Many of these are new adopters seeking to replicate the success of the minority of project participants who succeeded to commercialize their farms through integrated agriculture-aquaculture.

This experience has shown that the SME sector is more likely to have the assets (educational and health; cash or access to credit to invest in larger ponds and use of off-farm resources, especially seed, fertilizers and feed) to develop and adopt the more productive and profitable technologies. Greater quantities of fish are produced and production is primarily market oriented. Opportunities are thus created for employment not only in production but also in supplying input markets (especially seed), trading and transport in addition to the benefits to poor consumers secured through stabilization of fish prices. As Brummett *et al.* (2008, 2010) have shown in Cameroon, providing public investment to SME aquaculture producers generates more income and food per development dollar invested, and when projects end they are better able to continue to grow, proliferate and generate jobs and food throughout the value chain, ultimately stabilizing fish prices for the benefit of lower income consumers.

Aquaculture in Asia

There is a long tradition of farming herbivorous and omnivorous carps in Asia, especially in wetland areas (Beveridge and Little, 2002). Despite this, aquaculture production was largely only of local importance until the 1970s. Since then growth in production has been substantial, often exceeding 10% annually, and the region now contributes 90% of global production.

As with the green revolution in Asia in the 1960s that was led by smallholders, so has much of the increase in aquaculture production. Growth was spurred by a number of factors: strong and growing demand from rapidly urbanizing populations, stagnating fish and shellfish supplies from fisheries, highly productive farms, availability of fast growing strains of fish such as genetically improved farm tilapia (GIFT) (Asian Development Bank, 2005), investment in education and research, a dynamic private sector, and high levels of public investment in agriculture and in roads needed to get farm produce to market. The past 15 years has also seen the emergence of a vibrant SME aquaculture sector in many Asian countries, especially in China, Vietnam, Thailand, Indonesia and the Philippines. This SME sector targets not only local, national and regional markets but, increasingly, international markets.

In Bangladesh, agriculture is dominated by small and marginal farms. Nonetheless, aquaculture production has risen almost five-fold in 20 years, from 337 818 tonnes in 1988 to 1 612 969 tonnes in 2007 (FAO, 2009). Aquaculture now accounts for two-thirds

of fish production, all of which comes from freshwater farms, most of which are operated by smallholders. Fishponds largely originated as borrow pits, excavated to raise homesteads above flood levels. Growth in production has come from an increase in number of aquaculture farmers and improvements in individual farm productivity. This has been achieved through the involvement of public and private sectors and civil society which have driven increases in stocking densities, increased fertilizer and feed use and better management. The impacts of extension are illustrated by the study of Jahan *et al.* (2008). As the result of a five-year USAID funded aquaculture development project, productivity of farms receiving NGO-led provision of technical advice increased by 25% per annum compared to less than 4% per annum for non-project farmers.

Aquaculture and policy coherence for development

Introduction

Fish is one of the most widely traded commodities, and trade from the developing world to the developed is increasing in both volume and in value. OECD member states import 60% of their fish from developing countries (OECD, 2008). South-North trade not only responds to consumer demand but also to the growing requirement for fish oil and fishmeal for intensive fish farming, especially for farmed Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) in Western Europe and North America, and sea bass (*Dicentrarchus labrax*) and sea bream (*Pagrus major*) in the Mediterranean. While globalisation underlies much of the policy discussion on fisheries and aquaculture, there remain significant challenges in understanding, gauging and developing appropriate policy responses (OECD/FAO, 2007). Foremost are how best to address concerns about food security, food safety and public health, and potential conflicts with domestic economic policy in developed countries. Increasingly, too, concerns over impacts of trade on internationally agreed targets on limiting greenhouse gas emissions, can be expected to influence policy.

Policy Cohesion for Development, defined by the OECD as 'the pursuit of development objectives through the systematic promotion of mutually reinforcing policy actions on the part of both [developed] and developing countries', is one of the MDGs. Development cannot occur through aid alone: globalisation and liberalization increase the gains from interdependence and integration, while lack of PCD has an economic cost both for the global poor and for taxpayers in the developed world. The importance of fisheries in PCD is explicitly recognized in OECD documents (OECD, 2006, www.oecd.org/dataoecd/41/0/41412053.pdf). However, the pursuit of domestic policies, both with regard to aquaculture and to cross-sectoral issues such as environment, energy and consumer protection, can result in a lack of coherence towards development. Key policy sectors and questions to be considered are summarized in Table 17.1.

Table 17.1: Key cross-sectoral policy areas and issues pertaining to aquaculture

Policy area	Issues
Domestic economies and trade	What are the risks associated with an increasing reliance on aquaculture and can the sector absorb growing demand? How much of domestic demand should policy makers accept being met from developing countries and what proportion of the value added throughout the value chains should policies facilitate in domestic as opposed to developing economies?
Sanitary and phytosanitary standards	What are the public health risks associated with aquaculture and with developing country aquaculture in particular? What policies must be implemented and by whom and where to ensure sanitary standards for import of farmed fish and shellfish are met?
Environment	What ecosystem services are consumed by the different types of aquaculture production systems and value chains? What policies both minimize use of ecosystem services and foster equitable use?
Energy	How energy efficient are the different fisheries and aquaculture sub-sectors? What is the effect on global warming potential - and more specifically on national targets - of international trade of fish from different parts of the world and what policies are needed to minimize these whilst maintaining essential commodity supplies?

Sanitary and phytosanitary standards

Trade in aquaculture products is subject to stringent sanitary and pohytosanitary standards with regard to food hygiene, packing traceability and labeling (OECD, 2008). The food safety issues associated with aquaculture products and trade have been reviewed by the WHO and others (WHO, 1999; Jahnke *et al.*, 2002). International standards are developed through CODEX but there are an increasing number of other mandatory and voluntary (public and private) standards being developed. While there are legitimate concerns, these can be unnecessarily protectionist. Private standards are often driven by consumer demands but also to sustain retailers own brands, which may have higher margins (OECD, 2008). Developing countries are concerned about access to information on standards, predictability, transparency and lack of involvement in standards setting, and insufficient funds and knowledge to comply with standards and implement traceability processes. Private production standards for many important aquaculture sub-sectors, such as tilapia, catfish and shrimp, are being developed, but there are fears that the plethora of emerging standards will confuse consumers. There are also concerns about the clarity and stability of standards, and the costs and capacity of developing countries to conform with, in particular, a concern that small, poor producers are particularly disadvantaged by such standards.

Domestic economies and trade

Developed country fisheries catches have stagnated or declined at the same time as demand has been growing due to increasing wealth and changing consumer preferences (FAO 2007; Ernst & Young 2008). The strategy launched in 2002 to help meet demand and engender economic growth and employment by implementing policies to foster growth of domestic production in Europe by 4% per annum (European Commission,

2002), however, has failed (Eurostat, 2007) due to increased competition, the success of substitution products (*e.g.* striped catfish for marine white fish), reduced profit margins, higher investment risks, sector fragmentation, lack of sites for expansion, poor image and increasingly stringent environmental and health regulations. As a result fish imports, which until recently have largely excluded value added products, increased three-fold between 2002 and 2007 (Ernst and Young, 2008).

In 2009, the EC launched a new strategy for the development of a sustainable aquaculture industry: to promote its competitiveness, to establish conditions for sustainable growth and to improve the sectors organization and governance (European Commission, 2009). If successful, and there are those that question how the strategy can be implemented in the face of ever stricter environmental policies, notably the Water Framework Directive, the policy will also likely have adverse impacts on fish imports from developing country aquaculture. What might be better for both exporting and importing counties would be to encourage stronger partnerships across value chains for aquaculture products, and communication and cooperation that explores and brings mutual benefits to producers and consumers, such as is promoted by the Asia-Europe Meeting (ASEM) aquaculture platform: http://www.asemaquaculture.org/content/view/2/5/

Energy

There have been several recent analyses of impact of aquaculture on climate change (*e.g.* Tyedmers, 2009). Henriksson (2009) examined the global warming potential (kg CO_2 tonne production^{-1}) of Asian aquaculture. Confining his analyses to up-stream and on-farm processes, the GWP of shrimp and fish culture was found to be greater than that of oyster farming, while the GWP of extensive fish farming was less than that associated with more intensive aquaculture practices. For shrimp and fish culture the greatest GWP was generally linked with feed use; the exception was for intensive *Pangasius* catfish farming systems in the lower Mekong, where pumping accounted for the greatest proportion of GWP. Extending the boundaries of such analyses is likely to also highlight the importance of not releasing carbon already locked in storage materials such as mangroves when seeking areas for sectoral expansion. Large quantities of carbon are also sequestered in fishpond muds (Bunting *et al.*, 2007). Releases to the atmosphere can probably be greatly reduced through the development of polyculture or use of sediments in crop and vegetable production.

There is also increasing interest in the high transport mileage, and thus high energy use and global warming potential, when importing aquaculture produce from developing countries. However, research is needed on the energy and ecosystem services costs of aquaculture in different parts of the world and policies must strive to balance concerns about climate change with the need for countries to be able to trade their way out of poverty.

Conclusions

Aquaculture has grown dramatically in recent decades to become a major provider of fish and other aquatic foods. The greatest increases in production have been in the developing world, which now supplies not only much of its own demand but also that of the developed world. However sectoral growth has been very uneven, with Asia (including China) producing some 45 million tonnes per annum, and Africa producing

less than 0.2% of this amount. The relatively poor performance of African aquaculture has been caused by a number of factors, among them the different market conditions in Africa, but also the externally driven focus on smallholder aquaculture. While this has proved successful in building resilience of poor smallholder farmers to external shocks through improving household nutrition, building social capital (through exchange of fish within communities) and reducing sensitivity to periodic drought, it has not led to significant growth in production at national or continental levels. Rather, current evidence indicates that significant increases in farmed fish production in Africa are most likely to be achieved through careful investment in well targeted value-chain approaches to the development of the SME aquaculture sector in places where this can respond to strong markets and harness the potential of an emerging private sector. In this sectoral context smallholder aquaculture still has an important place, but should be pursued where it provides a viable crop alternative for improving livelihoods of poor smallholders and improving on-farm resource use efficiency. It is unlikely to be a viable approach for increased fish production at national levels.

The importance of aquaculture, and the need for a more holistic approach to its development, is now acknowledged by a number of African countries, as seen in the development of national strategies and in the plans of regional and sub-regional research and development organizations. Although fisheries and aquaculture were something of an afterthought in the CAADP (Comprehensive Africa Agriculture Development Programme), their potential role in achieving the 6% growth annual growth target is recognized through the new Partnership for African Fisheries (PAF) (www.caadp.net/news/?p=133) and elsewhere. The development community has a major opportunity to build on this through the promotion of aquaculture in those countries where market conditions now favour development of the SME sector.

The sustainable growth of aquaculture for poverty reduction and improved food security and nutrition in developing countries needs coherent, mutually supportive policies across a wide range of economic, social and environmental issues. Both national and donor communities have roles to play. To create a favourable investment climate, developing countries must continue to improve governance, promote transparency, accountability, effective user rights and tackle corruption (OECD 2008). Aquaculture will not flourish everywhere but where prospects seem good and where the benefits appear attractive, countries should facilitate dialogue among policy makers, stakeholders, civil society and consumers to assess the prospects for the sector to contribute to meeting MDGs and to resolve trade-offs with other economic sectors and with environmental requirements. National strategies and sectoral plans help establish clear sectoral goals but must be developed within a broad economic, social and environmental policy context. Strategies and plans should focus on addressing key challenges to sectoral growth but are of no value if the resources or political will for implementation are lacking.

For their part, development agencies need to continue to strive for PCD. They must understand the likely development benefits from different types of aquaculture, the economic, social and institutional realities of the countries with which they engage, and the effectiveness and cost-effectiveness of different types of intervention. In any such analysis, the present focus on producers must enlarge to consider the entire value chain, the impacts on ecosystem services and the policy and institutional environment needed for sustainable development of the sector. Investment in training and capacity building is needed with a view to developing technologies to meet local needs, and institutions strengthened so as to develop and implement supportive policies. World Trade Organization and OECD policies make it tough for developing country aquaculture

produce, especially from small producers, to enter international markets (Umesh *et al*., 2009). Producers need stability in standards, which must also be clearly communicated. Support is often needed to help meet standards. Some sub-sectors, such as the Vietnamese striped catfish industry, have secured access through investments from government and international development agencies as well as the private sector. A lack of investment hampers others, however. Bangladesh, for example, currently faces constraints on export of farmed freshwater prawns and shrimp to the EU due to concerns related to chemical contamination of products, which it finds difficult to resolve without technical expertise.

There remain concerns that unconstrained expansion of aquaculture, combined with intensification of production methods and demands on ecosystem services, may have undesirable impacts on poverty. While existing approaches such as Life Cycle Analysis help identify and quantify some of the environmental impacts, a wider suite of tools, such as vulnerability frameworks and those being developed in support of the emergent Ecosystem Approach to Aquaculture, are needed to determine and manage both social and ecological impacts, essential for sustainable growth of the sector (Soto *et al.*, 2009). These novel approaches need to be applied more widely and lessons drawn from their strengths and weaknesses. Only by doing so will aquaculture realise its full potential to increase fish production in ways that strengthen livelihoods and national economies in ways that are sustainable.

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