Alleviating poverty through aquaculture: progress, opportunities and improvements

Expert Panel Review 6.2

David C. Little[1 (*)], Benoy K. Barman[2], Ben Belton[2], Malcolm C. Beveridge[3], Simon J. Bush[4], Lionel Dabaddie[5], Harvey Demaine[6], Peter Edwards[5], M. Mahfujul Haque[7], Ghulam Kibria[8], Ernesto Morales[9], Francis J. Murray[1], William A. Leschen[1], M.C. Nandeesha[10], and Fatuchri Sukadi[11]

1 Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA. E-mail: UK.dcl1@stir.ac.uk ; fjm3@stir.ac.uk ; wl2@stir.ac.uk
2 The WorldFish Center, Bangladesh and South Asia Office, House 22b, Road 7, Block, F, Dhaka 1213. E-mail: b.belton@cgxchange.org
3 WorldFish Center, PO Box 51289 Ridgeway,Lusaka, Zambia. E-mail: M.Beveridge@cgiar.org
4 Environmental Policy Group, Wageningen University, P.O. Box 8130, 6700 EW, The Netherlands. E-mail: simon.bush@wur.nl
5 Aquaculture and Aquatic Resource Management, Asian Institute of Technology, Klong Luang, Pathum Thani, 12121, Thailand. E-mail: pedwards1943@gmail.com
6 Regional Fisheries and Livestock Development Project, Noakhali Component, Agricultural Sector Programme Support Danida, Bangladesh. E-mail: hdemaine@yahoo.com
7 Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh. E-mail: mmhaque1974@yahoo.com
8 Ministry of Fisheries and Marine Resources (MFMR), Windhoek, Namibia. E-mail: kibriamg@mfmr.gov.na ; ghulam.kib@gmail.com
9 Sustainable Fisheries Partnership, 4348 Waialae Ave.692, Honolulu, HI 96816 USA. E-mail: jack.morales@sustainablefish.org
10 Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Tuticorin-6289008, Tamil Nadu, India. E-mail: mcnraju@yahoo.com
11 Research Center For Aquaculture. Jalan Ragunan No, 20 Jati Padang Pasr Minggu, Jakarta. 12540 Indonesia. E-mail: fatuchri_sukadi@yahoo.com

Little, D.C., Barman, B.K., Belton, B., Beveridge, M.C., Bush, S.J., Dabaddie, L., Demaine, H., Edwards, P., Haque, M.M., Kibria, G., Morales, E., Murray, F.J., Leschen, W.A., Nandeesha, M.C., & Sukadi, F. 2012. Alleviating poverty through aquaculture: progress, opportunities and improvements, In R.P. Subasinghe, J.R. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mohan & P. Sorgeloos, eds. Farming the Waters for People and Food. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. 22–25 September 2010. pp. 719–783. FAO, Rome and NACA, Bangkok.

Abstract

Significant changes in our understanding of the interrelationships between aquaculture and poverty have occurred in the last decade. In particular, there is a growing realization that the impacts of aquaculture need to be assessed from a

* Corresponding author: d.c.little@stir.ac.uk

value-chain perspective rather than through a narrow production focus. In recent years, understandings of poverty and the forms, outcomes and importance of aquaculture have also shifted. Terms in current use are first clarified, including those related to scale and location of aquaculture. The evolution of aquaculture from traditional to modern forms and its role as a central feature or more secondary part of household livelihoods are considered. Definitions of poverty and resilience and the potential roles of aquaculture in supporting poorer people are discussed in the light of recent research. The role and impacts of targeted interventions to support poverty alleviation are discussed and the potential negative impacts of aquaculture on poor peoples' livelihoods are presented. The concept of "well-being" is presented to support interpretation of the potential impacts of aquaculture on food and nutritional security. Strategies to ensure self sufficiency of aquatic foods at the household, community, national and international scale are considered. Access and food security issues affecting aquaculture and capture fisheries and the nature of farming are critiqued in the light of a broader literature. The role of ponds in meeting broader nutritional security needs and within rural livelihoods is discussed and the importance of incorporation into both local and more extended value chains examined. Since its take off as a major food-producing activity in the last few decades, aquaculture in many places remains a family business. Private governance through certification has emerged as a potential game changer in aquaculture, bringing with it the potential for exclusion of poorer producers from global value chains and associated implications for poverty alleviation. A distinction between the dynamic changes accompanying quasi-commercial and commercial aquaculture development, often in transforming economies, is contrasted with the incremental benefits associated with "quasi-peasant" aquaculture previously most associated with poverty alleviation through interventions supported by national and international organizations. A rethink regarding how poverty is most effectively reduced or its alleviation supported through aquaculture by supporting actors within value chains rather than with a sole-producer focus is advanced. An agenda allied to that proposed in the World Development Report 2008 (World Bank, 2007) for agriculture generally is proposed. This assesses the importance of aquaculture development as part of the measures to mitigate water scarcity and to support sustainable intensification of food production generally, while acknowledging the need to strengthen rural-urban linkages and continue the development of appropriate safety nets for the poorest groups.

KEY WORDS: *Aquaculture, Poverty alleviation.*

Background

Major changes in perspective have occurred since the Bangkok Declaration on Aquaculture ten years ago. These include: changes in the forms and outcomes of the activity and the profile and importance of the sector; thinking regarding the impacts on food security and broader development of the varied forms of

aquaculture that have evolved and; understandings of the nature of poverty and its alleviation. In the same year, the United Nations (UN) initiated and agreed upon eight Millennium Development Goals (MDGs) to guide development efforts and focus efforts towards significant poverty reduction by 2015. The present overview sets out to assess progress since Bangkok 2000, informed by both a wealth of new evidence from the field of aquaculture and a review of experience from the broader fields of agriculture, development and the environment.

The conventional view of aquaculture development based on the promise of "teaching a man to raise a fish" is still current (e.g. "Teach a women to fish", www.teachawomantofish.com/), but the very understanding of what constitutes aquaculture and how it should be developed, and poverty and its opposite, well-being, have undergone significant evolution in the last decade. Approaches to reducing poverty and their implications for aquaculture development, or aquaculture for development are considered based on recent research.

The broader development changes at policy level and how they have affected development thinking on poverty alleviation are first outlined before revisiting current views on the nature of aquaculture and how these have changed in the wake of accelerated globalization. The nature of poverty, vulnerability and well-being and evidence for links with aquaculture are then considered, followed by impacts on food security. Progress, opportunities and an assessment of the drivers required to enhance the poverty impacts of aquaculture are discussed in a final section.

Development

At the turn of the millennium, there was a "malaise" that beset support for rural development (Ashley and Maxwell, 2001), particularly regarding agriculture, for which support had fallen to 4 percent of official development assistance, despite 75 percent of the global poor living in rural areas (World Bank, 2007). A number of milestones have seen this situation change: the recognition that there were deep structural changes occurring within global agriculture, particularly regarding steep increases in demand for more animal-product rich diets in China and India; competition for food crops to support this demand; and biofuels. The first World Development Report (WDR) with a specific agricultural focus since 1989, criticized the World Bank's past record on rural development (World Bank, 2007).

TABLE 1
Agriculture and poverty

	Descriptors	
Countries	**Contribution of agriculture to growth (%)**	**Rural poor as a proportion of total poor (%)**
Agricultural	>20	>50
Transforming	<25	>60
Urban	<20	<60

Source: modified from World Bank (2007).

It also identified three broad categories of country (Table 1) based on the contribution of agriculture to growth and the ratio of rural poverty to total poverty. Most of the countries in which aquaculture has been promoted to reduce poverty are transforming countries for which there are common structural characteristics, as well as a good deal of diversity (Table 2; World Bank, 2007). A pertinent paradox is that there are more poor people in countries considered medium income (MICs) than in the remaining 39 low income states (LICs) (Summer, 2010). A large proportion of this so-called "bottom billion" (Collier, 2007) live in countries where aquaculture is already important and expanding. The WDR agenda concerns seven broad recommendations for agriculture and poverty to which we return in the final section of this report.

Towards the end of the 1990s and the post-Asian financial crisis, a Post Washington Consensus (PWC) emerged around the need for a better balance between the neo-liberal and alternative views on development. The rise of neo-liberalism, i.e. a market-driven approach to development emphasizing the role of private enterprise, liberalized trade and a reduced role for the state,

TABLE 2
Structural features of transforming countries

Structural feature	Characteristics
Demographic pressures and declining farm size	The average farm size in Asia is already quite small – in Bangladesh, China and the delta areas of Viet Nam, it is a mere 0.4 to 0.5 ha. That decline will continue in South Asia because the rural population is growing at 1.5 percent a year and is not expected to peak until at least 2020. Continued population growth, declining farm size and growing landlessness put huge pressures on rural jobs.
Water scarcity	Freshwater supplies are already fully used in many countries, and escalating demands for industrial, urban and environmental uses will reduce the water available to agriculture. Water scarcity is particularly acute and projected to worsen with climate change and rising demand in the Middle East, North Africa and large parts of China and India. High reliance on groundwater irrigation in many countries has led to over-pumping, falling groundwater tables in aquifers with low recharge and deteriorating groundwater quality.
Lagging areas	Some rural areas have prospered with overall economic growth, but others have stagnated with high levels of poverty. Lagging areas are found in most countries in sub-Saharan Africa, the interior of China, several states in eastern and central India, the upland areas of Viet Nam and the drier areas of North Africa. The causes are varied – poor agricultural potential, low investment in roads and irrigation, poor governance, and social and ethnic marginalization. But some of those areas have good potential for agricultural growth and could be future breadbaskets, as in eastern India.
Political economy of agricultural policies	The political pressure of farmers to reduce the urban-rural income gap through protection and subsidies is increasing. Because of the large number of poor people, protecting food prices to raise farm incomes may have high costs for poor consumers, including most small farmers, who are net food buyers. Another form of support to farm incomes is through subsidies on inputs such as water and fertilizer. Those subsidies are not only regressive in distributing benefits to larger farmers and harmful to the environment but also distort fiscal priorities away from investment in core public goods, such as rural infrastructure. Political capture of protection and subsidies by larger farmers can slow the reform process.

Source: modified from World Bank (2007).

had previously divided opinions (Ashley and Maxwell, 2001; Onis and Senses, 2005). Since that time, dialogue between these polar opposites has continued and fresh thinking on bridging the gap has emerged (Dorward, 2009). Ashley and Maxwell (2001) identified several of the elements of the PWC including agriculture remaining an engine of rural development, the future viability of small farms, the potential of the non-farm economy and impacts of new thinking on poverty, governance and participation which are pertinent to framing ideas about support for aquaculture and its role in rural development and poverty alleviation.

The World Development Report (2001) recognized the multidimensional aspects of poverty, and since then there have been new avenues of thinking that articulate the links between poverty and the environment, particularly the concept of social and environmental resilience (Folke *et al*., 2002). The WDR 2008 (World Bank, 2007) focus on agriculture was timely, as the global food shock occurred in the same year, galvanizing renewed interest in the sector and, as acceptance that climate change was a reality, a need for structural transformations of political and social institutions to meet expected challenges in the coming decades. Another milestone in the last decade has been acknowledgement of the central role of the private sector in aquaculture development (private sector development, PSD), set out in the World Bank's *Aquaculture: Changing the Face of the Waters: Meeting the Promise and Challenge of Sustainable Aquaculture* (World Bank, 2006).

Defining aquaculture systems

A range of terms is in common usage to define and describe aquaculture systems and those who operate them. In principle, definition should reflect clarity of purpose and thereby interpretation of impact. Does investment in "small-scale" aquaculture necessarily result in more poverty reduction than in "larger-scale" aquaculture? Do classifications based on simple physical scale indicators allow comparisons between species and across locations or between alternative property rights (formal and informal), for example? The various classifications in current use are explained and compared in the context of evaluating their values for understanding the relationship with poverty.

Classifications

Aquaculture systems have been defined in terms of location (e.g. inland/coastal, lowland/upland, rural/urban), salinity (i.e. freshwater, brackishwater, seawater) and level of intensification (i.e. extensive, semi-intensive and intensive). They have also been characterized by the form of containment (e.g. rice field, pond, cage, tank/raceway) and the trophic level of the species cultured (e.g. autotrophs, herbivores, omnivores, carnivores). In terms of impacts on people, definitions that embrace aspects of consumption (e.g. subsistence compared to commercial orientation) have been commonly used, often in tandem with consideration of market (i.e. "local", urban, regional or international).

All of these classification systems have connections to the issue of impacts on poverty alleviation. Some forms of aquaculture undoubtedly require investment beyond the reach of poorer people: raising carnivorous species using nutritionally complete feeds in intensive systems might be expected to be less poverty focused than producing herbivorous species in rice fields. Furthermore, poverty may be spatially concentrated in rural or urban contexts or be more extreme and/or widespread among certain ethnic communities. Promoters of aquaculture in upland or mountainous areas of Viet Nam for example have used the poorer, more marginalized nature of resident populations as a rationale for securing funding.[1]

Scale as a descriptor

Scale of production, with definitions typically based on indicators of area, numbers of culture units and levels of inputs and/or outputs, has been a common identifier of aquaculture systems and habitually linked with its role in poverty alleviation. In particular, "small-scale" aquaculture and "poverty alleviation" have become almost synonymous. The usefulness of such definitions has recently been challenged (Edwards, in press[a]), as has the usefulness of relating scale to policy (Tripp, 2001) or poverty alleviation at all (Belton, Haque and Little., in press). Defining both small-scale fisheries and farming (Ashley and Maxwell, 2001 and Grigg, 1966, respectively) have also been problematic. Differentiating between scale on the basis of size of holding, dominance of aquaculture within the livelihood, or status as owner, lessee, operator, employee or subcontractee of the enterprise reveals inconsistencies.

A recent Food and Agriculture Organization of the United Nations (FAO) workshop (Bondad-Reantaso and Prein, 2010) defined small-scale aquaculture as a continuum across a fairly broad range of characteristics. For example, in the Viet Nam *Pangasius* industry the "medium-size" farmers involved tend to have the critical mass of capital which allows them to create the economies of scale large enough to maintain access to global value chains (Bush and Duijf, 2011). This contrasts markedly with shrimp in Viet Nam, where production systems are large in terms of area but have relatively small outputs (Thanh *et al, unpubl. data*. However, the macro-data suggest that *Pangasius* and shrimp farmers are similar in that their main livelihood activity is aquaculture, largely because their land has been converted to ponds, or they have very little alternative given the location of their land in often marginal and/or coastal ecosystems. Some studies have indicated that *Pangasius* systems are more heterogenous than recent publications might suggest (Labrousse, 2008) and point to a basic issue that undermines understanding of the diverse forms of aquaculture: sampling frameworks are often either *ad hoc* or absent, leading to generalizations based on what are essentially case studies.

[1] An example is the presentation by N.T. Tung on *Aquaculture and poverty reduction: experiences of UNDP Vietnam* given at the EC Workshop on Sustainable Rural Development in the Southeast Asian Mountainous Region, Hanoi, 28–30 November 2000.

TABLE 3
Typology of the social and material characteristics of pond-based finfish culture

	Characteristics					
Relations of production	**Quasi-peasant**		**Quasi-capitalist**		**Capitalist**	
Production intensity	Low	Low or moderate	Moderate	Moderate or intensive	Moderate or intensive	Highly intensive
Capital & operating costs	Limited	Moderate	Substantial	Substantial	High	Very high
Ownership & labour	Family owned & operated	Family owned & operated	Family owned & operated	Family owned & operated or absentee owner Part-time &/ or permanent labour	Family owned & operated or absentee owner Permanent labour Managerial staff	Absentee owner or corporate ownership Permanent labour Professionalized managerial, technical & clerical staff
Organization of production	Minor activity in a portfolio of livelihood options	One of a portfolio of livelihood options	Primary livelihood activity	Primary livelihood activity or entrepreneurial investment activity	Primary livelihood activity or entrepreneurial investment activity Possible or partial or complete vertical integration	Entrepreneurial investment activity or large business Likely partial or complete vertical integration
Market orientation	Subsistence/local/district		District/urban/national		National/export	

Source: from Belton *et al*, in press.

More recent research suggests that a focus on scale can be misleading, and a "relations of production" approach has been advocated to better understand the various impacts of aquaculture on poverty (Belton, Haque and Little, in press; Belton and Little, 2011a). These authors proposed that the use of scale be abandoned and aquaculture be categorized in terms of relationships (e.g. "quasi-peasant", quasi-capitalist and capitalist) to overcome some of the inherent problems relating scale to production intensity, capital and operating costs, ownership and labour, and organization of production (Table 3).

Undoubtedly these redefinitions that have been developed primarily for pond-based aquaculture are closely aligned with previous definitions that differentiate between subsistence and commercial orientation or "small-scale" and "large-scale" aquaculture (see below). But the new terms, based on a Marxist analysis as applied by sociologists, are a significant improvement for understanding aquaculture development across a broad landscape, both geographically and socially. Using labour as the unit of interpretation, it allows a better analysis of motivations and outcomes and a closer articulation of where aquaculture

"fits" in complex livelihoods. Its application allows the fast-changing realities in the sector in countries both termed "agricultural" and "transformational" and a better framework to assess the links between aquaculture and poverty alleviation that extend beyond the pond, outside the farm and along the value chain.

Definition by location: rural vs urban

Rural aquaculture derives from the attempt to differentiate between "rural and agricultural" and "urban and industrial" (Edwards, in press[a]). Martinez-Espinosa's binary classification of rural aquaculture that separated Type 1 (poor, subsistence oriented) from Type 2 (less poor, commercially oriented) in 1995 set the scene for its reinterpretation, but this has been beset with problems of definition and boundary setting. Definitions of "rural" (see Edwards, in press[a]) as synonymous with small-scale farming and poverty (Edwards, Little and Demaine, 2002) have also remained largely uninformed by the growing literature on rural-urban linkages and the complexity that this adds to the issues of addressing poverty in specific locations. Increasing interpenetration of rural and urban livelihoods makes urban and rural poverty interconnected (Rigg, 2003). For example, in the rural context of Thailand, few "farmers" are totally reliant on agriculture and increasingly base their livelihoods on non-farm income; people in rural areas are becoming "land short, farming shy and consumption inclined" (Rigg and Natapoolwat, 2001). Moreover, trajectories of rural change that influence attitudes and practice penetrate across borders into hitherto "remote" rural areas (Wiggins and Proctor, 2004); Bouahom, Douangsavanh and Rigg (2004) describe such changes in agriculturally marginal areas of Lao PDR.

In the case of some peri-urban aquaculture, this works both ways. The production of water spinach (*Ipomoea aquatica)* is commonplace around urban centers in Asia, and this aquatic vegetable tends to be produced by people poorer than those who produce finfish, which requires more resources. Access to shallow converted rice fields or common-pool resources such as urban waterways and lakes is the main requirement. In Boeung Cheng Ek, a large waterbody that receives and treats most of the sewage in Phnom Phen, Cambodia, poor communities are actively engaged in producing and trading the vegetable that makes up an estimated 50 percent of the green vegetables consumed in the city. Many of these people are migrants from rural provinces, and the population rises and falls with the labour requirements for rice production in their home villages (Leschen, 2006).

Such types of urban-rural linkages complicate the challenge to define any generic form of "rural" or "urban" aquaculture; recent characterizations of rural aquaculture include "to provide low-cost fish for poor rural and urban consumers" (Edwards 2000, in press[b]). Certainly, much of the growth in aquaculture in recent decades has been stimulated by urban demand and supported by urban-based services, whether government, non-governmental organization

(NGO) or commercial (Little and Bunting, 2005). Drivers for the development of aquaculture are often related to urbanization to meet demand for food in towns and cities, and underpinned by reciprocal investment and inputs, both knowledge and physical requirements such as feed, seed and equipment. The implications for poverty impacts are important, as urbanization itself is changing the very nature of poverty (see below). One approach is to accept that terms such as "rural" and "small-scale" are only useful in respect to specific contexts; another approach is to provide more location and context-specific definitions.

Edwards and Demaine (1997) originally linked the term rural aquaculture to "rural development" but more recently, Demaine (2010) asserts "rural aquaculture should be retained for low-cost production systems suitable for implementation by the rural poor". This definition is undoubtedly more precise and therefore potentially more valuable for targeting interventions and development assistance but could effectively exclude much of the aquaculture more recently appreciated to have impacts on poverty. Not only has there been accelerated development and uptake of higher-input aquaculture in many areas, but it is also clear that many, if not most, of the poor who benefit from aquaculture in rural areas are not producers (Hambrey, Edwards and Belton, 2008). Moreover, better-off rural producers may prefer "low-input" aquaculture, and poorer producers "higher input" aquaculture for a range of reasons. This may be linked to the fact that whereas aquaculture may constitute a very small part of better-off households' overall portfolio of activities, it may be far more significant for the poor.

Edwards (in press [a]) also differentiates between "traditional" and "modern" aquaculture and identifies many of the inherent contradictions in assuming traditional aquaculture is always small-scale and poverty focused. The extensive holdings characteristic of traditional brackishwater aquaculture in Hawaii, Indonesia and the Philippines suggest otherwise (Wyban, 1992; Costa-Pierce, 2002). Clearly, the emerging diversity of "modern" systems has varying direct relationships with poverty alleviation.

From tradition to modernity

"Traditional" aquaculture was, until the hatchery revolution that began in the 1980s on a large scale in Asia, probably highly geographically limited to relatively better-off pond owners able to obtain naturally sourced juveniles. There is little evidence that it benefited the poor to any great extent, although it undoubtedly took place in poor rural societies (Beveridge and Little 2002, Edwards, in press[a]). Rural people generally met their subsistence needs for fish through accessing natural stocks from resilient flood-plain, lacustrine and coastal resources. Such resources supported large numbers of full-time or part-time artisanal fishers in areas where these were abundant. Of the large diversity of "modern" systems that have evolved, many have evolved, sometimes incrementally, from "traditional" forms and remain integrated into local agricultural and broader livelihood systems. They are characterized by a dependence on seed and feed

from outside the farm and the immediate community and derived from specialist actors (i.e. hatcheries and feed processors, respectively).

Responding to increased demand for farmed fish and a decline in the relative abundance of natural stocks, "modern" systems can generate large networks of opportunity from which poorer people can benefit. A good deal of this employment is outside the production enterprise; use of purchased formulated feeds reduces the need for on-farm labour but can stimulate employment in the supply chain. Other types of "modern" aquaculture are introduced enterprises distinct from surrounding food production and may be fully integrated with global value chains from the outset. To fully assess these opportunities requires that boundaries be set further than the farm gate and, increasingly at distance from the site of production by considering the whole value chain and how poorer actors are affected as employees, service providers and consumers. This approach is also required to assess environmental impacts of aquaculture, given that recent life cycle assessments (Bosma, Hanh and Potting, 2009; Pelletier and Tyedmers, 2010) have suggested that the majority of the environmental impacts (e.g. embodied energy, global gas emissions) of such "modern" forms of aquaculture result from feed production and use. Pumping and aeration for intensive systems and postharvest processing and distribution can also be very important.

Evolving forms of aquaculture

Fresh perspectives are also required on what constitutes "aquaculture" in order to inform our understanding of its importance in alleviating poverty. While most observers agree that the household-level enterprise, whether relatively small or larger-scale, located in a more or less rural location, remains the dominant type of enterprise in contrast to "corporate" enterprise, the utilization of aquatic resources encompasses an increasing variety of forms of social organization. This is partly an outcome of the increase in demand for and pressure on access to water, particularly hitherto common-pool resources. These range enormously in size and management approach and offer both new opportunities and potential conflicts with poverty alleviation.

Knowledge of property rights is a key determinant of aquaculture potential in common-pool resources which necessitates some degree of collective action or agreement. Potential for free-riding, difficulties guaranteeing returns to individual effort and the associated difficulties in meeting transaction costs of management mean that such development efforts tend be relatively extensive in nature. Requirements for external institutional mediation may increase with scale.

Security of access to smaller group "common property" systems or those with seasonal common-pool characteristics (e.g. flood plain areas of Bangladesh) is often complicated by dynamic systems of overlapping statutory and informal

property rights referred to as "legal pluralism" (Meinzen-Dick and Pradhan, 2002). Depending on resource context, this can result in greater uncertainty, i.e. due to imperfect knowledge, or greater flexibility resulting from interaction of the different rule-systems.

Cage and enclosure-based aquaculture located in common-pool resources and typically dominated by commercial interests effectively privatize the resource, and this can have implications for multiple use through access modifications and environmental impacts (Beveridge, 2004). Some forms of management have developed from traditional fishery models, e.g. fishing "lots" in the Tonle Sap (Lamberts, 2001) and the leasing of perennial waterbodies in the Indian subcontinent that have been revenue generating and extraction oriented. Stocking hatchery seed in such culture-based or enhanced fisheries has now become a major type of development initiative and often cloaked in "participatory" and pro-poor approaches. Increasingly, smaller waterbodies, "community" ponds or rainfed irrigation tanks or areas of inundated floodplain enclosed by bunding are being leased for stocking and management to individuals or groups (Gregory, Brooks and Toufique, 2006; Valbo-Jørgensen and Thompson, 2007). These types of aquaculture raise issues concerning the continued traditional rights of the poor for access and exploitation of wild stocks (Nguyen Khoa *et al.*, 2005). This parallel trend towards more extensive forms of aquaculture, often based around managing both stocked and unstocked species, points towards alternatives to intensive monoculture as approaches to increase aquatic food production. As for agriculture more generally, the production of farmed and wild aquatic foods is often complementary (Beveridge and Little, 2002; Bharucha and Pretty 2010). The boundaries of the various practices considered to be aquaculture and capture fisheries are therefore becoming blurred, and previous truisms that aquaculture is "for" the resource rich and fishers are the "marginalized poor" are open to debate. A study that identified and characterized household-managed aquatic systems in five countries in Asia found that farmers generally regarded stocked and unstocked animals, especially in less intensive systems, as complementary and more capable of meeting their diverse household needs (Morales, 2007). Up to 90 percent of rice farmers in Cambodia and northeast Thailand harvested aquatic animals, and 70 percent created aquatic habitats such as ponds, principally to reduce seasonality and enhance catch per unit effort (Amihat *et al.*, 2009a, b).

Aquaculture as a component of livelihoods

An appreciation that aquaculture may be one part of a complex livelihood portfolio (Scoones, 1998) rather than being the sole or main income-producing focus for a household also changes the way in which it can be perceived and defined. This also has implications for its relationship with poverty alleviation. Involvement in aquaculture value chains may be seasonal, part-time, or both and this may have very different consequences for household poverty than a complete dependence on the activity. Furthermore, many types of aquaculture are, and always have

been, too small or unproductive to support livelihoods entirely or to make large contributions to them. The planned or primary roles of many on-farm ponds were typically multipurpose; water storage for supplementary irrigation and domestic needs and trap ponds for wild fish were commonly cited as the original intention in a study of three countries (Little *et al.,* 2007[a]). This study suggested a shift towards aquaculture becoming a relatively more important use for such ponds, although the importance varied considerably; the crucial aspect remained that ponds were viewed as assets integrated within diversified livelihoods (see also Dey *et al.*, 2010).

Focusing on the pond leads to a more asset-based understanding of aquaculture. For both small-scale rural aquaculture (the type addressed by Edwards, Little and Demaine, 2002) and globally integrated production systems, the pond remains the central asset. The integrated farming systems literature certainly places the pond at the center of household livelihoods, usually as a managed sink and source of nutrients used to improve low-cost growth of fish, livestock and cash crops (Edwards, Little and Yakupitiyage, 1997; Nhan *et al.,* 2007). An alternative "integrated" understanding of ponds in inland floodplain areas of Southeast Asia is as a dry season water source and/or as monsoonal trap pond systems (Demaine *et al.* 1999; Shoemaker, Baird and Baird*,* 2001; Dey *et al.,* 2010). Ponds in these farming systems have a central role in rural livelihoods; as such, once a pond is dug it may well change use but is rarely if ever abandoned.

The promotion of aquaculture separate from, or integrated within, broader livelihoods therefore becomes an important policy issue. In the last decade, aquaculture has in some cases been embedded within national poverty reduction strategy plans or has become a key part of macro-economic growth or, in some cases (e.g. Viet Nam), both. The renewed interest in the ways in which various types of aquaculture can contribute to poverty alleviation at household, community and national levels is critical.

Current theory and concepts related to poverty and its alleviation

Introduction

A general assessment of current knowledge regarding poverty alleviation is presented with an outline of some of the current thinking about poverty, well-being and life satisfaction among development and related sectors. The key approaches to describe and assess poverty from economic (particularly income and expenditure) approaches through to broader analysis of assets, to more holistic well-being approaches that consider how poverty is experienced are described. The assessment of these multiple natures of poverty also considers the relationship with vulnerability and resilience, as well as intergenerational poverty, its causes and characteristics of approaches to alleviate it. One aspect of the dynamics of poverty is that in any given context some households are

falling into poverty while others are escaping from it, and this is considered in terms of the potential roles of aquaculture. The impacts of aquaculture on equity are also considered, given recent illustrations of the rapid increases in wealth and wealth differentials that are possible in communities and issues related to power relations constraining benefits to the very poor.

The multiple nature of poverty has made it a challenge to link its reduction or mitigation directly to development initiatives, both informal and formal, in any sector. Stevenson and Irz (2009) made the point that "ideally the impact of aquaculture development on the poor would be investigated by measuring robust poverty indicators to allow comparison of the existing situation with a counterfactual (i.e. situation without aquaculture) built from convincing data to establish causality/attribution". Aquaculture development has been advocated for its potential benefits for the poor and linked, sometimes implicitly, to development of this specific group, although it has tended to have a strong technocentric focus and favour the better off (Edwards, 2000). The opportunities for aquaculture to benefit the poor, given its often resource-intensive nature, have been challenged (Harrison *et al*., 1994; Lewis, 1997) and indeed implicated in the development of greater inequalities (Adger, 1999; Van Mulekom *et al*., 2006).

Since the 1950s, there has been a focus on "small-holders" as producers as the main channel for poverty reduction in line with mainstream agriculture: the so-called "small-farmer-first narrative" (Ellis and Biggs, 2001). Although the earliest attempts to promote aquaculture throughout sub-Saharan Africa involved digging household ponds, an exact parallel in aquaculture is less clear in many countries in Asia, as historically pond owners have often been a relative elite in rural communities; and furthermore, many forms of aquaculture are resource intensive. This has always been context specific, for example, where anyone relatively poor is virtually landless, such as in Bangladesh, as opposed to areas where even the poorest people have significant landholdings. This view also ignores the spread of pond construction among even poor households as the real cost of excavation and earthworks has declined, often in tandem with the expansion of road networks across much of Asia. It also reflects too narrow a view of the range of aquatic resource management now embraced by the term aquaculture (see above).

Critical questions on the characteristics of the poor and their involvement in, or exclusion from, aquaculture (as producers, intermediaries, consumers) are considered below. A key issue is whether such involvement or exclusion reduces vulnerability, enhances security or, more dramatically as is often claimed, supports escape from poverty. The nature of poverty and how it can be assessed are considered and implications for the potential roles of aquaculture in its mitigation. Conceptual frameworks such as livelihoods, global value chain and resilience models are invoked. An issue for assessment of aquaculture

stakeholders is their absolute and relative levels of wealth or well-being: are they poor; and if so, assessed by what criteria? Are they poor in "absolute" terms or relatively poor compared to others in their communities? Critically, is involvement in aquaculture the most appropriate means to escape poverty? The causes of poverty may be related mainly to limited assets at a household or individual level or to broader institutional factors. In most situations, it will be a complex of these factors that results in the specific impoverished livelihood and asset accumulation of various types that is critical to escape from poverty. The specific mechanisms through which involvement in aquaculture as a stakeholder enhances various types of asset and reduces vulnerability are also explored in this section.

Definitions

The various definitions of poverty are first considered. Simplistic and all-embracing views of poverty such as use of financial indicators or USD1.25/day income are useful but disguise a much greater range of "conditions" ranging from absolute degrading poverty to the various types of poverty recognized, such as income, nutritional and cultural. The Millennium Development Goal (MDG) 1 is to halve poverty and hunger by 2015. It has five indicators that span the more orthodox measures used: the proportion of population living on less than USD1.25/day, the poverty gap ratio, the share of the poorest quintile in national income or consumption, the prevalence of children under five who are underweight and the proportion of the population that is malnourished.

The multifactorial nature of poverty is well recognized. The World Bank has developed multifactoral indices, a "descendant" of the United Nations Development Programme (UNDP) Human Development Index, for measuring and describing the complexities of poverty. An issue with such combined measures is the degree to which progress away from poverty in one aspect is correlated with the others. Gentilini and Webb (2008) found that describing a given country performance in attaining MDG1 using a poverty and hunger index (PHI) could describe a given country performance in attaining MDG1 in a single number, while at the same time showing that progress in one dimension such as income poverty did not automatically translate into improvements in others such as children underweight, and vice versa.

The term "trapped in poverty" is a reminder that although there has been much dynamism with regard to poverty, some is also chronic and intergenerational. Moving away from this state, either individually or collectively, can be constrained by a variety of factors including powerlessness, uncertainty and insecurity (Wood, 2003) and/or is related to poor physical and mental health.

The terms alleviation, mitigation and reduction are used interchangably and when applied to aggregate levels of poverty can be synonymous. On an individual or household level, however, use of the first two terms suggests

that people remain poor but that the worst symptoms or outcomes of poverty are "relieved", whereas poverty reduction suggests the underlying causes of poverty are addressed. It is also useful to differentiate poverty from vulnerability and insecurity. "Vulnerability" is not synonymous with poverty but means defencelessness, insecurity and exposure to risks, shocks and stress (Gordon and Spicker, 1992 in Hallman, Lewis and Bugum, 2003). The role of a resilience perspective for understanding the dynamics of social and ecological systems for effective change in governance has also been advocated (Duit *et al.,* 2010).

Uncertainty underpins the condition of poverty in many contexts and also prevents investment by individuals – the so-called "Faustian bargain" (Wood, 2003). Chronic, rather than random, or stochastic, insecurity is the major challenge to poor people. Longer term goals are put on hold. The idea that households and the individuals therein can "graduate" away from poverty and vulnerability in the face of a hostile environment, both social and environmental, is in many cases naïve unless pro-active support is given. In practice, the "extent of their capacity for social action" is a major constraint, and the poorest people are excluded. For example, poor fishers cannot make the time for, or through low social status are excluded from, decision making or participation in group resource management.

Aspects of vulnerability may be most intense at the intra-household level (Hallman, Lewis and Bugum, 2003), e.g. females' dependence on males or subordination, lack of knowledge of production technologies or market opportunities. Ex-household factors such as law and order, threats of violence (e.g. to minority households at times of social tension), forced sales of land, takeover of waterbodies previously communally accessed (resource capture), theft of fish, malpractice by local hierarchies, low levels of trust in government/ NGOs and lack of access to services are also clearly critical.

Various aspects of prevailing culture may intensify social norms; the distinction of "outside" and "inside" work in the Bangladesh context for women makes their roles in aquaculture highly dependent on its location. Barman and Little (2011) found this in piloting of fish nursing systems in northwestern Bangladesh – hapas in seasonal ditches within the homestead could involve women whereas "in the field" technologies effectively excluded all but the poorest, for whom such social rules were less constraining.

Differences in mechanisms through which aquaculture might impact on wealth and "well-being" are also considered below.

Poverty dynamics

A large number of studies indicate that many households fall into poverty, including non-borderline households, due to a combination of factors that typically include poor health of the major breadwinner. Using a "stages of

progress" methodology, Krishna (2007) showed that decline was typically gradual and cumulative – ill health and high healthcare costs were by far the most important reason for decline, adding to costs and reducing income-generating opportunities. Social/customary costs (e.g. dowry, funerals and weddings), high-interest debt, drought/flood and other land-related factors were also associated with descent. The extent to which, if at all, participation in aquaculture can protect households from decline or indeed exacerbate it (e.g. through taking loans for non-productive ponds) needs further study. In a comparative study of the role of self-recruiting species in aquaculture in Cambodia, Thailand and Viet Nam Morales (2007) found that loss of a household head and a relatively large number of dependents were major factors in households being viewed as poor within communities.

Aquaculture is also relatively new, and intergenerational impacts are far from clear, although some studies in Central America (Lovshin, Schwartz and Hatch, 2000) and Thailand (Belton and Little, 2008) suggest that these are occurring. Haque *et al.* (2010) found that primary adopters of fingerling production in ricefields were more likely to invest the income from fish sales in their children's education than the secondary adopters, who tended to be slightly wealthier.

Aquaculture can contribute to producer household livelihoods in terms of improved nutritional and health outcomes, and transferable skills such as business and networking, i.e. enhanced human assets and productivity elsewhere on the farm, or the capacity to work more profitably off-farm.

Krishna's multicountry study (2007) found that income diversification (either on or off-farm) was the most important pathway out of poverty, a finding also supported by a study carried out in Bangladesh (Sen, 2003). Private and public-sector employment was far less important, as was education or public or NGO assistance. Access to on or off-farm irrigation was important to over a quarter of households escaping poverty in the three parts of India assessed by Krishna. The extent of aquaculture's potential to support escape from poverty in irrigated, high-potential contexts, as compared to more marginal rainfed environments where ponds provide on-farm water storage, is likely to be different and is considered later.

The perception that aquaculture is not an option for poorer households because of a requirement to access resources has already been challenged above, but the extent to which adoption of aquaculture has resulted in greater wealth, has also been under-assessed. Initiating aquaculture outside of the geographically highly restricted areas that had ready access to wild seed was historically limited by availability of hatchery-produced juveniles and knowledge of how to raise them. Adoption studies suggest that when demand was sufficient, even variable levels and quality of information and seed have been sufficient for pioneers to embrace the practice, typically followed by others after

demonstration of its potential (Surintaraseree and Little, 1998). The nature of rural extension networks has often resulted in those with closer relationships to such social resources accessing them first – typically these would be wealthier, more mobile and better educated individuals. Often they have high social status, with public-sector positions themselves or strong kinship links with those that do. Commonly, it can be observed that farmers who upgraded their position in the value chain, particularly from growing food fish to hatchery production, would possess these characteristics.

As with other development initiatives, the knowledge that promoting aquaculture among the relatively better off is both easier and potentially more cost effective has led donors aiming to focus on reduction of poverty through aquaculture to re-evaluate their approaches and introduce some form of targeting, and these are now considered.

Targeting poverty

Reasons for the dynamic nature of poverty (i.e. that at any particular time people are simultaneously both falling into poverty and escaping from it in large numbers) need to be understood and targeted, rather than just the people (Krishna, 2007). An improved understanding of the extent to which aquaculture can improve people's well-being while they remain poor, as compared to being part of a process that removes them from poverty (i.e. allows them to "escape"), is required.

Targeting of poverty relief programmes has used indicators: geographical, community and self-targeting; all have problems. It is not unusual for targeting to result in contradictory outcomes. The social and political networks of the better off may give them significant advantages to claiming benefits, potentially further undermining the situation of the needier. Mixed approaches are also common, such as when aquaculture has been promoted in a certain geographical context; areas where fish is perceived as being particularly important and/or lacking among ethnic minorities for whom aquatic foods are relatively more important than for mainstream communities would be an example of this (Barman, 2009). Community-based approaches may aim to support the poorest households wanting to access ponds (self-targeting). Examples of this are food-for-work programmes in which the poorest are attracted to daily waged employment constructing ponds. Depending on the programme structure and prevailing institutions, however, this does not necessarily result in any sustained access to the completed resource by those who have built it.

Elite capture is a regular criticism of development projects, even those in which participatory approaches at the "community" level are central to the approach (Plateau, 2004); aquaculture extension projects appear to be particularly vulnerable to such outcomes. Some studies have found that this problem is not insurmountable, especially where inclusion of both elites and non-elites in democratic self-governance was established (Das Gupta and Beard, 2007).

Targeting, through a focus on poorer individuals or groups rather than the broader community may also create or exacerbate social tensions and has been the rationale for not attempting to target within communities (e.g. the Northwest Fisheries Extension Project's village fishponds approach; Islam, 2002). Those at most risk of falling into poverty have rarely been targeted by specific poverty-reducing programmes, although they possibly have been the target for rural aquaculture promotion, i.e. farming households with small ponds. Recent analysis in Mymensingh District, Bangladesh, suggested that marginal farming households were quite likely to have ponds, but that poorer households were not (Belton, Haque and Little. *in press*). A similar conclusion was reached in Malawi (Dey *et al*., 2010).

Targeting the poor to benefit through aquaculture may be more straight forward in contexts where a larger proportion of the rural poor have land, especially where ponds or small waterbodies of various types are a common asset and used to some extent for fish culture. In Central Luzon, Philippines, an Asian Development Bank (ADB) funded study found that almost 50 percent of farmers with ponds less than 1 000 m^2 were below the poverty line (ADB, 2004). In Sisaket, northeastern Thailand, ponds of poorer people more dependent on off-farm income were more likely to be abandoned or used as trap ponds and much less likely to be in active use (Turongruang, unpub. data). In the Red River Delta, ponds are a traditional component of the integrated homestead systems, for example, the vegetables, aquaculture and cage system (VAC) (Luu *et al*., 2002). Morales (2007) found that both the well-being status of households and the specific agro-ecosystem (i.e. low-lying flood-prone areas compared to drier more upland sites) affected the likelihood of having a homestead pond. Better-off households in more upland sites were more likely to have a pond (>60 percent) whereas poorer households in flood-prone environments were least likely, but even in the latter group, more than 20 percent of poorer households had ponds.

Project interventions

The PWC on how rural poverty could be reduced is based on the premise that most poverty remains rural (Ashley and Maxwell 2001), but "rural" is a highly diverse and dynamic category. In less well-connected or remote rural areas with few resources, there are few proven strategies to reduce poverty through agriculture except outright subsidies (Wiggins and Proctor, 2004). Where rural areas are well endowed in terms of natural resources, agricultural development is possible and desirable; but reducing poverty may still require interventions to make markets work by correcting for failures and by strengthening institutions to that end (Dorward *et al.,* 2004); hence, the concept of the project-based intervention that promotes aquaculture in targeted areas and to targeted groups that otherwise would miss out on such opportunities. Typically, however, such projects have neglected institutional issues, at best recognizing their importance as part of an "exit strategy" rather than as core objectives. A major

issue is if project-oriented subsidized approaches to development have resulted in significant improvements in poverty alleviation, and if these have been cost effective compared with other forms of investment. Brummett, Lazard and Moehl (2008) described the failure of aquaculture development approaches in sub-Saharan Africa and urged a re-alignment towards support for small and medium enterprises (see also Beveridge *et al*., 2010).

Claims regarding the linkage between poverty alleviation and aquaculture, particularly "small-scale" aquaculture, have intensified in recent decades in response to donor pressures and the "small-farm first" paradigm, despite the weak theoretical underpinning of the latter with respect to aquaculture (see Belton, 2010; Belton and Little, 2011a).

Strategies to benefit the poor through aquaculture – a commercial aquaculture focus?

A key reason for definitions is the issue of targeting – focusing development efforts in its various forms at those most in need and/or where the maximum impact can be achieved for a given level of resource.

The case that enhancing agricultural productivity as a whole is the most effective mechanism for reducing chronic poverty remains current and has recently been revisited by economists (e.g. Irz *et al.,* 2001). More commercially oriented aquaculture, rather than aquaculture geared primarily to meeting subsistence needs, appears to generate larger employment networks which offer more opportunities for poorer people to benefit than smaller-scale more subsistence-oriented systems (Hambrey, Edwards and Belton*,* 2008; Belton Haque and Little*,* in press). This view has recently been discussed among aquaculture professionals working in Africa, with similar overall conclusions (Leschen and Dabbadie, 2010) and both Brummett *et al*. (2008) and Beveridge *et al.* (2010) came to similar conclusions.

A study of commercial aquaculture in the Philippines produced strong evidence that aquaculture benefited both non-poor and poor but that the latter derived a relatively larger share of their income from it and that across a range of production systems that aquaculture tended to reduce inequality (Stevenson and Irz, 2009). The range of employment opportunities that commercial aquaculture stimulates, while showing high variability between different systems in the same location, appears to be the major benefit, particularly in areas with large surpluses of labour. It also attracts more highly qualified individuals into the sector who themselves leverage greater private-sector investment. A further series of studies in the same area in the Philippines identified that while the poorest members of communities in which aquaculture was located did not benefit through direct employment, indirect employment was "enriched" through the opportunities for informal gleaning of emptied ponds and associated fishing and trading (Parker, 2008). Gleaned by-products (e.g. shrimp) entered global value chains and supported local

subsistence of the gleaners themselves and even more impoverished community members through gifting and reciprocal exchange. A major concern was that these long-established systems, while showing resilience to environmental and population pressures, would be sensitive to further technological improvement that resulted in any reduction in such by-catch.

Faruque (2007), in his study of commercial *Pangasius* culture in Mymensingh District, Bangladesh, found that employment opportunities had been greatly enhanced in the last decade as commercial aquaculture became established. In particular, opportunities for agricultural day labourers appeared to have improved, inflation adjusted wages rising by around 50 percent and the number of days worked by 1.7 to 4.4/week. Fishers, in a context of diminishing opportunities for livelihood based on wild stocks, saw similarly improved wage rates, and there was evidence of large-scale entry into this activity by those formerly outside it. This contrasts with Ahmed and Lorica (2002) who, - undoubtedly referring to the "quasi-peasant" carp polycultures described by Belton, Haque and Little (in press) - observed that while there was clear evidence of positive income and consumption effects on households, employment effects were not significant. Belton, Haque and Little interpreted this outcome in terms of the limited labour demands of such systems. However, both more and less commercial types of aquaculture coexist in many areas of Asia and support a large network of ancillary services ranging from individuals and teams of poor people repairing ponds, harvesting, transporting seed and feed, and transporting and processing the outputs. Some may be highly specialized, such as the sludge divers who clean *Pangasius* ponds of sediment in Viet Nam during the culture cycle (Quach, 2008), whereas others may supply more generic services.

Improving understanding of aquaculture and poverty

A clear message and emerging consensus from research conducted in the last decade is that any analysis of the poverty impact of aquaculture has to acknowledge its variable importance within livelihoods of individuals and households and take a value-chain (Bolwig *et al.,* 2010) or "whole industry" approach (Beveridge *et al.,* 2010).

Initiatives to promote aquaculture towards poverty alleviation in the last decade have increasingly been based on the livelihoods framework (Ellis, 2000), acknowledging the concept of a diversity of asset type, the reality of diverse portfolios of activities and access to key resources as being critical for securing improved livelihood outcomes. Recognition of the importance of long-term trends of various types, and shocks and seasonality on peoples' vulnerability has been mainstreamed among development practitioners and within the research and development (R&D) community.

Poverty and resilience

The resilience framework is showing potential to bring the linkages between social and ecological systems into a coherent framework in which efforts to

address poverty can be addressed, although the integration of social issues has proved challenging. Uncertainty and risk have been central to understanding livelihood responses to ecological, economic and political perturbations, as outlined above. The main line of thinking in the resilience literature towards social responses to change has been through an analysis of the capacity of a society or community (of aquaculture farmers, for instance) to self-organize. In doing so, the group can enhance opportunities to adapt to changing circumstances (Walker *et al.,* 2004). In turn, such collaboration may enhance the capacity to cope with uncertainty, the openness to learning, the acceptance of the inevitability of change, and the ability to treat any intervention as experimentation or "adaptive management" (Lebel and Anderies, 2006). The challenge then becomes to institutionalize the "adaptive capacity" within a socio-ecological system by supporting collaboration, pluralism and linkages between multiple types of stakeholders, diversity of interests represented, multiple perspectives on the problem domain, and connections across multiple scales and levels (Armitage, Marschke and Plummer, 2008). Resilient systems therefore not only have the capacity to maintain their functional interactions, but also the ability to adapt to external change and evolve through learning. This thinking underpins initiatives to establish and empower community-based organizations (CBOs) that can support social learning and adaptive capacity to better manage the aquatic resources central to the livelihoods of poor communities in Bangladesh and other shock-prone wetland-dominated environments (Demaine, 2010).

So, while there are structural sources of poverty as emphasized in early aquacultural social science literature (Bailey, 1988; Hannig, 1988; Stonich, Bort and Ovares, 1997), the (social) resilience literature emphasizes the capacity of individuals and groups to institutionalize learning and adaption to reduce their vulnerability to adverse changes. These issues are discussed later in this review with regard to applying the resilience concept to aquaculture value chains and as part of a livelihood portfolio in marginal agro-ecosystems.

Macro-impacts

An initial drive towards projects promoting aquaculture in "high-potential" agricultural areas has been commonplace, e.g. the Mymensingh Aquaculture Extension Project (MAEP) in which the areas selected in Mymensingh retained water throughout the year and had a high density of ponds (Rand and Tarp, 2009). The earliest established provincial fishery stations in Thailand were located in water-abundant areas. Naturally, such areas are relatively better endowed and likely to be more productive for agriculture *per se* (and indeed other value-added opportunities), making such areas better off. When aquaculture has been promoted in areas that are "poorer" and more marginal for agriculture, both the relative importance of aquaculture and the horizontal benefits (e.g. through improved water availability for surrounding horticulture) have been found to be more critical for alleviating the poverty of producers (proximate and related impacts) than better endowed areas. Promoting aquaculture in such areas,

characterized by greater abundance of perennial water resources and typically, wild stocks of aquatic animals, has often been less successful; in Cambodia a shortage of perennial surface water and related natural fish stocks in some provinces distant from the Great Lake and major rivers stimulated interest in aquaculture based on hatchery seed (Gregory and Guttman, 1996; Morales, 2007).

Agriculturally high productivity areas may be home to the greatest numbers of poor people; Minot and Bausch (2005) found that most poor people lived in areas of Viet Nam outside of the areas that had proportionally more poor. This makes the issue of targeting important; the Vietnamese Government recently chose to promote aquaculture actively in areas with higher proportions of poor (e.g. mountain and coastal areas) and yet immanent development of aquaculture through stronger commercial drivers has been rapid in the main delta areas. Belton and Little (2011b) have challenged the idea that project-driven interventions typically result in large-scale adoption and benefit for the poor. Instead, they claim that development in various forms typically drives entrepreneurial activity and the strongly commercial forms of aquaculture that develop result in large-scale benefits through employment throughout the value chain.

Sometimes aquaculture development projects, such as the Northwest Fisheries Extension Programme (NFEP), focused on a poorer region particularly deficient in wild stocks and undeveloped with respect to aquaculture infrastructure, such as northwest Bangladesh. Once the project had been initiated, however, it soon became apparent that private-sector networks were already well established (particularly with respect to seed supply), and the challenge then became to support them to benefit poorer stakeholders (Lewis, Wood and Gregory, 1996; Islam, 2002).

A long-term relative decline in the price of fish in markets is one important outcome of areas where commercial aquaculture has become established. Given the high income elasticity of demand exhibited for fish in much of Asia (Dey *et al.,* 2005), this means that poorer consumers particularly benefitted. This too has occurred in Egypt, where aquaculture has expanded from 50 000 tonnes to 700 000 tonnes between 1998 and 2008 and stabilized the source of fish, making it the most affordable source of animal protein for the poor.

Aggregate data on a regional or national level often lead to misinterpretation of the importance of aquaculture to local economies, as national aquaculture statistics are notoriously unreliable, and especially so for widely scattered small-scale farms (Bondad-Rentaso and Prein, 2010). Although aquaculture is considered important to the Philippines on a national level, the country featuring within the top-ten of global aquaculture producers (FAO, 2009), only 1 percent of the national labour force is employed. In contrast, tilapia culture contributes 50

percent of municipal income and employs 10 percent of the labour force in the Lake Sebu area of Mindanao (Hishamunda *et al.,* 2009).

The simple substitution of common-access aquatic natural resources by privately owned aquaculture has rightly been identified as a mechanism through which poorer people dependent on natural stocks can suffer directly through loss of access to a key food (Islam, 2009; Adduci, 2010). Furthermore, poorer people may suffer indirectly through impoverishment of other aspects of their livelihood. Such impacts may range from reduced agricultural productivity through salinization effects on crops caused by inland saline shrimp production (Goss, Burch and Rickson, 2000) to reduced quality of freshwater for the neighbours of catfish production and processing in Viet Nam linked to effluents (Quach, 2008; Anh *et al.,* 2010). Much greater productivity and employment benefits are often used as rationale to legitimize support for such transformations, for example, from mangrove to shrimp, that involve changes in tenure and often disenfranchisement (van Mulekom *et al.*, 2006). Intensified management of common property also has a mixed record in terms of success. In practice, group or "community"-focused support often delivers only short-lived benefits, entirely fails to live up to expectations of the participants, or actually creates or exacerbates conflicts among those involved.

The substitution of open-access but low-yielding, biodiverse aquatic commons into more intensive productive entities has a mixed record reflecting both practical constraints and prevailing cultural norms. Local organizations may have quite variable capacities to support adaptive learning and ensure that access to, and governance of, the resource remains inclusive and poverty oriented. In Laos, the relative success of stocking and management of common-pool resources which reflects efforts to ensure adaptive management has been core to the development effort (Arthur *et al.*, 2010). In contrast, developments in Bangladesh have been more uneven. While Valbo Jørgensen and Thompson (2007) documented successful socio-economic impacts for the poor, partly achieved through long-term consensus building (Sultana and Thompson, 2004) and a variety of other tools critical to achieving positive impacts of the institutional transformation of managed common-pool resource, others (e.g. Toufique and Gregory (2008) in their case study of floodplain aquaculture) found that in spite of attempts to protect the access and rights of poorer stakeholders, elite capture and exclusion of the poor had occurred. Hallman, Lewis and Bugum (2003) found that promotion of group-focused pond aquaculture among women in Bangladesh resulted in lasting embitterment because of the failure of the collective action required.

Adger *et al.* (2002) described the situation of coastal shrimp farming in Viet Nam as resulting in poorer fishers' livelihoods being negatively impacted and reduced social resilience; similar reports have arisen elsewhere in Southeast Asia (e.g. in the Philippines, Primavera, 2006). Flaherty, Vandergeest and Miller

(1999) detailed the specific perceived negative impacts in rice growing areas of the introduction of inland shrimp farming in Thailand. Over a longer time scale, many of these fears have been assuaged; Belton and Little (2008) detected that unsustainable shrimp development in parts of central Thailand have underpinned the evolution of more sustainable forms of aquaculture over the longer term as entrepreneurs and farmers have demonstrated adaptive learning on a broad scale. Islam (2009) describes the phases of resistance, ambivalence and normalization for shrimp culture in the semisaline zone in Bangladesh as local people have gradually perceived greater benefits of the changes from rice to shrimp farming.

Farming seaweeds for carageenan is a popular alternative livelihood approach that has been introduced into several tropical developing countries to provide income for poor coastal fishing households (Sievanen *et al*., 2005). Initially developed in the Philippines, it has been introduced into Indonesia, which is now the world's largest producer, and has been introduced from Asia to coastal regions of Tanzania (Rice *et al*., 2006). The majority of the product (90 percent) enters the global value chain for carrageenan, an ingredient in foods and other products, that has grown at 5–7 percent per annum. Seaweed farming certainly has many positive attributes (e.g. see Msuya, 2009), but the producers may be particularly vulnerable to exploitation with boom and bust cycles.[2]

Towards well-being

Well-being, as opposed to income or "wealth", has emerged as an important approach to distinguishing "experienced", economic and income poverty (Rojas, 2008).

To paraphrase White and Petit (2004) "does more aquaculture development mean greater well-being?" Such a question begs the questions what is well-being and how can it be measured. Well-being has been related to three sets of issues "having", "doing" and "thinking" (White and Petit, 2004). The "thinking" questions, i.e. how people assess and value aspects of their lives, how they prioritize and "join up" the various strands of their lives, complement a livelihoods approach that focuses on the assets, access and activities embodied in the other two aspects. The "being" in the term stresses the importance of security, both physical and economic, but also underlying social relationships and the "state of the mind". These aspects are critical because there may be real conflicts between wealth generation *per se* and enhancing well-being, e.g. the trading off required by households of their young female members migrating to work in seafood processing factories and supporting rural households with remittance income compared to "losses" in other values. The studies of Bouahom, Douangsavanh and Rigg (2004) of the dichotomy occurring

[2] Presentation by I. Bryceson on *Linkages and interactions between fisheries, aquaculture, aquatic ecosystem health, human poverty-wealth and human health* presented at the 7th Asian Fisheries Forum, 2 December 2004, Penang, Malaysia.

between generations in Lao villages based on migration for work and the urban pull and that of Rigg *et al.* (2008) on the impacts of the reconfiguration of rural space occurring in parts of central Thailand on well-being related to modernity encapsulate some of these contradictions.

Well-being stresses the positive and avoids the stigma that can heighten tensions between better off and poorer in any community. The NFEP "village fish pond" approach (Islam, 2002) sought to diffuse tensions by targeting whole communities for support rather than only poorer households within them. Increasing social status through successful adoption of aquaculture even when financial returns remain limited may be critical: "According to Anil, a member of the Garo Adivashi tribe in Bangladesh 'success of pond culture earned him respect in the community, with Adivasis and Bengalis alike coming to him for advice on fish culture'" (Barman, 2009).

Haque *et al.* (2010) found that the motivations for irrigated rice farmers adopting and retaining the production of seed and food fish in ricefields were multifactorial and poorly explained by dominant factors (i.e. availability of land and broodfish), reflecting the versatility and utility of the activity. Rainfed pond-owning farmers in northeastern Thailand rarely optimized fish production but valued the multiple products and services that an on-farm perennial water source supplied in such a seasonal marginal agro-ecosystem (Little *et al.* 2007). Important among their reasons were the improved availability and convenience of food and medicinal products once obtained from the wild and the satisfaction of growing food uncontaminated with pesticides, all of which heightened their sense of well-being.

Non-financial exchanges, especially the gifting of fish to neighbours and extended family, were found to be relatively more important in poorer areas of Bangladesh than the better off (Haque *et al.,* 2010). The practice was highly important among extended kin networks of pond gleaners in Manila Bay, Philippines, particularly the old and infirm, who were unable to participate themselves (Parker, 2008).

Improvements to the absolute standards of living of the largest and poorest rural group in Bangladesh, agricultural day labourers and fishers, have occurred in areas of commercial aquaculture development. Most (90 percent) of fishers, now working in harvest teams contracted by *Pangasius* farms to thin out and harvest fish in Trishal, Mymensingh, Bangladesh, improved their household food consumption since fish farming became established in the area and were satisfied by improvements in their overall standard of living with regard to clothing, housing and healthcare (Faruque, 2007). Ito (2002) questioned if the gains made by such poorer actors as a result of expansion in *Macrobrachium* culture in parts of Bangladesh were sustainable, noting a tendency for migrants to take local peoples' jobs over time and for womens' employment to be particularly low paid and hazardous.

The roles of aquaculture in improving human welfare can therefore certainly exceed monetary values and range from enhanced self-confidence and self-worth to stabilizing and sustaining the natural resource base. The rationale for a farming family or a family without land to become involved in aquaculture is based on multiple factors, the drivers for which are typically linked through positive feedback mechanisms. Fundamental to these are improved availability of food and security of access to food of high nutritional quality in the face of seasonality and environmental and economic shocks. Total or partial self-sufficiency by the household or access to purchase locally produced fish are typically highly regarded where fish has an important cultural value; quality, particularly freshness and convenience of fish supply are highly regarded.

Food security and consumer entitlements

Background

Food security has been defined as "all people, at all times, having physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). However, recent food shocks have focused policy-makers in some countries towards ensuring food security as a national goal, and its use has often become confused with self-sufficiency (Economist, 2009). Food sovereignty, the concept that a given country has enough resources to make available food demanded by its people, irrespective of its origin, has become the practical "norm" for governance of food systems in many countries. However, the term has more recently been associated with the growing food sovereignty movement that advocates greater local control of food production and freedom from the organized power of science, business and mainstream politics in agriculture (Pimbert, 2006). In contrast to the use of the term food security at national and global levels to focus on the supply side of the food system, its greatest value is probably as a measure of household and individual welfare in combination with assessments of household food acquisition and allocation behaviour (Pinstrup-Anderson, 2009).

Food is often shorthand for "dietary energy". However, food availability does not guarantee access, and enough calories does not ensure people consume a healthy and nutritious diet. Hence the emphasis in the FAO definition on nutritional value and the inclusion of the concept of nutritional security. The addition of "food preference" also changed the focus of security towards socially and culturally acceptable food.

At the household level, the idea of food security has been used as a measure of welfare and focus for development (Pinstrup-Anderson, 2009). Food insecure households cannot meet the needs of all members either on a permanent (chronic insecurity) or transitory basis; the latter normally relates to periodic shortages often relating to seasonality. In practice, seasonality in availability

of fresh fish, and/or variability in capacity to preserve aquatic animals can undermine "fish security" in a range of contexts. Variation in the intrahousehold allocation of food, however, can mean that individuals remain malnourished although the household as a whole is food secure; this is particularly prevalent in some cultural contexts. Even when access to high-quality food is possible for all individuals, a range of other non-food factors such as sanitation and health care can influence its nutritional impact. The necessity to integrate food and nutritional security is clear, since ill health related to micronutrient imbalance has been identified as a greater problem than hunger in achieving the MDGs (Shetty, 2009). The relative success of promoting aquaculture to support dietary diversification rather than alternative approaches such as biofortification also needs analysis. The nutritional significance of the poverty trap has been identified as a key element because of the power of the positive feedback linkages that nutritional status has, especially on the well-being of the most vulnerable. Access to quality food (and water) may be the single most important requirement to escape poverty because of the positive feedback associated with nutritional status and potential for other development.

The contribution of smallholder aquaculture to food security has been another important aspect of its promotion (Prein, 2002). The broader aspects of aquatic food security are first considered before implications for expansion of fish production either displacing or complementing other food production are considered. The potential nutritional impacts of replacing wild with farmed fish are discussed before the changing roles of farmed fish in diets, particularly of poorer people, are examined. The implications for the pond on a farm acting as focus for agricultural and nutritional diversification and methodological issues in their study are assessed. Finally some of the potential negative impacts of aquaculture on food security are reviewed.

Broader aspects of food security

The implications for aquaculture on food security cannot be divorced from supplies from capture fisheries, since they typically enter the same markets and are often indistinguishable. The politics of aquatic food security at the national level is demonstrated by countries such as Japan that enjoy high levels of per capita consumption and cultural attachment to fish in the diet (Smith, 2008). Japan has had long-term policy to achieve food "self-sufficiency" through expansion of its fishery sector and negotiation of international arrangements to reduce the economic burden of importing its necessary supplies. In common with other wealthy but food-poor states, Japan has long looked to become aquatic food secure, and in recent years has increasingly augmented fisheries with investment in and/or purchase of farmed fish and shrimp from poorer countries (Hall, 2004). The European Union (EU) is similarly dependent on importing fish from third, often less-developed countries (NEF, 2011). This position has effectively undermined the aquatic food security of many poorer countries. China, having rapidly increased consumption of livestock (including

aquaculture) products in the diet in recent years, has an alternative strategy, i.e. to exceed its food selfsufficiency requirements through importing feed ingredients and through a range of technological innovations to increase its production of farmed seafood (Zhao *et al.,* 2008).

There are many other threats to aquatic and broader food sovereignty and security for poorer countries, however, including the impacts of broader development that damage natural resources. In the rush to extract energy and mineral wealth, often in partnership with regional powers, poor states such as Lao PDR which are heavily reliant on aquatic food, are undermining their food security and urgently need to invoke the precautionary principle around the fundamental importance of food (Fullbrook, 2010).

The implications for sustaining local production and consumption of aquatic foods under pressures of global seafood markets are considered later in the review.

Quality vs quantity

The prioritization at international and national levels of "calorie security" rather than food security in the holistic sense remains problematic. The case for optimizing grain production through intensification over nutritionally more valuable food stuffs inevitably imposes a trade-off, particularly given shortages of water and land. This has been documented for the relative lack of focus on development of pulses in South Asia (Negin *et al.,* 2009) and is clearly the case for impacts on wild fish stocks in Asia.

In contrast to many other foods, fish and other aquatic products harvested at the community and household levels often contribute to daily subsistence, but the productivity of the system is sensitive to changes in agriculture, particularly water management practices. "Poor in all but fish" (Gregory and Guttman, 1996) makes the case that at low levels of rice production, typically in rainfed agro-ecosystems in Southeast Asia, rural people essentially support their subsistence needs for fish (and thus high-quality food) through managing wild stocks in and around their rice fields. Irrigated agriculture, in which flood control is introduced, historically has been followed by a rapid decline in such natural productivity. Lower yields of a wide diversity of aquatic products are the direct result of pursuing higher yields of rice.

At a more fundamental level and in contrast to many other food products, fish and other aquatic foods are still obtained from natural stocks at community and household levels, but these are increasingly managed to some extent. However, the productivity of these systems is sensitive to changes in agriculture, particularly water management practices. Nguyen Khoa *et al.* (2005) assessed the impacts of irrigation on ricefield-based fish production and found that wet season and large–scale off-farm managed irrigation systems were more likely

to be detrimental to the productivity and diversity of wild stocks than small and medium-scale structures on or near farm, for which impacts were generally benign.

Expansion of aquaculture at the expense of rice fields, while considered a positive diversification of the rural economy in many quarters, is considered to be a threat to grain self-sufficiency and rationale for limiting expansion of fish pond construction by others. On a macro-level, it may strengthen the case for promoting the integrated production of rice and fish, since in addition to benefits such as reducing pesticide use, multiple land functions are retained and more balanced nutrition likely (Halwart, 2006).

Pond construction has often been a by-product of house and road construction.[3] Large expansions of pond construction have occurred in some geographical locations over very short periods of time. This has often been in areas that were low lying and relatively unproductive but has also included the use of high-quality agricultural land, with implications for production of staple grains and other forms of diversification.

In tandem with this has been a process of aquaculture intensification, particularly through the use of increased supplementary feeding and formulated diets that has in some cases resulted in land use for aquaculture either not expanding very fast in recent years or actually contracting. These trends are particularly clear where the cost of land rental has risen fast, for example in some peri-urban areas or where clusters of commercial aquaculture have become established.

Implications for farmed fish substituting for wild

There are potentially important nutritional implications for any change in human diets based on a shift from wild fish to farmed fish. Farmed fish fed on supplementary and complete diets tend to be higher in lipids than wild fish, even of the same species. For rural diets traditionally deficient in fat, it can be speculated that this may be highly advantageous where chronic protein-energy malnutrition remains common in vulnerable groups.

The quality of fats, a key element that fish bring to rice-based diets in addition to high-quality protein, is likely to change. Generally with intensification, studies have shown ratios of the critical highly unsaturated fatty acids (HUFA; W3:W6) decline and become less optimal. Karapanagiotidis *et al*. (2006) found that wild tilapia had more optimal ratios than fish raised intensively in cages (with fish raised semi-intensively more variable, depending on the specific method of production). The same authors (Karapanagiotidis *et al.,* 2007) also showed that

[3] Presentation by D.C. Little, N.R. Biswas, B.K. Barman, M.M. Haque, D. Turongruang, A. Shinn, M.A.R Hossain, P. Price, G. Milwain, E. Morales, Z.F. Ahmed & F. Ul Islam on *Enhancing aquatic diversity while promoting aquaculture among the poor – 'win-win' development in Asia* presented at World Aquaculture 2009, September 25–29, World Trade Center, Vera Cruz, Mexico.

the composition of farmed fish could be modified through change in the diets fed. Widespread substitution of wild fish by farmed fish with suboptimal lipid profiles to feed urban populations could exacerbate the nutritional impacts of changing diets. The widely believed generalization that pellet-fed fish are more expensive and less affordable for poorer consumers than those from semi-intensive systems is, in some cases, no longer true. Intensively raised pellet-fed *Pangasius* is now one of the cheapest fish available to poor consumers in Bangladesh, while semi-intensively produced carps are much more expensive and often beyond their reach (Belton, Haque and Little, in press).

Fish are nutritionally important in many rice-based diets through their micronutrient content and, importantly, their bioavailability. Vitamin A, calcium, iodine, iron and zinc are known to be important (Roos, Thisted and Wahab, 2002; Roos, Thilsted and Islam, 2004). Research by Roos, Thilsted and others has established the potential nutritional impacts of substitution of small indigenous fish by farmed fish. Impacts are related not only to differences in the nutritional content of different species but also to how their size and taste affect preparation and consumption. Thus, the particularly high vitamin A content of mola carplet (*Amblypharyngodon mola*), especially concentrated in the eye, its small size and likelihood to be consumed whole optimizes intake of this vitamin and calcium, since the head, eyes and soft bones of small fish are also typically consumed. In contrast, farmed species eaten at a larger size tend to have much lower levels of micronutrients. In another study, Roos, Thisted and Wahab 2002) suggested that regular consumption of small fish met 40 percent of vitamin A and 32 percent of calcium needs during the peak fishing season of poor rural families in Bangladesh. A major issue is that wild fish often attract a premium in the market and cultured fish, often of relatively small size, have now become cheaper, more available and thus a mainstay of poorer peoples' diets (see footnote 3).

Farmed fish – roles in the diets of the poor

Access to farmed fish by the poor is highly context specific. The increasing numbers of urban poor are mainly dependent on purchase from markets, although open-access urban waterbodies, typically highly eutrophic and productive, may also be important sources. The rural poor were traditionally and, in many cases still are, dependent on wild fish for meeting their dietary needs. In areas with a strong wet:dry seasonal pattern, this has always imposed constraints on the availability of fresh fish, often leading to a strong cultural reliance on, and affinity for, processed forms: fermented, salted and dried.

Promoting smallholder aquaculture has often been based on the premise that this results in fish farming households eating more fish (Ahmed and Lorica, 2002), but there has been little research to correlate increased production, resultant levels of consumption and impacts on household nutritional security. Rural livelihoods in Southeast Asia are still mainly based around the production

of rice and aquatic animals, both stocked and unstocked, which are increasingly managed as an intrinsic part of the system.

A three-country study in the region that evaluated the roles of farmer-managed aquatic systems (FMAS) in two agro-ecological settings (i.e. low-lying, flood-prone and higher, drier sites) found that better-off and poorer households sourced aquatic animals from four major sources, namely FMAS, open-access waterbodies, the market and as gifts (Morales, 2007). This study found large differences in dependence on stocked hatchery fish compared to non-stocked fish, with poorer households being relatively more dependent on small household ponds than the better off. In contrast, Belton, Haque and Little (in press) found that the better-off households raising carps in ponds in Mymensingh, Bangladesh, were less food insecure than the general population and that the impact of consuming self-produced fish on their food security was probably less significant because of their ability to access fish from the market and elsewhere.

More recent interviews to understand consumption habits of some of the poorest people in Bangladesh by Barman *et al.* (unpub.data) found that for female-headed households employed as brick and stone breakers, expenditure levels on basic foodstuffs exceeded 90 percent of income. Unable to catch fish themselves, the limited amount of fish they consumed was purchased as cheaper small wild or farmed fish, with trends in consumption towards the latter. Milstein, Kadir and Wahab (2008), as part of their research in polyculture development, reported on the interest in small silver carp (*Hypophthalmichthys molitrix*) by poorer farmers "because they can afford to eat rather than sell". This sentiment has been found widely among poorer households managing to stock fry (that are increasingly affordable and available) and manage self-recruiting stocks of tilapia and a variety of unstocked indigenous species in small ponds, ditches and rice fields that they can access.

Barman Little & Edwards (2002) found that over several decades tilapia had become established in the patchwork of perennial and seasonal ponds of northwestern Bangladesh as a "silent harvest". It was recognized as a "local fish" because it was too small and too low in value to be worth marketing (principally by men) but easily accessible by women and children by angling.

Production and even consumption, rather than sale of fish produced in small-holder systems, does not necessarily result in those most requiring high-quality nutrition accessing it. Intrahousehold fish consumption patterns are strongly related to gender and age in Bangladesh. Thus, nutritionally vulnerable adolescent girls, whose nutritional status affects not only their own but future generations' capacity for development, may have far poorer diets than males of the same age and other household members.

Haque *et al*. (2010) identified a wide range of factors that made the low-cost, low-risk entry into ricefield-based tilapia culture a net benefit for poorer rice farmers in northwestern Bangladesh, subject to certain conditions. Despite their value as seed fish, small tilapias were highly valued as food; their convenience and accessibility appeared to have particularly supported consumption by some of the more nutritionally vulnerable household members, the young, old and women.

Recent studies (Morales, 2007; Haque *et al.*, 2010; Karim *et al*., 2011) revealed aquaculture to be a coping mechanism for poorer farmers' security in a number of ways, providing both quality food and income but also allowing investment in both human and social capital. In studies of more commercially oriented nursery operations in neighbouring West Bengal, Barman (unpub) observed the land-poor people involved operating such high-input:high-output systems through lease arrangements. In such cases, cash may be used to purchase cheaper foods. Several studies have shown that fish producers often continued to buy and/or catch fish from natural sources for much of their needs (Karim, 2006; Faruque, 2007; Morales, 2007; Kawarazuka and Bene, 2010). This is typically strongly variable from season to season and year to year, with periods during the wet season when consumption is still dominated by the wild catch of ricefield fish. Farmers may be strategic in their behaviour towards managing their on-farm water resources. In Cambodia, farmers only showed interest in stocking hatchery seed when early rains were poor and wild fish yields were expected to be low (Gregory and Guttman, 1996).

Methodological issues

There are numerous methodological constraints to understanding food security and the supporting role of aquaculture. Determining household size and per capita consumption, and their interpretation in terms of poverty, is beset with practical problems and interpretation issues (White and Masset, 2003). Hiogh sHigh levels of seasonality of access to, and consumption of, fresh aquatic foods are common, necessitating costly repeat measures. Intrahousehold perceptions of food insecurity can be quite variable, particularly where food-related responsibilities are strongly related to gender. There were significant amounts of discordance between genders regarding the perception of food insecurity in Bangladesh, with women far more than men, claiming that a consumption reduction strategy that included not eating "big fish" to be important. This illustrates the necessity for individual-level and age and gender-specific measures to complement household data and for proportionate representation of vulnerable individuals (Coates *et al.,* 2010). The recall of fish consumption information, even when supported with broader dietary data, is often piecemeal and uninformed by type, size and source (i.e. purchase, self-catch or gifting) or information regarding preparation and actual consumption data. In this context and especially where household-managed systems are used as day-to-day sources of food, reliable estimates of intrahousehold consumption are often lacking.

Claims made as to the importance of specific nutrients (e.g. iron or vitamin A) need to be assessed in the context of whole diets. Estimates of fish consumption alone are, therefore, quite limited in determining the nutritional impacts of increasing fish production and consumption. In recent years, the promotion of smallholder fish culture has often come as part of an integrated package as promoters have increasingly advocated building linkages between the fish pond as an on-farm reservoir and surrounding horticulture. Such integrated aquaculture-agriculture systems (IAAS) have often aimed to improve household nutrition and generate income, and these are now assessed.

Impacts of water and nutrients from fish ponds on broader food security

Ponds often have a key or principle role as an on-farm water source rather than for fish production, particularly in marginal rainfed agro-ecosystems. This may even be the case where ground water exists but pumping costs preclude its economic use. Where fish production was not a key focus in pond construction, its role in food security therefore requires broader interpretation. Development initiatives have often promoted fish and vegetable production because of the presumed synergies and expected greater efficiency of land and water use. Such systems have also been a key part of traditional Asian IAAS, such as the integrated mulberry dyke system in the Pearl River Delta, China (Ruddle and Zhong, 1988) and VAC systems in Viet Nam. The role of aquaculture in terms of overall food nutrition often begs reassessment, especially with regard to consumption of other quality dietary items increased as an outcome of such IAAS.

In an assessment of impacts of aquaculture and vegetable promotion projects in Bangladesh, Hallman, Lewis and Bugum (2003) found that “at risk” groups (i.e. school-age children, adolescents and older adults) in adopting households had a larger share of calories derived from green leafy vegetables. Adolescent girls, who are both nutritionally and socially vulnerable, consumed more total calories in adopting households and, in general, school-aged children and adolescents in adopting households were slightly taller. Preschoolers and older adults in adopting households had less acute and chronic illness.

Promotion of IAAS in Malawi has also demonstrated the nutritional significance of on-farm pond-based diversification for improving household well-being. While fish yields have remained low, mainly due to limited on-farm resources for pond nutritional inputs and a lack of availability of external inputs required to enhance productivity, farming households used pond water to support vegetable production for sale and consumption (Brummett, Lazard and Moehl, 2008; Dey *et al.*, 2010).

Karim *et al.* (2011) observed important differences in consumption among rural and peri-urban located pond-owning households in Bangladesh, suggesting their different strategies. Whereas rural households consumed relatively more of their

own fish and vegetables, those located closer to urban centers produced more of both and tended to sell more and eat less themselves. The context of food item substitutability is clearly different, with market purchases being relatively more important for those located closer to urban areas. Few differences were found for better-off and worse-off households in production or consumption of fish or vegetables, but this might reflect the limited distinction between the groups in terms of agricultural assets; an analysis of purchasing behaviour found significantly lower overall expenditure in the poorer group (Karim *et al.,* 2011).

Potential negative impacts of aquaculture on food security

Aquaculture has been identified as a major route through which poorer people with few assets are denied access to common-pool fisheries on which they have great dietary reliance. Such developments have been observed for both coastal and inland environments, as the returns from commercial aquaculture have led to resource grabbing by elites, whether locals or outsiders (e.g. Stonich, Bort and Ovares, 1997; Vandergeest, Flaherty and Miller, 1999; Islam, 2009; Adduci, 2010). This is undoubtedly an area of major controversy and research need given the multiple stressors that common-pool resources face. There is evidence that aquaculture in areas with a previous high dependence on fishing by the poor, such as in ghers (trenched rice fields) in Jessore, Bangladesh, has resulted in greater employment and social mobility (Faruque, 2007), but there is also evidence to the contrary (e.g. Ito, 2004). Livelihood diversification through aquaculture value chains, whether domestically or internationally driven, undoubtedly leads to higher employment, but the quality and sustainability of such employment of the poor in many instances requires further research.

The indirect loss of access to small wild fish by poor people as they are increasingly sourced as feed ingredients for cultured fish is another important potential threat to the food security of vulnerable groups. This appears to be a transitional arrangement in many cases, however, as once a significant demand for feed is in place, private-sector feed producers, often diversifying from poultry feeds, tend to begin supplying the demand. The trend toward use of formulated diets, of course, may merely shift the impacts, both environmental and social, towards the world's declining industrial and artisanal fisheries (Hasan and Halwart 2009). The high value of small wild fish to local people appears to have raised its value, making its use as a fish feed uneconomic in some contexts (Hambrey, Edwards and Belton, 2008; Hasan and Halwart, 2009). There is some evidence that this means that the poor lose access, however (see above).

There may be qualitative impacts on an increased proportion of farmed versus wild fish in the diet (see above) but equally, the control that farming allows can reduce certain nutritional risks that consumption of enduring wild stocks pose. The contamination of wild fish through industrial dumping led to high levels of dioxin and other persistent compounds in wild fish in Viet Nam (Minh

et al. 2009), causing serious public health impacts that are still evident. Such contamination risks from farmed fish are, theoretically, more avoidable but remain a major issue in terms of improving traceability and trust.

The widespread occurrence of foodborne trematodes (FBTs) in certain parts of Asia makes the promotion of further fish consumption through aquaculture potentially a risky strategy if such fish are not well cooked before consumption (Phan *et al.,* 2010). Studies have shown that both wild and cultured fish were at similar risk from infection currently at the sites in northern Viet Nam (Phan *et al.,* 2010), but that given management safeguards within culture systems, these could be reduced for farmed fish. Any relatively greater reliance of the poor on wild and farmed fish may therefore pose differential risks and requires further investigation.

Concerns are regularly raised about contamination of food chains for all farmed livestock including fish. Some of these relate to purposeful attempts to reduce feed costs through adulteration, such as the use of melamine (Anderson *et al.*, 2011). Others involve accidental contamination such as that which caused unacceptably high levels of dioxin in eggs and milk. In Egypt, there are concerns that the law, which proscribes use of any surface water for aquaculture other than agricultural drainage water, may increase risks of contamination of farmed products with pesticides and metals. Other potentially significant indirect mechanisms for a decline in overall food security include the loss of environmental resources and reduction in water quality associated with poor disposal of aquaculture effluents. Groundwater extrusion for intensive aquaculture resulting in salinization of aquifers remains a risk to peoples' well-being in many semisaline zones. The need to purchase bottled drinking water by residents downstream of intensive *Pangasius* production in the Mekong Delta (Quach, 2008) is likely to disproportionately impact poorer people. Both require careful regulation, which is notoriously difficult in LDCs with rapidly growing, dynamic and geographically dispersed aquaculture. The maintenance of public health safeguards under such conditions appears likely to become polarized between products destined for domestic consumption and international markets that are becoming increasingly subject to various forms of certification and oversight (Broughton and Walker, 2010). This raises the issue of how the globalization of aquaculture value chains may potentially benefit or adversely affect the poor which is considered in the next section.

Progress, opportunities and improvements – aquaculture as a driver for development

Local and global aspects of aquaculture development

The last decade has witnessed a massive expansion in export-oriented aquaculture, but the vast majority of aquaculture production in LDCs remains for domestic consumption. Even the recent history of massive export growth

in China is dwarfed by the significance of its rapidly growing domestic market (Broughton and Walker, 2010; Little, 2010), much of which is carps with little potential for export. There is, however, a significant regional trade in Indian major carps between South Asian countries and the Middle East and Europe for migrant workers. In terms of impacts on poverty, the effects of changes in demand for farmed fish within producer LDCs, often linked to urbanization, are likely to have more impact. Given comparative growth potential and expected changes in purchasing power together with trade governance mechanisms being developed, this is unlikely to change greatly in the future.

The rapid demographic and accompanying settlement changes evident in some of the key LDCs in which aquaculture has grown rapidly explain many of the changes in the field. Rapidly escalating demand for cheap, usually freshwater, fish to feed migrant workers in cities as far apart as Delhi, Lagos and Cairo has been an important early driver of growth in commercial production and marketing networks, but there are now a number of second and third generation developments underway. Often centers of production are located in essentially peri-urban areas and/or along development corridors such as Dhaka-Mymensingh in Bangladesh or Hanoi-Hai Duong in Viet Nam.

In Nigeria, intensive culture of North African catfish (*Clarias gariepinus*) in and around urban centers is a growing success. In contrast to the problems that constrain aquaculture development generally in sub-Saharan Africa (Brummett., Lazard and Moehl, 2008), both high-quality seed and feed are available from a competitive private sector, and unfulfilled demand from urban markets is driving demand from the 5 000 or so commercial enterprises in operation (Miller and Aleem, 2010).

In Southeast Asia and other areas where fish is a preferred food, people tend to both consume more fish as they become wealthier and demand greater variety. This is confirmed in many of the national consumption surveys around the region (Delgado *et al.*, 2003). This, in turn, drives diversification of demand and in turn, production by farmers. The migration of rural populations to urban centers appears to have stimulated what might be termed "cuisine shifts", where once low-value rural foods are now in higher demand. The (cultural) value of wild-caught riverine fish has certainly increased as a result of becoming more scarce, leading to higher cuisine-led demand in urban centers, creating a higher demand for alternative, indigenous species to which farmers have responded. The promotion of the various high-value catfishes and carps (Mekong giant catfish (*Pangasianodon gigas*) and *Hemibagrus wyckioides* are being cultured in Thailand, and stinging catfish (*Heteropneustes fossilis*) and pabdah catfish (*Ompok pabda*) in Bangladesh) are good examples, as are the recent development of climbing perch (*Anabas testudineus*) in the same country. This can have other impacts. There is now an established market for silver carp previously raised only for direct human consumption as a feed for Chinese softshell turtle (*Pelodiscus*

sinensis) and other carnivorous species raised in the Red River Delta, Viet Nam, for the high-value Hanoi market. Demand for the same and other turtle species in China, some of them endangered in the wild, has reached massive scale (Haitao *et al.,* 2008), with implications for sourcing appropriate feeds.

Urbanization can have impacts on the development of aquaculture in rural areas, through influencing acceptability of novel species and their preparation. The widespread acceptability of small deep-fried tilapia by rural migrants in urban Thailand has undoubtedly impacted on its popularity in rural areas over time as migrants have returned home (Little and Bunting, 2005), illustrating the influence of rural-urban linkages.

Regional markets, particularly trade between neighbouring countries, have long been a feature of fishery marketing systems in LDCs. Aquaculture products have now become well established, especially as high-value live products (e.g. freshwater and brackishwater seed) and food that is often transformed as dried, salted or smoked products. These value chains afford opportunities for employment, often for poor people. Thus seed networks have been examined in some detail, with research showing the potential for poorer farmers to participate in nursing (e.g. Little, Surintaraseree and Innes-Taylor, 1996; Haitook, Kosy and Little, 1999; Litdamlong, Meusch and Innes-Taylor, 2002). However, other research indicates the multiplier effects, typically around ethnic and kinship linkages that develop and drive trade. Hence, displacement of Bengalis from Bangladesh during its liberation war to far-flung locations in western India, as well as to the major fish culture area in West Bengal, India, has led to transcontinental trade (by train) in freshwater seed. Similar trade typically carried out on a seasonal basis by poor people occurs between neighbouring states such as Bangladesh and India, Nepal and India, and Viet Nam, Laos and Cambodia. Live hybrid catfish from Thailand are traded far into Laos, but processed snakeskin gourami (*Trichogaster pectoralis*) have a much longer established trade throughout Southeast Asia, founded on one of the earliest occurrences of fish culture in Thailand.

Higher market value fish are sold live from mainland China to Hong Kong SAR. Subtle differences in climate within the region can also drive the market. The year-round production of soft-shell turtle, mainly on the eastern seaboard of Thailand, supported a lucrative trade in air-freighted live turtle to southern China for several years until trade restrictions were imposed. Expensive marine fish such as grouper, fattened from wild-caught juveniles by part-time fishers in southern Thailand, are sold to premium Chinese urban markets throughout the region (Sheriff, Little and Tantikamton, 2008). This system is a good example of poor marginalized communities being able to complement fisher livelihoods with high-value products through aquaculture. It is also an example of how a technical gap (i.e. the lack of hatchery-produced juveniles) can favour such disadvantaged groups. The pros and cons of technical changes that are characteristic of aquaculture on the poor are now considered.

Technological development and the poor

The high prices that poor coastal fishers who have adopted grouper farming in southern Thailand continue to enjoy (Sheriff, Little and Tantikamton, 2008) reflect the scarcity and status of the product. The constraints to hatchery production of grouper juveniles ensure that over-production is avoided. Fishers have a comparative advantage, as they are able to source wild juveniles and the trash fish needed to fatten them locally for the opportunity cost of their time. Poor shrimp and prawn postlarvae fishers in Bangladesh have been identified as a particularly vulnerable group (Ahmed and Troell, 2010) but appear much less secure, as their activities have been associated with unsustainable environmental impacts and banned. Probably more importantly, a competitive hatchery sector is now established that can supply demand more consistently, although hatchery postlarvae continue to be perceived as being of poorer quality than wild-sourced seed.

Although once established in the private sector, hatcheries and nurseries may have modest direct impacts on poor livelihoods (Belton, 2010), they can have considerable multiplier effects. Prior to the development of carp and catfish hatcheries in Asia, harvest and nursing of wild seed was a seasonal activity for people living close to major rivers. In these cases, development of hatcheries has permitted a vast scale-up of food fish production and ancillary networks. One study of a cluster of nursery enterprises in northern Viet Nam found that the number of nursery enterprises had increased from three in 1950 to more than 100 by 2000 (Prax *et al.,* 2000), with concomitant impacts on forward and backward linkages that tend to provide livelihood opportunities for poor people.

Edwards (2010b) has documented several case studies indicating the benefits to the poor as producers within the nursery sector in Asia from carps and tilapias in West Java, Indonesia, shrimp in Thailand to marine finfish in Bali, Indonesia. Some of these occur on a significant scale. There are reportedly 26 000 small-scale hatcheries owned by individual smallholder farmers or farmer groups using traditional technology to breed freshwater fish species in West Java. Studies including Little, Nietes-Satapornvanit and Barman(2007) suggest that expansion of the nursery sector away from hatchery clusters and closer to sites of grow-out could greatly benefit poorer actors, and this is considered below.

The technological barriers to entry to certain parts of the value chain by the poor have often been shown to be surmountable by innovative practice. Early hatchery designs were typically capital intensive and developed by engineers for the public sector. Once in the private sector, design and practice have often been simplified and costs reduced, leading to considerable local social learning and adaptation. Ponds and hapas have substituted for concrete tanks, use of surface water for deep tube well water and converted ricefields instead of lined ponds. The case of prawns and shrimp in Thailand serve as good examples of such farmer-level innovation (Kongkeo and Davy, 2010). A major threat to the enduring success

of the Thai small-holder shrimp hatchery sector is the increasing dominance of specific pathogen-free (SPF) broodstock and postlarvae that has developed based on imported brood shrimp. A paradox is that the disease-free postlarvae produced appear to have contributed in large part to the improved sustainability of shrimp production by both smaller and larger grow-out producers.

International markets for farmed aquatic products and the poor

The capacity that producers have shown in adapting systems to their own resources and local markets is now potentially challenged in terms of reaching and maintaining access to international markets. The challenge of smallholders responding to globalization has been the focus of an increasingly heated debate of the benefits to development of such trade and efforts to regulate it, particularly through standards setting and certification (Bush, Khiem and Sinh, 2009; Belton *et al.,* 2011a). Smallholders have largely formed the bedrock of the rapidly developed aqua-product export industries, but the degree to which they can either link into or stay connected to these dynamic markets is now determined largely by their capacity to comply with market safety and quality requirements (Beveridge *et al.,* 2010). They also remain vulnerable to market forces and politics, in addition to the "usual" environmental, quality and disease-related vulnerabilities. The recent history of trade in *Pangasius* between Viet Nam and the United States of America and, subsequently, Europe is sobering (Bush and Duijf, 2011) and indicates how value chains need capacity to adapt, often over very short periods of time.

The observation that aquaculture is perhaps more likely to benefit farmers who are able to negotiate access to higher-value market chains means that this category of farmer is also likely to increase his/her vulnerability to a wider set of (market) processes. This is in contrast to enterprises less exposed to such economic forces and for which environmental vulnerability may be more important. It also suggests that vulnerability in value chains might well be a more useful concept than poverty when assessing the potential of aquaculture in supporting the livelihoods of small-holder aquaculture farmers and those associated in ancillary services. The exposure of small holders to international markets through global value chains has in many instances increased their earning power, as well as their exposure to what for many are new forms of economic risk. In many value chains, smallholders are considered powerless to avoid exploitation. Marginal groups in global value chains are therefore often considered as being systematically disadvantaged within increasingly globalized relations of production (Nadvi, 2004). These groups may well be "poor" in either or both national or international "a-dollar-a-day" quantitative terms. However, more importantly, they are those who are restricted in developing the necessary capabilities to improve their livelihood by wider political, social and economic factors and relations of production (Bebbington, 1999). Following this logic, farmers who are labeled as "poor" are not the only vulnerable group in the context of global, regional or even domestic value chains.

As such, vulnerability may well prove a more useful analytical concept than poverty in understanding the marginalization of smallholder aquaculture farmers in value chains. Vulnerability provides a more considered appraisal of the contextual factors that determine the capability of producers to upgrade their position in value chains (Nadvi, 2004). Following Bolwig *et al.* (2010), we can use the concept of vulnerability to:

1. identify the dynamics, patterns, arrangements and processes that may lead to durable inequality and marginality;
2. understand the sensitivity of livelihood systems to external shocks and the factors that reinforce their resilience;
3. analyze the degree of leverage producers have to access and control resources in markets, change the terms of market access and respond to governance arrangements such as quality standards.

The vulnerability of farmers and other actors in such value chains is therefore derived from their capacity to negotiate the terms and conditions of incorporation into different value chains, in addition to their capacity to command control over the factors of production and improve production processes. A failure to do so on favourable terms results in what is known as "adverse incorporation" (Ponte, 2008).Farmers may also decide to "opt-out" or choose, dependent on their capability, to "upgrade", "downgrade" or "outgrade" their production through engagement in alternative, or modified activities (Humphrey and Schmitz, 2004). In some cases, farmers may well be forced out of production, or decide to "hang in" with the hope of high returns at a later date (Dorward, 2009). Alternatively, they may be able to intensify production and in so doing negotiate better terms of incorporation in global markets (Dorward, 2009).

Many of these alternatives are associated with mitigating risk. For instance, some aquaculture systems in which the primary product is raised for export also produce significant secondary products with local value at both production and processing levels. Thus, freshwater prawn culture in Bangladesh producing tails for export typically occurs in polyculture with carps and self-recruiting species that are sold locally; this can diversify income for the producer and form part of the fish-catching team's benefit. This situation is analogous to the co-production of an export crop such as coffee or cocoa with subsistence or domestic market-oriented crops in traditional home gardens; such systems are both ecologically and socially more resilient than monocultures, and many have potential for further improvement (Chandrashekara, 2010). Potential strategies to support smallholders and other poor actors in negotiating their positions in value chains are discussed later.

The varied forms and scales of aquaculture now in existence suggest a relationship with poverty alleviation that can be defined by the level and scope of change in livelihoods. Strongly commercially oriented aquaculture can support radical and significant change to livelihoods at the household, community, regional

and even national level. In contrast, the uptake and adoption of aquaculture can also have impacts which are seemingly more modest and harder to quantify but which support incremental change at the individual, household or broader societal level.

Impacts on livelihoods – local and global options

Aquaculture that has occurred in Asia, the Americas, Africa and Europe and been linked to global export products such as salmon, shrimp and tilapia has had radical impacts on supplies of these products in the market and the livelihoods of those involved. However, it also relates to the much more heterogeneous commercial aquaculture that has emerged to supply growing urban domestic markets in Asia and elsewhere. Other characteristics of such radical change stimulated by aquaculture include the contexts where it has become a dominant source of income and major determinant of labour organization at the household or community level. This has occurred in a variety of ways, from the single corporate entity in a formerly poor area in Honduras producing tilapia intensively in cages and claiming to have transformed employment opportunities and well-being of significant numbers of local people, to fish seed production and marketing clusters in Asia that in recent decades have measurably improved livelihoods among the majority of inhabitants.

These types of examples are, through their very nature, relatively geographically concentrated. In the Mekong Delta, *Pangasius* catfish production has grown at an unparalleled rate and brought multiple benefits directly and indirectly, through production, processing and elsewhere in the value chain. Shrimp production has probably achieved similar change in parts of coastal Asia, over a longer time scale, but criticisms of negative social and environmental impacts (e.g. Skladany and Harris, 1992; Stonich, Bort and Ovares, 1997; Stonich and Bailey, 2000), once warranted, now need review and holistic reevaluation. The impacts on poverty through enhanced employment opportunities, particularly in the processing sector, still require comprehensive assessments, particularly from the view of overall well-being. Moreover, significant changes in production technology and management have reduced proximate environmental impacts in shrimp through much reduced effluents from low-water exchange shrimp production systems (McIntosh, 2010).

Barriers to poorer producers entering or staying in global value chains appear to be rising however, partly in response to the rise of private regulatory systems. Over the last decade, there has been a shift from quantitative to qualitative policies and governance. The most direct impact of such policies has been the rise of grades and standards through a variety of state and international voluntary certification schemes. The impacts of this shift have been manifold. The first point relevant to the present review is the impact this shift has had on small and medium-sized producers. A second related point concerns what "services" are being developed to support these farmers as they are drawn into (sometimes multiple) international regulatory networks over food safety

and quality, including social and environmental issues (Vandergeest, 2007). The evidence suggests that the cost of compliance with such standards greatly advantages larger, capitalist and corporate types of aquafarming and that the outcomes of various approaches to support collective action of smallholders are still unproven (see below).

In Asia, there are now several examples of how "boom and bust" aquaculture based on a single valuable crop (i.e. shrimp, *Pangasius*) can be followed, after an adaptive response at various levels, with the development of a more diversified and perhaps sustainable aquaculture. Such second or third generation forms of aquaculture may be more rooted in local markets and demand or continue to serve international markets. Belton and Little (2008) report on such a process in central Thailand for shrimp, and Loc *et al.* (2010) in Viet Nam record an interesting shift in production for smaller farmers producing shrimp and *Pangasius* for global markets towards lower risk, domestically traded species – tilapia, mudskippers, gourami and crab. The resilience and ability of producers to adapt are uncertain, and likely to be variable and relate to their broader livelihood asset portfolios. Labrousse (2009) reported the different outcomes of a decline in farm-gate price on *Pangasius* farms in the Mekong Delta, Viet Nam. Whereas smallholders retaining their orchards have been largely able to stay on-farm, many households who had completely converted to *Pangasius* were forced to find off-farm labour opportunities. While both types of farmers were forced to "step-out", those with more diversified on-farm resources retained more options.

There are likely to be broader implications for the failure of a significant proportion of the current aquaculture industry to meet international standards. One scenario proposed for China is that a two-tier system will result in local, especially poorer, people missing out on independent oversight and products destined for local markets potentially becoming a source of contaminated food (Broughton and Walker, 2010).

There are other outcomes of aquaculture remaining and further developing a domestic market orientation. Belton *et al.* (2011a), in a comparison of Viet Nam (export oriented) and Bangladesh (domestic oriented), identify the latter as having greater pro-poor characteristics overall. The less intensive Bangladeshi production has relatively greater employment opportunities, enhances local low-cost food availability and is more resilient in the face of unstable international markets.

There are clear prerequisites for aquaculture delivering such radical outcomes to livelihoods in a given context. These include access to markets and input supplies, in turn typically related to functioning roads and other infrastructure. An effective legal framework and functioning land market are also necessary, although the large-scale adoption of commercial aquaculture has been questioned in terms of its impact on equity. While Irz *et al.* (2007) reported a positive impact on rural equity for coastal aquaculture in Pampanga Province in

the Philippines, despite ownership of land being highly skewed, in Bangladesh aquaculture may have the opposite effect in some instances (e.g. Toufique and Gregory, 2008). In some areas where land costs have increased sharply in response to commercial aquaculture becoming established, poorer farmers lacking in capital opportunities to develop ponds themselves gain more through higher lease incomes than is possible from rice cultivation and diversification to other livelihood opportunities.

Incremental change to complex livelihoods through aquaculture

Aquaculture has also impacted on poverty and well-being through incremental change despite forming a relatively minor part of livelihood portfolios in some instances. This may relate to seasonal employment or returns from production constituting less than 50 percent of total household income, often much below. Belton *et al*. (2011b), in a meta-analysis, found that most "quasi-peasant" aquaculture in Bangladesh made up less than 15 percent of total household income. Similar results have been found elsewhere in Asia (e.g. Morales, 2007). Motivations for adoption and retention in the household's portfolio of activities typically relate to a range of continued, often qualitative, benefits. Many of the advantages associated with smallholder aquaculture may relate to its complementarity to overall household labour use. Inputs are typically modest during the culture cycle, and contracting out of labour-intense activities is a common practice, especially at harvest.

Pond-based culture may be complementary with incentives to store water on farm as a multipurpose resource, particularly in a strongly wet:dry climate, considering that fish production within on-farm water management strategies is an increasingly important aspect of agriculture in areas of inconsistent rain-dependent marginal agriculture. Despite the examples of more commercially oriented aquaculture and the most productive agriculture being developed in "high-potential" areas in Asia, LDCs generally remain heavily dependent on rainfed production; 55 percent of the gross value of the global food supply is still produced under rainfed conditions on more than 70 percent of the world's harvested cropland (Woolley, Cook and Molden, 2009). It is thought that more than half of the world's rural poor live in low-potential areas, mainly in Asia (Leonard, 2009 in Ashley and Maxwell, 2001), and the proportion who become functionally landless is expected to grow. On-farm storage and management of water supporting diversification have emerged as one part of such a strategy (Woolley, Cook and Molden, 2009), but for the landless, improved access to rainfed common poor resources that are currently under-utilized presents a major opportunity[4].The incorporation of aquaculture within watershed approaches to development may require a focus on developing capacity for social adaptive learning, market development and/or cash transfers, depending on the context.

[4] Presentation by G. Haylor and S.D. Tripathi on *Contemporary aquaculture policy and practice in rural India reassessed from the perspective of social inclusion* presented at the National Workshop on Social Inclusion in Rural Development, 9 July, 2008, Bhubaneswar, Orissa.

The well-being of smallholders, in spite of livelihood diversification that includes or may be dominated by off-farm employment is, in the words of Enfors and Gordon (2008), "often intimately linked with local agro-ecological productivity which is largely constrained by water availability". Ponds, of which one use may be fish production, are "water system technologies" that might have value in escaping dry-land poverty traps. A critical part of how households that incorporate aquaculture within mixed and largely rainfed farming systems enhance their overall well-being appears to be highly related to seasonal benefits to subsistence and/or through small cash benefits during "hungry gaps". A range of studies in the last decade that have evaluated aquaculture on a "stand alone" basis suggest it makes little economic sense and does not explain adoption or retention, but even relatively small ponds and associated waterbodies can become part of a coping mechanism to avoid nutritional distress, conserve meager cash resources at critical times and maintain social relationships. As such, they may be playing an important part in preventing vulnerable farming households falling into poverty (see comments relating to Krishna earlier) by increasing their overall resilience.

In tandem, the costs of initiating and maintaining aquaculture as a minor strategy on farm have also fallen. Opportunities to obtain required inputs, knowledge, cost of seed and nutritional inputs, together with a decline in the real costs of pond construction have occurred particularly in areas where economies have been growing.

The importance and impacts of local market development to support both "quasi-peasant" and "quasi-capitalist" aquaculture are clear from case studies from both Asia and Africa, as is their coexistence. The importance of aspiration towards "subsistence" in fish production at a household or even community level where continued availability of a variety of species, including indigenous varieties, retains a strong cultural and increasingly, cash value are motives for aquaculture to be retained and further developed as a minor household enterprise (Rossiligni, 2008). The emergence of systems combining aspects of both fish culture and capture mirrors trends to part-time farming and extensification of rice production in some parts of Asia as the urban-based component of many livelihoods strengthen. However, for all the benefits of smallholder aquaculture, the evidence suggests that the most resource-poor people, when adopting secure off-farm employment as the mainstay of their livelihood, benefit only incrementally through direct production. Experience suggests that the provision of subsidies of various types do not appear to change this situation.

Strategies moving forward

A major lesson from the last decade has been improved data to support the hypothesis that commercially oriented "quasi-capitalist" aquaculture can radically change livelihoods of the poor, mainly though generation of employment opportunities through the value chain. The benefits from "quasi-peasant"

aquaculture to the poor are more context dependent and in general of a secondary and incremental nature. Rapid spread of this form of farm diversification among even poor farmers suggests that it enhances well-being on a number of levels. There are clearly a number of policy measures that can support one or both of these types of aquaculture. Tenure to use of land and water may be critical. Efforts to promote aquaculture in the Philippines, Viet Nam and Egypt included the issue of long land leases to provide security to investors and reassurance to lenders. In the Philippines, fish ponds were granted long leases and once developed, lands were titled and transferable and exempted from the comprehensive agrarian reform programme designed to redistribute land (Hishamunda *et al.* 2009; Stevenson and Irz, 2009). Such policies could easily have unintended consequences, however; original grants of 400 ha, later reduced to 250 ha for corporations and 50 ha to individuals, resulted in lop-sided distribution towards large farms and speculative holdings and also encouraged extensification and mangrove destruction. Viet Nam has promoted aquaculture through making it an obligation on local authorities to grant 20–50 year leases and within 90 days of applications being submitted.

Targeting

There is still a widespread assumption by some that aquaculture can and will benefit the poor wherever it is promoted, and that its impacts are always positive. Others believe that any benefits have been vastly overplayed and that aquaculture remains a bastion of the wealthy and often undermines both social and environmental resilience.

A major question in contexts where its role in the mitigation of poverty has been demonstrated remains, what are the most cost-effective means to achieve this objective? For all its potential pitfalls, targeting is clearly a requirement given the heterogeneity of low and medium income countries and the nature of poverty and vulnerability that occurs among their people.

Most efforts over the last decade, and indeed prior to this, have in some way attempted to build adaptive capacity among the poor, typically poor producers, through advocacy, training and local institutional strengthening. Given the primary roles of the poor as intermediaries in value chains and as employees, a major focus should be training and other forms of support for poor actors within value chains who are non-producers. The costs of specialization required of outsiders (whether government, NGO or commercial knowledge brokers) mean that the focus should be on building capacity within the targeted stakeholder groups and, in parallel, a broad level of dissemination of any critical new technical or market knowledge through low-cost approaches that the poor can access locally. Advances in, and reduced costs of, communication technology should support exchange or practical-based visits to successful but otherwise similar contexts. In areas where commercial aquaculture has gained a significant presence, the cost of delivering such support should be shared through public-private

initiatives. Tripp (2001) suggested that new agricultural technology development remains critical for lifting people out of poverty, although arguably appropriate generic technologies exist for aquaculture, and constraints relating to adoption of aquaculture by the poor are more likely to be social and institutional. Certainly support strategies are likely to be very different for the emerging class of commercial farmers, many engaged with global commodity chains, who need support in managing information and skill-intensive knowledge in contrast to the needs of a semisubsistence often part-time farming class.

New thinking has emerged over the last decade as to how this can be best and most cost-effectively implemented. The concept of producer clubs, such as has been promoted in India by the Network of Aquaculture Centres in Asia-Pacific/ Marine Export Promotion and Development Authority (NACA/MPEDA) among small shrimp producers to upgrade their systems and market their products (Umesh *et al.,* 2010), is an example of adaptive management in practice and an approach to social and environmental resilience. Detailed analyses on impacts on poverty, both among the producers and wider networks are urgently required, as are lessons learnt on the effective governance of such institutions in India and similar developments elsewhere (Little, 2010).

The role and sustainability of private and non-formal sector approaches to delivering information and services through information and trading nodes (one stop aqua shops, OSAS) also requires more widespread piloting and development. Initiated in eastern India and Bangladesh as project-based initiatives, they have recently been piloted in East Africa (SARNISSA, 2010). In Uganda, technical support to fish farmers is now provided by private-sector consultants, facilitated by the dissemination of public-sector agricultural support funds to farmer organizations.

Opportunities for aquaculture interventions in common-pool resource contexts are likely to persist in LDCs. The shared characteristics of such resources underpin claims for increased potential for inclusion of the poor, especially the functionally landless. However, despite such seemingly democratic credentials, aquaculture development has a poor track record in these systems. Failure is often attributed to associated physical constraints, including the inherent unpredictability of production parameters in semiclosed systems. However, institutional failures are a major contributory and arguably underlying cause for many examples of unsustainable "sunset" development. Indeed, there are many examples of poorly considered interventions creating or igniting latent resource conflicts. These failures operate at the non-governmental and governmental levels, as illustrated by case studies from Sri Lanka (Murray, 2006). Traditional village settlements in rainfed lowlands occur around seasonal reservoirs used for a range of functions. Development interventions typically focus on the primacy of one or more productive-functions, ignoring a wide range of alternative functions: symbolic, religious, social, etc., with a mix of competing

and synergistic interactions. Furthermore, interactions occur at much wider levels beyond the immediate resource boundary, both physically and socially. Such relations are the focus of watershed development models elsewhere but have seen little effective integration of aquaculture.

Current impacts on the poor are strongly related to benefits through employment which are magnified by the fragmented and complex nature of value chains; these provide a multitude of niche opportunities partly through technical "inefficiencies" that include the "leakage" of systems through stock losses and postharvest gleaning. In the interim, these provide opportunities for safety valves for the poor, but population trends suggest that rural areas will potentially become holding grounds for the very young and old as a majority of working-age adults migrate to industrial and urban areas for better paying off-farm livelihood opportunities (Ashley and Maxwell, 2001). This will have implications for employment and labour efficiency. Also, as relative increases in functional landlessness are likely, most farms will become commercial, larger and more closely integrated with respect to inputs and outputs, logically resulting in less "niches" currently filled by poor actors. Rural livelihoods will increasingly become more non-agricultural in origin, but often linked to agriculture. This is amply demonstrated in areas of commercial aquaculture for which employment in ancillary services has grown rapidly and investments made to support further employment growth in these areas.

Better methodological approaches are required to understand the impacts of aquaculture on poverty that seek to clarify negative outcomes on stakeholders who are not producers or even involved directly in the value chain. A key necessity is a better understanding of the variability and dynamics of the physical and human systems that define aquaculture through a well-defined and adequate sampling frame.

Matching the agricultural agenda for transforming countries (World Development Report 2008) – an aquaculture agenda.

The World Development Report 2008 (WDR) (World Bank, 2007) identified seven themes in a development agenda for transforming countries (Table 3) around which this review is summarized.

Arguably the "blue revolution" has occurred on many fronts in the last few decades and is not characterized by a series of narrow technocentric developments in germplasm development and chemistry such as launched the green revolution several decades earlier. The role of urban income drivers within transforming countries in kick-starting aquaculture development are clear, as indicated by many of the examples given above. The global trade in aquaculture products has been largely initiated through smallholder production, but such producers face many challenges and significant consolidation has occurred. Survival of smaller producers will require both institutional and technical innovation to

TABLE 3
Themes to the agenda for transforming countries

	Theme	Notes
1	Green revolution to new agriculture	Rapid growth of urban incomes and demand for high-value products are the major drivers for faster agricultural growth and poverty reduction in transforming countries, although sustainable productivity growth in food staples requires continued attention. Because there are scale economies in processing and marketing of many high-value products, institutional innovations such as contract farming can reduce the transaction costs and risks to smallholders. Linking smallholders to processors and retailers can also create access to more financial capital through banks – and provide technology, extension and buyback arrangements, while monitoring food safety. A high priority is to improve the investment climate for agribusiness and facilitate collective action through producer organizations to reach scale in marketing and to bargain for better prices. Reform of price and subsidy support to cereals will also be needed in many cases to provide the incentives to diversify to high-value products.
2	Dealing with water scarcity	Reforming institutions in irrigation, removing policy distortions such as water and electricity subsidies, and providing a supportive environment for trade and macroeconomic policies are all important steps in improving water productivity and meeting competing demands. Broad-based reforms require strong champions and equitable allocation of water rights to overcome the political obstacles. As scarcity worsens, water markets may come into play, with support needed for their emergence and eventual regulation.
3	Making intensive systems more sustainable	Reducing the environmental footprint of intensive agricultural systems, especially agrochemical and animal waste pollution, is a priority for improved environmental and human health. It will also reduce the drag on productivity growth from land and water degradation. More sustainable agricultural practices will require a judicious combination of getting incentives right (through input and output prices), application of improved management technologies such as integrated pest and nutrient management, and better regulation.
4	Development of lagging areas	With the shift to the new agriculture and the declining farm size in high-potential areas, increasing farm productivity and incomes in less-favoured regions can secure the livelihoods of subsistence farmers and bring them to the market. Productivity growth in these regions rests on major investments in soil and water management, in agricultural research and in new approaches to extension, supported by reforms in pricing and marketing for grains.
5	Rural development off the farm linked to towns	Growth in rural non-farm employment in many cases remains closely linked to growth in agriculture, as agriculture is the main supplier of intermediate inputs to other sectors such as processed foods (forward links). Regional and territorial development of agricultural clusters – with the processing and packaging of high-value products – is an opportunity for rural non-farm development. In densely populated countries, urban-based industries will drive the rural non-farm sector through urban-to-rural subcontracting. Investments in infrastructure and skills and improvements in the investment climate for the private sector are the policy priorities. Developing land market to enable small farms to consolidate for efficient operation and to shift labour to non-farm activities and migration is also a priority.
6	Skills for successful migration	Successfully moving out of agriculture, whether by moving to the rural non-farm sector or by migrating to urban areas, depends on more and better quality education. Massive investments in human capital are needed to prepare the next generation to leave agriculture. Programmes that provide conditional transfers, such as cash grants in Bangladesh conditioned on school attendance, can increase the demand for education, but they will fail unless the quality of rural education is greatly improved.
7	Safety nets for those left behind	Transforming countries have the largest concentration of the world's poor, so direct support through well-designed and well-governed employment schemes in rural areas – including rural infrastructure, reforestation, soil conservation structures, small dams and desilting of canals and ponds – can reduce poverty, improve the rural investment climate and restore degraded natural resources. Significant monitoring, accountability mechanisms and rigorous evaluations are needed to ensure effective and equitable resource use.

Source: World Bank (2007).

reduce transaction costs and risks through better linking to, and greater equity within, value chains.

Overcoming water scarcity is a key linkage between aquaculture and broader agriculture, since some forms of the former are profligate users of water and a major issue is the extent to which they are consumers. IAAS have been promoted mainly on a small scale as part of diversified smallholder food production systems, but similar thinking now needs to be applied at all scales of production. Intensification of aquaculture has implications for efficiency of water use, both direct and indirect, through use of more feeds requiring irrigation for their production. Approaches to aquaculture promoted for poorer people such as integrated rice-fish systems will also need to consider water efficiency as a key parameter as water regulation and costs increase.

A major and continuing developmental trend is the intensification of aquaculture. A key element in making intensive aquaculture systems more sustainable is the reduction of adverse environmental impacts, both proximate and global, and this requires more interdisciplinary approaches to R&D. Measures taken to ensure greater sustainability are also likely to support further growth in global trade. The widespread and increasing use of formulated diets is expected to further expand, even as aquaculture in extensive forms becomes better integrated into overall water resource use.

Aquaculture, even when "inefficient" in stand-alone terms, can be an important component to approaches aiming to enhance well-being in marginal agro-ecosystems "lagging" in development, and relatively greater attention should be shifted to the governance and use of the numerous and often under-utilized rainfed waterbodies.

The huge growth in commercially oriented quasi-capitalist and capitalist aquaculture, typically in location-specific contexts, particularly in Asia, indicates the benefits for addressing rural poverty of improved linkages and often, migration, to urban areas. The rise in importance of the development of rural non-farm value chains, both for input supply and processing, has been documented. Skilled migrants have been important to the transfer and adoption of aquaculture in many parts of the world. Much of the aquaculture now present in Southeast Asia, for example, originated through Chinese immigrants and their descendants (Edwards, 2004), and movement of ideas and products continues to energize and advance the sector. The mobility of a variety of "actors", from poor seed traders to employees of transnational corporations (e.g. Goss, Burch and Rickson, 2000) implementing turnkey projects, is a continuing and critical part of this story.

Transforming countries have the largest number of poor people most dependent on fish for their nutritional security. The further development of urban-rural

linkages is critical to the safety net that aquaculture development can support. In addition to remittance income, where appropriate, the further development of water storage infrastructure and institutional changes that allow access to water resources for the rural poor for subsistence and income generation are warranted. Support for adaptive change towards efficient and equitable resource use should be at the centre of these efforts. A summary of poverty issues in relation to development of aquaculture s given in Table 5.

	Characteristics					
Relations of production	**Quasi-peasant**		**Quasi-capitalist**		**Capitalist**	
Production intensity	Low	Low or moderate	Moderate	Moderate or intensive	Moderate or intensive	Highly intensive
Capital & operating costs	Limited	Moderate	Substantial	Substantial	High	Very high
Ownership & labour	Family owned & operated	Family owned & operated	Family owned & operated	Family owned & operated or absentee owner Part-time &/ or permanent labour	Family owned & operated or absentee owner Permanent labour Managerial staff	Absentee owner or corporate ownership Permanent labour Professionalized managerial, technical & clerical staff

TABLE 5
Summary of poverty issues in relation to development of aquaculture

	Poverty issues	Positive	Negative
1	Low and erratic income flows	Involvement in aquaculture value chains can increase seasonal or year-round income generation, either through ownership or leasing of production facilities or through employment. Intermittent harvest and trading of fish can smooth income flows and consumption demand. Short-cycle systems such as aquatic vegetables and juvenile production tend to particularly good cash flow.	Income flows from small household managed systems are often marginal, and the risks of loss (e.g. flooding, theft) predicate against further investment.
2	Low and erratic food availability	Increased levels of aquatic farming increase abundance and availability of products for consumption and/or purchase. May supply food during hungry gaps, particularly in marginal agro-ecosystems.	Resources used for aquaculture (e.g. "trash" fish, fishmeal/oil) may have direct human consumption value for the poor or result in inputs being diverted away from traditional uses (e.g. brans, oilcakes, etc.), with negative impacts on livelihoods of the poor.
3	High opportunity costs of land/water	Opportunities for rental income for those with land/water.	Poorer people lose access to resources year-round, seasonally or periodically.
4	Landlessness	Rise of a market in leased ponds may allow opportunities for landless people to participate. Landlessness does not constrain access to other employment opportunities in the value chain, i.e trading of inputs and products, processing. Cage farming can be practiced by land-poor households.	Landlessness and poor access to other assets may constrain opportunities for direct involvement in culture. Landless people may not have the other resources and capacities to support high-input cage systems.
5	Price of aquatic products in markets	Aquaculture development can lead to stabilization or even declines in the real price of aquatic foods, which is good for poor consumers.	Price declines can also reduce margins for farmers and others in the value chain
6	Nutritional quality of aquatic products	Farming can allow manipulation of the nutritional quality of fish and other aquatic products. Potential environmental contaminants affecting unmanaged stocks in open waters can be controlled or avoided.	Pressures to decrease production costs can stimulate the use of poorer quality feed ingredients and/or inputs that may negatively impact on human health (e.g. antibiotic residues, etc). Difficulty in controlling contaminants from the external environment.
7	Lack of knowledge	Households learning about fish culture and/or other aspects of the value chain that may enrich other aspects of life and potential employment.	Lack of knowledge may constrain uptake and adoption of activities within aquaculture value chains.

TABLE 5 (Continued)

	Poverty issues	Positive	Negative
8	Intergenerational food and income security	Evidence for poorer households, even those with small culture systems, consuming more fish and, if integrated, also have improved access to meat, eggs and vegetables. Adoption of aquaculture may lead to the returns being preferentially invested in children's education .	Intrahousehold access to, and consumption of, fish and other related cultured products may not reflect greatest needs of household members.
9	Enhancing well-being	Benefits from adoption of aquaculture are often numerous and relatively minor when considered individually but taken together meet many social, consumption and other felt needs.	
10	Difficulty in targeting poor groups	Interventions have been successfully targeted to groups most at need, including those involved as service operators in value chains	Danger of creating conflicts and competition among poor people and between the poor and the better off, exacerbating tensions. Ignorance of stakeholders who can "lose out" through aquaculture development.
11	Elite capture of benefits of aquaculture	See 10. Sustaining benefits among poorer groups typically requires culturally sensitive institutional change, capacity building and on-going support. Even in contexts where elite capture has occurred, the range of employment niches generated can be positive to poorer people.	Aquaculture can support elite capture of common-pool resources and lead to gross inequities within value chains.
12	Risk and resilience of farming aquatic products	Household ponds and diked embankments, particularly those that can store water year-round, can support socio-ecological resilience for both producer households and other community members through maintaining consumption and income flows (see 1, 2) and offer protection against both drought and flood and associated crop productivity and survival. Institutional development among members of aquaculture value chains (e.g. producer groups) may be critical to longer-term risk management strategies, especially those exposed through use of high input, open culture systems dependent on global markets.	Aquaculture, particularly high input, intensive systems, can be highly risky, potentially exposing producers and others in the value chain to risk. Dependence on external markets for inputs and products intensifies such risks.
13	Ponds as multipurpose resources, especially on-farm water storage	Ponds that support multicommodity food production are likely to enhance resilience (see 12). Polycultures within ponds and the use of ponds both as a location and source of water for irrigation of surrounding crops are key features that can enhance benefits and mitigate production or market failure. The value of aquaculture systems as nutrient sinks that can be exploited by surrounding agriculture is typically under-optimized.	Multiple outputs from IAA often demand more complex management and access to resources that are not compatible with poor livelihoods dependent on off-farm employment. Sustained, commercially oriented IAA typically require significant access to knowledge and inputs.

References

ADB. 2004. *Small-scale freshwater rural aquaculture development for poverty reduction. Special evaluation study*. Manila, Operations Evaluation Department, Asian Development Bank. 67 pp.

Adduci, M. 2010. Neoliberal wave rocks Chilika Lake, India: conflict over intensive aquaculture from a class perspective. *Journal of Agrarian Change,* 9(4): 484–511.

Adger, W.N. 1999. Social vulnerability to climate change and extremes in coastal Vietnam. *World Development,* 27(2): 249–269.

Adger, W.N., Kelly, P.M., Winkels, A., Huy, L.Q. & Locke, C. 2002. Migration, remittances, livelihood trajectories, and social resilience. *Ambio*, 31(4): 358–366.

Ahmed, M. & Lorica, M.H. 2002. Improving developing country food security through aquaculture development – lessons from Asia. *Food Policy*, 27: 125–141.

Ahmed, N. & Troell, M. 2010. Fishing for prawn larvae in Bangladesh: an important coastal livelihood causing negative effects on the environment. *Ambio,* 39: 20–29.

Andersen,W.C., Turnipseed, S.B.,Karbiwnyk,C.M., Evans,E., Hasbrouck, N., Mayer,T.D.,Gieseker,C.M., Nochetto,C., Stine, C.B.,&Reimschuessel,R.2011Bi oaccumulation of Melamine in Catfish Muscle Following Continuous, Low-Dose, Oral Administration J. Agric. Food Chem. 59, 3111–3117.

Anh, P.T., Kroeze, C., Bush, S.R. & Mol, A.P.J. 2010. Water pollution by *Pangasius* production in the Mekong Delta, Vietnam: causes and options for control. *Aquaculture Research*, 42(1): 108–128.

Armitage, D., Marschke, M. & Plummer, R. 2008. Adaptive co-management and the paradox of learning. *Global Environmental Change,* 18: 86–98.

Arthur, R.I., Lorenzen, K., Homekingkeo, P., Sidavong, K., Sengvilaikham, B. & Garaway, C.J. 2010. Assessing impacts of introduced aquaculture species on native fish communities: Nile tilapia and major carps in SE Asian freshwaters. *Aquaculture,* 299: 81–88.

Ashley, C. & Maxwell, S. 2001. Rethinking rural development. *Development Policy Review*, 19(4): 395–425.

Bailey, C. 1988. The social consequences of tropical shrimp mariculture development. *Ocean and Coastal Management,* 11: 31–44.

Barman, B.K. 2009. *Fisheries and aquaculture enterprise development for Adivasi (tribal) communities in the northern and northwestern regions of Bangladesh (Adivasi Fisheries Project).* Final Project Report. Dhaka, WorldFish Center. 64 pp.

Barman, B., Little, D.C & Edwards,P. 2002 *Small-scale fish culture in Northwest Bangladesh: a participatory appraisal focusing on the role of tilapia*. p.227-244. In Rural Aquaculture. CABI Publishing, Wallingford

Barman, B.K. & Little, D.C. 2011. Use of hapas to produce Nile tilapia (*Oreochromis niloticus* L.) seed in household foodfish ponds: a participatory trial with small-scale farming households in northwest Bangladesh. *Aquaculture,* 317: 214–222.

Bebbington, A. 1999. Capitals and capabilities: a framework for analysing peasant viability, rural livelihoods and poverty. *World Development,* 27(12): 2021–2044.

Belton, B.D.N. 2010. The Social Relations of Aquaculture Development in South and Southeast Asia. Ph.D. Thesis. Stirling. University of Stirling. 211pp.

Belton, B., Haque, M.M. & Little, D.C (in press). Does size matter? Reassessing the relationship between 'small-scale' aquaculture and poverty in Bangladesh. *Development Policy Review.*

Belton, B., Haque, M.M., Little, D.C. & Sinh, L.X. 2011a. Certifying *Pangasius* in Vietnam and Bangladesh: who will make the grade and will it matter? *Food Policy,* 36(2): 289–299.

Belton, B., Karim, M., Thilsted, S., Jahan, K.M., Collis, W., Phillips, M. 2011b. Review of Aquaculture and Fish Consumption in Bangladesh. Studies and Reviews 2011-53. Penang: The WorldFish Center

Belton, B. & Little, D. 2008. the development of aquaculture in central Thailand: domestic demand versus export-led production. *Journal of Agrarian Change*, 8(1): 123–143.

Belton, B., & Little, D.C. 2011a. Contemporary Visions for Small-Scale Aquaculture. In: Chuenpagdee, R. (ed.) Contemporary Visions for World Small-Scale Fisheries. pp151-170. Eburon, Delft.

Belton, B. & Little, D.C. 2011b. Immanent and interventionist inland Asian aquaculture development and its outcomes. *Development Policy Review,* 29(4): 459–484.

Belton, B., Haque, M.M., Little, D.C. & Sinh, L.X. 2011. The social relations of catfish production in Vietnam. *Geoforum*. 43: 567–577.

Beveridge, M.C.M. 2004. *Cage aquaculture.* Oxford. Blackwell Publishing Ltd. 368 pp.

Beveridge, M., Phillips, M., Dugan, P., and Brummett, R. 2010. Barriers to aquaculture development as a pathway to poverty alleviation and food security: policy coherence and the roles and responsibilities of development agencies, in: Advancing the Aquaculture Agenda. Proceedings of a Workshop, Paris, 15–16 April 2010, pp. 199–209. Paris: OECD.

Beveridge, M.C.M. & Little, D.C. 2002. History of aquaculture in traditional societies. *In* B.A. Costa-Pierce, ed. *Ecological aquaculture,* pp. 3–29. Oxford, Blackwell Science.

Bharucha, Z. & Pretty, J. 2010. The roles and values of wild foods in agricultural systems *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences,* 365(1554): 2913–2926.

Bolwig, S., Ponte, S., du Toit, A., Riisgaard, L. & Halberg, N. 2010. Integrating poverty and environmental concerns into value-chain analysis: a conceptual framework. *Development Policy Review*, 28(2): 173–194.

Bondad-Reantaso, M. & Prein, M. (eds.) 2010. *Measuring the contribution of small-scale aquaculture: an assessment.* FAO Fisheries and Aquaculture Technical Paper No. 534. Rome, FAO. 180 pp.

Bosma, R.H, Hanh, C.T.T. & Potting, J. 2009. *Environmental impact assessment of the Pangasius sector in the Mekong Delta.* Wageninen, Wageninen University. 57 pp. (available at: www.afi.wur.nl/UK/publications/).

Bouahom, B., Douangsavanh, L. & Rigg, J. 2004. Building sustainable livelihoods in Laos: untangling farm from non-farm, progress from distress. *Geoforum*, 35: 607–619.

Brooks, S.E., Reynolds, J.D. & Allison, E.H. 2008. Sustained by snakes? Seasonal livelihood strategies and resource conservation by Tonle Sap fishers in Cambodia. *Human Ecology*, 36: 835–851.

Broughton, E.I. & Walker, D.G. 2010. Policies and practices for aquaculture food safety in China. *Food Policy,* 35: 471–478.

Brummett, R.E., Lazard, J. & Moehl, J. 2008. African aquaculture: realizing the potential. *Food Policy*, 33: 371–385.

Bush, S.R. 2004. *A political ecology of living aquatic resources management and development in the Lao PDR.* Ph.D. Thesis. Sydney, School of Geosciences, University of Sydney.

Bush, S.R. & Duijf, M. 2011. Searching for (un)sustainability in *Pangasius* aquaculture: a political economy of quality in European retail. *Geoforum,* 42: 185–196.

Bush, S.R., Khiem, N.T. & Sinh, L.X. 2009. Governing *Pangasius* for sustainable rural livelihoods and environmental performance: a review. *Aquaculture & Economics Management*, 13(4): 271–293.

Chandrashekara, U.M. 2010. Tree species yielding edible fruit in the coffee-based home gardens of Kerala, India: their diversity, uses and management. *Food Security,* 1: 361–370.

Coates, J.C., Webb, P., Houser, R.F., Lorge Rogers, B. & Wilde, P. 2010. "He said, she said": who should speak for households about experiences of food insecurity in Bangladesh? *Food Security,* 1: 81–95.

Collier, P. 2007. *The bottom billion. Why the poorest countries are failing and what can be done about it.* Oxford, Oxford University Press. 224 pp.

Costa-Pierce, B.A. 2002. The Ahupua'a aquaculture ecosystems in Hawaii. *In* B.A. Costa-Pierce, ed. *Ecological aquaculture*, pp. 30–43. Oxford, Blackwells Publishing.

Das Gupta, A. & Beard, V.A. 2007. Community driven development, collective action and elite capture in Indonesia. *Development and Change,* 38(2): 229–249.

Delgado, C., Wada, N., Rosegrant, M.W., Siet, M. & Ahmed, M. 2003. *Fish to 2020: supply and demand in changing global markets*. Washington, D.C., International Food Policy Research Institute and Penang, WorldFish Center. 226 pp.

Demaine, H. 2010. Rural aquaculture: reflections ten years on. *In* M.G. Bondad-Reantaso & M. Prein, eds. *Measuring the contribution of small-scale aquaculture: an assessment.* FAO Fisheries and Aquaculture Technical Paper No. 534. Rome, FAO. 180 pp.

Demaine, H., Innes-Taylor, N., Turongmang, D., Edwards, P., Little, D.C. & Pant, J. 1999. *Small-scale aquaculture in northeast Thailand. A case study from Udorn Thani.* Bangkok, Aquaculture and Aquatic Resources Management Program, Asian Institute of Technology. 86 pp.De Silva, S.S. & Davy, F.B. 2009. Aquaculture success in Asia: contributing to sustained development and poverty alleviation. *In* S.S. De Silva & F.B. Davy, eds. *Success stories in Asian aquaculture*, pp. 1–14. Dordrecht, Springer.

Dey, M.M., Paraguas, F.J., Kambewa, P. & Pemsl, D.E. 2010 The impact of integrated aquaculture–agriculture on small-scale farms in southern Malawi. *Agricultural Economics,* 41*:* 67–79.

Dey, M.M., Rab, M.A., Paraguas, F.J., Piumsombun, S., Bhatta, R., Alam, M.F. & Ahmed, M. 2005. Fish consumption and food security: a disaggregated analysis by types of fish and classes of consumers in selected Asian countries. *Aquaculture Economics & Management,* 9(1): 89–111.

Dixon, J., Gulliver, A. & Gibbon, D. 2001. *Farming systems and poverty, improving farmers' livelihoods in a changing world.* Rome, FAO and Washington, D.C., World Bank. 412 pp.

Dorward, A. 2009. Integrating contested aspirations, processes and policy: development as hanging in, stepping up and stepping out. *Development Policy Review*, 27(2): 131–146.

Dorward, A., Kydd, J., Morrison, J. & Urey, I. 2004. A policy agenda for pro-poor agricultural growth. *World Development*, 32(1): 73–89.Duit, A., Galaza, V., Eckerberg, K. & Ebbesson, J. 2010. Governance, complexity, and resilience. *Global Environmental Change,* 20: 363–368.

Duit, A ,Galaz, V, Eckerberga, K & Ebbesson, J. 2010. Governance, complexity and resilience, *Global Environmental Change*, 20: 363-368

Economist. 2009. Feeding the world. If words were food nobody would go hungry. November 21s-27, pp. 76–78.

Edwards, P. 1994. *A systems approach for the promotion of integrated aquaculture*. Integrated Fish Farming International Workshop, 11–15 October 1994, Wuxi, PR China.

Edwards, P. 2000. Aquaculture. Poverty impacts and livelihoods. *Natural Resource Perspectives,* No. 56. London, Overseas Development Institute. 4 pp.

Edwards, P. 2004. Traditional Chinese aquaculture and its impact outside China. *World Aquaculture* 35(1):24-27.

Edwards, P. 2010a. Review of small-scale aquaculture: definitions, characterization, numbers. Hanoi, Vietnam, FAO Expert Workshop on Enhancing the Contribution of Small-Scale Aquaculture (SSA) to Food Security, Poverty Alleviation and Socio-Economic Development, 21–24 April.

Edwards, P. 2010b. Successful SSAs and their contribution to economic growth at the national level and poverty alleviation and rural development at the local level. Hanoi, Vietnam, FAO Expert Workshop on Enhancing the Contribution of Small-Scale Aquaculture (SSA) to Food Security, Poverty Alleviation and Socio-Economic Development, 21–24 April.

Edwards, P., Little, D.C. and Yakupitiyage, A. 1997. A comparison of traditional and modified inland artisanal aquaculture systems. *Aquaculture Research* 28 : 777-788.

Edwards, P. & Demaine, H. 1997. *Rural aquaculture: overview & framework for country reviews.* RAP Publication 1997/36. Bangkok. RAP/FAO. 61 pp.

Edwards, P., Little, D.C. & Demaine, H. 2002. *Rural Aquaculture*. Wallingford, CABI Publishing. 358 pp.

Ellis, F. 2000. *Rural livelihoods and diversity in developing countries.* Oxford, Oxford University Press. 273 pp.

Ellis, F. & Biggs, S. 2001. Evolving themes in rural development 1950s–2000s. *Development Policy Review*, 19(4): 437–448.

Enfors, E.J. & Gordon, L.I. 2008. Dealing with drought: the challenge of using water system technologies to break dryland poverty traps. *Global Environmental Change,* 18: 607–616.

FAO, 1996. *Declaration on world food security.* World Food Summit. Rome, FAO.

FAO, 2009 *The State of World Fisheries and Aquaculture 2008*. FAO Fisheries and Aquaculture department, Food and Agriculture Organization of the United Nations, Rome

Faruque, G. 2007. *An exploration of impacts of aquaculture production and marketing on rural livelihoods in three regions in Bangladesh*. Ph.D. Thesis. Stirling, University of Stirling. 339 pp.Flaherty, M., Vandergeest, P. & Miller, P. 1999. Rice paddy or shrimp pond: tough decisions in rural Thailand. *World Development,* 27(12): 2045–2060.

Folke, C., Carpenter, S., Elmqvist, T., Gundersoin, L., Holling, C.S. & Walker, B. 2002. Resilience and sustainable development: building adaptive capacity in a world of transformations. *Ambio,* 31(5): 437–440.

Friend, R.F. & Funge-Smith, S.J. 2002. *Focusing small-scale aquaculture and aquatic resource management on poverty alleviation*. Bangkok, FAO Regional Office Asia and the Pacific. 24 pp.Fullbrook, D. 2010. Food as security. *Food Security,* 2010(2): 5–20.

Gentilini, U. & Webb, P. 2008. How are we doing on poverty and hunger reduction? A new measure of country performance. *Food Policy,* 33(6): 521–532.

Goss, J., Burch, D. & Rickson, R.E. 2000. Agri-food restructuring and third world transnationals: Thailand, the CP Group and the global shrimp industry. *World Development*, 28(3): 513–530.

Gregory, R., Brooks, A. & Toufique, K. 2006. *Common interests, private gains.* WorldFish Center, Bangladesh. (available at: http://shisuk.org/Publications/Common%20Interests%20glossy.pdf)

Gregory, R. & Guttman, H. 1996. Capture or culture? Management of rice fields fisheries in southeast Cambodia. *ILEIA Magazine*, 12(2): 20–21.

Grigg, D. 1966. The geography of farm size, a preliminary survey. *Economic Geography,* 42: 205–235.

Haitao, S., Parham, J.F., Zhiyong, F., Meiling, H. & Feng, Y. 2008. Evidence for the massive scale of turtle farming in China. *Oryx,* 42(2): 147–150.

Haitook, T., Kosy, S. & Little, D.C. 1999. New approaches to fish seed supply. *Appropriate Technology,* 25(4): 26–27.

Hall, D. 2004. Explaining the diversity of Southeast Asian shrimp aquaculture. *Journal of Agrarian Change*, 4(3): 315–335.

Hallman, K., Lewis, D. & Bugum, S. 2003. *An integrated economic and social analysis to assess the impact of vegetable and fishpond technologies on poverty in rural Bangladesh*. EPTD Discussion Paper No. 112. Washington, D.C., International Food Policy Research Institute. 68 pp.

Halwart, M. 2006. Biodiversity and nutrition in rice-based aquatic ecosystems. Journal of Food Compostion and analysis 19 (6-7):747-751

Hambrey, J., Edwards, P. & Belton, B. 2008. An ecosystem approach to freshwater aquaculture: a global review. *In* D. Soto, J. Aguilar-Manjarrez & N. Hishamunda, eds. *Building an ecosystem approach to aquaculture. FAO/Universitat de les Illes Balears Experts Workshop. 7–11 May 2007, Mallorca, Spain*, pp. 117–221. FAO Fisheries and Aquaculture Proceedings No. 14. Rome, FAO.

Hannig, W. 1988. *Towards a blue revolution: socioeconomic aspects of brackishwater pond cultivation in Java*. Yogyakarta, Gadjah Mada University Press. 404 pp.

Haque, M.M., Little, D.C., Barman, B. & Wahab, M.A. 2010. The adoption process of ricefield based fish seed production in northwest Bangladesh: an understanding through quantitative and qualitative investigation. *Journal of Agricultural Extension and Education*, 16(2): 161–177.

Harrison, E., Stewart, J.A., Stirrat, R.L. & Muir, J.F. 1994. *Fish farming in Africa: what's the catch?* Summary report and policy recommendations. Brighton, University of Sussex. 51 pp.

Hasan, M.R. & Halwart, M. (eds.) 2009. *Fish as feed inputs for aquaculture: practices, sustainability and implications.* FAO Fisheries and Aquaculture Technical Paper No. 518. Rome, FAO. 424 pp.

Hishamunda, N., Ridler. N.B., Bueno, P. & Yap, W.G. 2009. Commercial aquaculture in Southeast Asia: Some policy lessons. *Food Policy,* 34: 102–107.Humphrey, J. & Schmitz, H. 2004. Governance in global value chains. *In* H. Schmitz, ed. *Local enterprises in the global economy: issues of governance and upgrading*, pp. 95–109. Chapter 4. Cheltenham, Edward Elgar Publishing Ltd.

Irz, X., Lin, L., Thirtle, C. & Wiggins, S. 2001. Agricultural growth and poverty alleviation. *Development Policy Review,* 19(4): 449–466.

Irz, X., Stevenson, J.R., Tanoy, A., Villarante, P. & Morissens, P. 2007. The equity and poverty impacts of aquaculture: insights from the Philippines. *Development Policy Review*, 25(4): 495–516.

Islam, M.M. 2002. *An analysis of the role of extension methodology on poverty reduction: a comparative study of aquaculture extension programmes in the Northwest Fisheries Extension Project (NFEP) command area, Bangladesh.* Ph.D. Thesis. Wolverhampton, University of Wolverhampton 300 pp.Islam, M.S. 2009. In search of "white gold": environmental and agrarian changes in rural Bangladesh. *Society & Natural Resources*, 22(1): 66–78.

Ito, S. 2002. From rice to prawns: economic transformation and agrarian structure in rural Bangladesh. *Journal of Peasant Studies,* 29(2): 47–70.

Ito, S. 2004. Globalization and agrarian change: a case of freshwater prawn farming in Bangladesh. *Journal of International Development*, 16: 1003–1013. Karapanagiotidis, I.T., Bell, M.V., Little, D.C. & Yakupitiyage, A. 2007. Replacement of dietary fish oils by alpha-linolenic acid-rich oils lowers omega-3 fatty acid content in tilapia flesh. *Lipids,* 42: 547–559.

Karapanagiotidis, I.T., Bell, M.V., Little D.C., Yakupitiyage, A. & Rakshit, S.K. 2006. Polyunsaturated fatty acid content of wild and farmed tilapias: effect of aquaculture practices and implications for human nutrition. *Journal of Agricultural and Food Chemistry,* 54: 4304–4310.

Karim, M. 2006.The livelihood impacts of fishponds integrated within farming systems in Mymensingh District, Bangladesh. Ph.D. Thesis. Stirling, University of Stirling. 351 pp.

Karim, M., Little, D.C., Kabir, M.S.,Verdegem, M.J.C., Telfer, T. & Wahab, M.A. 2011. Enhancing benefits from polycultures including tilapia (*Oreochromis niloticus*) within integrated pond-dike systems: a participatory trial with households of varying socio-economic level in rural and peri-urban areas of Bangladesh. *Aquaculture,* 314: 225–235.

Kawarazuka, N. & Bene, C. 2010. Linking small-scale fisheries and aquaculture to household nutritional security: an overview. *Food Security,* 2: 343–357. Kongkeo, H. & Davy, F.B. 2010. Backyard hatcheries and small scale shrimp and prawn farming in Thailand *In* S.S. De Silva & F.B. Davy, eds. *Success stories in Asian aquaculture,* pp. 67–83. Dordrecht, Springer.

Krishna, A. 2007. For reducing poverty faster: target reasons before people. *World Development*, 35(11): 1947–1960.

Labrousse, C. 2009. *Assessment of the perceptions of the stakeholders on the emerging Pangasius aquaculture dialogue' standards in Vietnam and potential impacts on their livelihoods*. M.Sc. Thesis, Stirling, Institute of Aquaculture, University of Stirling.

Lamberts, D. 2001. *Tonle Sap fisheries: a case study on floodplain gillnet fisheries in Siem Reap, Cambodia*. RAP Publication 2001/11. Bangkok, FAO Regional Office for Asia and the Pacific. 133 pp.

Lebel, L. & Anderies, J.M. 2006. Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society,* 11(1), 21 pp. [online] (www.ecologyandsociety.org/vol11/iss1/art19/).

Leonard, H.T. 1989. *Environment and the poor: development strategies for a common agenda*. Oxford, Transaction Books. 215 pp. (not seen).

Leschen, W. 2006. *Production in aquatic peri-urban systems in South East Asia (PAPUSSA) Part 1.* Consolidated Scientific Report and Management Report 2006 European Commission INCO: International Scientific Cooperation Projects Contract No. ICA4-CT2002-10020. 72 pp.

Leschen, W. & Dabbadie, L. 2010. *Throwing stones. The future for African aquaculture?* Summary of discussions from the SARNISSA email forum: Eight days in June 2010. SARNISSA: Sustainable Aquaculture Research Networks in Sub Saharan Africa European Commission FP7 Project Contract No. 213143. 44 pp. (available at: www.sarnissa.org/tiki-index.php?page=SARNISSA++Project+Publications).

Lewis, D. 1997. Rethinking aquaculture for resource poor farmers: perspectives from Bangladesh. *Food Policy*, 22(6): 533–546.

Lewis, D.J., Wood, G.W. & Gregory, R. 1996. *Trading the silver seed: local knowledge and market moralities in aquacultural development*. London, Intermediate Technology Publications. 210 pp.

Litdamlong, D., Meusch, E. & Innes-Taylor, N. 2002. Promoting by building the capacity of local institutions: developing fish seed supply networks in the Lao PDR. *In* P. Edwards, D.C. Little & H. Demaine, eds. *Rural aquaculture*. Wallingford, CABI Publishing.

Little, D.C. 2010. Review: Success stories in Asian aquaculture (Eds Sena S. De Silva and F. Brian Davy) Springer. *Aquaculture,* 306: 24–26.

Little, D.C. & Bunting, S.W. 2005 Opportunities and constraints to urban aquaculture, with a focus on South and Southeast Asia. *In* B.A. Costa-Pierce, P. Edwards, D. Baker & A. Desbonnet, eds. *Urban aquaculture,* pp. 29–40. Chapter 3. Wallingford, CABI Publishing.

Little, D.C., Karim, M., Turongruang, D., Morales, E.J., Murray, F.J., Barman, B.K., Haque, M.M., Kundu, N., Belton, B., Faruque, G., Azim, E.M., Ul Islam, F., Pollock, L.J., Verdegem, M.J.,Young, J.A., Leschen, W. & Wahab, M.A. 2007[a]. Livelihood impacts of ponds in Asia – opportunities and constraints. *In* A.J. van der Zijpp, J.A.J. Verreth, L.Q. Tri, M.E.F. van Mensvoort, R.H. Bosma & M.C.M. Beveridge, eds. *Fishponds in farming systems, 2006.* Proceedings of a symposium held in Can Tho City, 28–30 April 2006, organised by Can Tho University, Vietnam and Wageningen University, Netherlands. pp177-202 Wageningen Academic Publishers.

Little, D C., Nietes-Satapornvanit, A. & Barman, B. 2007[b]. Seed networks and entrepreneurship. *In* M.G.Bondad-Reantaso, ed. *Assessment of freshwater fish seed resources for sustainable aquaculture*, pp. 549–562. FAO Fisheries Technical Paper No. 501. Rome, FAO.

Little, D. C., Surintaraseree, P. & Innes-Taylor, N. 1996. Fish culture in rainfed rice fields of northeast Thailand. *Aquaculture*, 140: 295–321.

Loc, N.T.T., Bush, S.R., Sinh, L.X. & Khiem, N.T. 2010. High and low value fish chains in the Mekong Delta: challenges for livelihoods and governance. *Environment, Development and Sustainability,* 12(6): 889–908,

Lovshin, L., Schwartz, N. & Hatch, U. 2000. *Impacts of integrated fish culture on resource limited farms in Guatemala and Panama: an ex-post evaluation*. Research and Development Series No. 46. Auburn, Alabama Agricultural Experiment Station.

Luu, L.T., Trang, P.V., Cuong, N.X., Demaine, H., Edwards, P. & Pant, J. 2002. Promotion of small-scale pond aquaculture in the Red River Delta. *In* P. Edwards, D.C. Little & H. Demaine, eds. *Rural aquaculture,* pp. 55–76. Wallingford, CABI Publishing.

McIntosh, R. 2010. *Increasing aquaculture productivity: shrimp*. [powerpoint presentation]; (available at: www.gaalliance.org/update/GOAL10/McIntosh.pdf)

Martinez-Espinosa, M. 1992. Rural aquaculture, from myth to reality. *FAO Aquaculture Newsletter,* No. 2, pp. 13–14.

Martinez-Espinosa, M. 1995.Development of type II rural aquaculture in Latin America. *FAO Aquaculture Newsletter,* No. 11, pp. 6–10.

Meinzen-Dick, R.S. & Pradhan, R. 2002. *Legal pluralism and dynamic property rights.* CAPRi Working Paper No. 22. CGIAR Systemwide Program on Collective Action and Property Rights. 35 pp. (available at: www.capri.cgiar.org/pdf/CAPRIWP22.pdf).

Miller, J.W. & Aleem, S. 2010. *Aquaculture buyers' guide for Nigeria.* USAID MARKETS Project (Maximizing Agricultural Revenue and Key Enterprises in Targeted Sites). 45 pp.

Milstein, A., Kadir, A. & Wahab, M.A. 2008. The effects of partially substituting Indian carps or adding silver carp on polycultures including small indigenous fish species (SIS). *Aquaculture,* 279: 92–98.

Minh, N.H., Boivin, T, Canh, P.M. & Son, L.K. 2009. Comprehensive assessment of dioxin contamination in Da Nang Airbase and its vicinities: environmental levels, human exposure and options for mitigating impacts. *In* Y. Obayashi, T. Isobe, A. Subramanian, S. Suzuki & S. Tanabe, eds. *Interdisciplinary studies on environmental chemistry – environmental research in Asia for establishing a scientist's network,* pp. 21–29. Tokyo, Terrapub.

Minot, N. & Baulch, B. 2005. Spatial patterns of poverty in Vietnam and their implications for policy. *Food Policy*, 30: 461–475.

Morales, E.J. 2007. *Self-recruiting species in farmer managed aquatic systems: their importance to the livelihoods of the rural poor in Southeast Asia.* Ph.D. Thesis. Stirling, University of Stirling. 537 pp.

Morse, S. 2008. Post-sustainable development. *Sustainable Development,* 16: 341–352.

Msuya, F.E. 2009. Development of seaweed cultivation in Tanzania: the role of the University of Dar es Salaam and other institutions. University of Stirling SARNISSA Case Study. Stirling, University of Stirling. 26 pp.

Murray, F.J. 2006. Strategies to integrate aquaculture within farmer-managed irrigation systems. Ph.D. Thesis, Stirling, 502pp.

Nadvi, K. 2004. Globalisation and poverty: how can global value chain research inform the policy debate? *IDS Bulletin,* 35(1): 20–30.

Negin, J., Remans, R., Karuti, S. & Fanzo, J.C. 2009. Integrating a broader notion of food security and gender empowerment into the African green revolution. *Food Security,* 1: 351–360.

Nguyen Khoa, S., Lorenzen, K., Garaway, C., Chamsinhg, B., Siebert, D. & Randone, M. 2005. Impacts of irrigation on fisheries in rain-fed rice-farming landscapes. *Journal of Applied Ecology,* 42: 892–900.

Nhan, D.K., Phong, L.T., Verdegem, M.J.C., Duong, L.T., Bosma, R.H. & Little, D.C. 2007. Integrated freshwater aquaculture, crop and livestock production in the Mekong Delta, Vietnam: determinants and the role of the pond. *Agricultural Systems,* 94(2): 445–458.

Onis, Z. & Senses, F.S. 2005. Rethinking the emerging post-Washington consensus. *Development and Change,* 36(2): 263–290.

Parker, S.J. 2008. *Extensive shrimp farming provides an important livelihood for poor rural communities in the Philippines: the Mangangapa and Degaton System described.* M.Sc. Thesis. Stirling, University of Stirling. 47pp

Pelletier, N. & Tyedmers, P. 2010. Life cycle assessment of frozen tilapia fillets from Indonesian lake-based and pond-based intensive aquaculture systems. *Journal of Industrial Ecology,* 14(3): 467–481.

Phan, V.T., Kjær Ersbøll, A., Nguyen, K.V., Madsen, H. & Dalsgaard, A. 2010. Farm-level risk factors for fish-borne zoonotic trematode infection in integrated small-scale fish farms in northern Vietnam. *PLoS Neglected Tropical Diseases,* 4(7): e742. doi:10.1371/journal.pntd.0000742.

Pimbert, M. 2006. *Transforming knowledge and ways of knowing for food sovereignty.* London, International Institute for Environment and Development. 43 pp.

Pinstrup-Andersen, P. 2009. Food security: definition and measurement. *Food Security,* 1: 5–7.

Plateau, J.P. 2004 Elite capture in community-driven development. *Development and Change,* 35(2:) 223–246.

Ponte, S. 2008. *Developing a 'vertical' dimension to chronic poverty research: some lessons from global value chain research.* Chronic Poverty Research Centre, Working Paper No. 111. 34 pp.

Prax, J., Little, D.C., Sao, P.V. & Tuan, P.A. 2000. *Seed production and distribution network in Mao Dien community Red River Delta, northern Vietnam* [Working Paper]. Institute of Aquaculture, University of Stirling, and Research Institute Aquaculture 1, Bac Nin, Viet Nam.58pp

Prein, M. 2002. Integration of aquaculture into crop–animal systems in Asia. *Agricultural Systems,* 71(1–2): 127–146.

Primavera, J.H. 2006. Overcoming the impacts of aquaculture on the coastal zone. *Ocean and Coastal Management,* 49: 531–545.

Quach, B.T.T. 2008. *Pangasius* catfish culture: impact on livelihoods in Mekong Delta, Vietnam. M.Sc. Thesis. Stirling, University of Stirling. 35pp

Rand, J. & Tarp, F. 2010. Impact of an aquaculture extension project in Bangladesh. *Journal of Development Effectiveness*, 1(2): 130–146.

Rice, M.A., Mmochi, A.J., Zuberi, L. & Savoie, R.M. 2006. Aquaculture in Tanzania. *World Aquaculture,* 37(4): 50–57.

Rigg, J. 2003. Southeast Asia, the human landscape of modernization and development. 2nd Edn. London, Routledge. 386 pp.

Rigg, J. & Natapoolwat, P. 2001. Embracing the global activism and pragmatism in an era of deagrarianization. *World Development,* 29(6): 945–960.

Rigg, J., Veeravongs, S., Veeravongs, L. & Rohitarachoon, P. 2008. Reconfiguring rural spaces and remaking rural lives in central Thailand. *Journal of Southeast Asian Studies,* 39(3): 355–381.Rojas, M. 2008. Experienced poverty and income poverty in Mexico: a subjective well-being approach. *World Development*, 36(6): 1078–1093.

Roos, N., Thilsted, S.H. & Wahab, M.A. 2002. Culture of small indigenous fish species in seasonal ponds in Bangladesh: the potential for production and impact on food and nutrition security. *In* P. Edwards, D.C. Little & H. Demaine. *Rural aquaculture,* pp. 245–252. Wallingford, CABI Publishing.

Roos, N, Thilsted, S.H. & Islam, M.M. 2004. Small Indigenous fish species in aquaculture in Bangladesh: contribution to vitamin A, calcium, and iron intakes. *In* N. Roos, H.E. Bouis, N. Hassan & K.A. Kabir, eds. *Proceedings of a Workshop on Alleviating Malnutrition through Agriculture in Bangladesh. Alleviating malnutrition through agriculture in Bangladesh: biofortification and diversification as sustainable solutions*, 101 Dhaka and Gazipur, Bangladesh, April 22–24, 2002.

Roos, R. Leth, T, Jakobsen, J. & Thilsted,S.H. 2002. High vitamin A content in some small indigenous fish species in Bangladesh: perspectives for food-based strategies to reduce vitamin A deficiency. *International Journal of Food Sciences and Nutrition,* 53: 425–437.

Rossignoli, C.M. 2008. *An assessment of the marketing of aquatic animals in Udon Thani Province, Thailand*. M.Sc. Thesis. Stirling, University of Stirling.

Ruddle, K. & Zhong, G. 1988. Integrated agriculture-aquaculture in South China. The ditch-pond system of the Zhujiang Delta. Cambridge, Cambridge University Press. 173 pp.

SARNISSA. 2010. *2nd annual periodic report: Sustainable Aquaculture Research Networks in Sub Saharan Africa.* European Commission FP7 Project Contract No. 213143. 52 pp.

Scoones, I. 1998. *Sustainable rural livelihoods: a framework for analysis.* IDS Working Paper 72. Institute of Development Studies.

Sen, B. 2003. Drivers of escape and descent: changing household fortunes in rural Bangladesh. *World Development,* 31(3): 513–534.

Sheriff, N., Little, D.C. & Tantikamton, K. 2008. Aquaculture and the poor – is the culture of high-value fish a viable livelihood option for the poor? *Marine Policy*, 32: 1094–1102.

Shetty, P. 2009. Incorporating nutritional considerations when addressing food insecurity. *Food Security,* 1: 431–440.

Shoemaker, B., Baird I.G. & Baird, M. 2001. *The people and their river: a study of river-based livelihoods in the Xe Bang Fai river basin in central Lao PDR.* Vientaine, Lao PDR/Canada Fund for Local Initiatives. 65 pp.

Sievanan, L., Crawford, B., Pollnac, R. & Lowe, C. 2005. Weeding through assumptions of livelihood approaches in ICM: seaweed farming in the Philippines and Indonesia. *Oceans and Coastal Management,* 48: 297–313.

Skladany, M. & Harris, C.K. 1995. On global pond: international development and commodity chains in the shrimp industry. *In* P. McMichael, ed. *Food and agrarian orders in the world economy*, pp. 169–191. Westport, Greenwood Press.

Smith, R.D. 2008. Food security and international fisheries policy in Japan's postwar planning. *Social Science Japan Journal,* 11(2): 259–276.

Stevenson, J.R. & Irz, X. 2009. Is aquaculture development an effective tool for poverty alleviation? A review of theory and evidence. *Cahiers Agricultures,* 18(2–3): 292–299.

Stonich, S.C. & Bailey, C. 2000. Resisting the blue revolution: contending coalitions surrounding industrial shrimp farming. *Human Organization*, 59(1): 23–36.

Stonich, S.C., Bort J.R. & Ovares, L.L. 1997. Globalization of shrimp mariculture: the impact on social justice and environmental quality in Central America. *Society and Natural Resources,* 10(2): 161–179.

Sultana, P. & Thompson, P. 2004. Methods of consensus building for community-based fisheries management in Bangladesh and the Mekong Delta. *Agricultural Systems,* 82: 327–353.

Summer, A. 2010. It's time to focus on poor people-not poor countries. PovertyMattersBlog; www.guardian.co.uk/global-development/poverty-matters/2010/dec/27/middle-income-countries-bottom-billion.

Surintaraseree, P. & Little, D.C. 1998. Thailand: diffusing rice-fish culture. The extension, adoption and retention of rice-fish technology in Thailand's north-east region. *Rural Extension Bulletin,* October, pp. 30–37. Tofique, K.A. & Gregory, R. 2008. Common waters and private lands: distributional impacts of floodplain aquaculture in Bangladesh. *Food Policy*, 33(6): 587–594.

Tripp, R. 2001. Agricultural technology policies for rural development. *Development Policy Review,* 19(4): 479–489.

Umesh, N.R., Chandra Mohan, A.B., Ravibabu, G., Padiyar, P.A., Phillips, M.J., Mohan, C.V. & Vishnu Bhat, B. 2010. Shrimp farmers in India: empowering small-scale farmers through a cluster based approach. *In* S.S. De Silva & F.B. Davy, eds. *Success stories in Asian aquaculture,* pp. 41–66. Dordrecht, Springer.

Valbo-Jørgensen, J. & Thompson, P.M. 2007. *Culture-based fisheries in Bangladesh: a socio-economic perspective.* FAO Fisheries Technical Paper No. 499. Rome, FAO. 41 pp.

van Mulekom, L., Axelsson, A., Batungbacal, E.P., Baxter, D., Siregar, R. & de la Torre, I. 2006. Trade and export orientation of fisheries in Southeast Asia: under-priced export at the expense of domestic food security and local economies. *Ocean and Coastal Management,* 49(9–10): 546–561.

Vandergeest, P. 2007. Certification and communities: alternatives for regulating the environmental and social impacts of shrimp farming. *World Development,* 35(7): 1152–1171.

Vandergeest, P., Flaherty, M. & Miller, P. 1999. A political ecology of shrimp aquaculture in Thailand. *Rural Sociology*, 64(4): 573–596.

Walker, B.H., Holling, C.S., Carpenter, S.R. & Kinzig, A.P. 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society,* 9(2), Article : 5 [online] (www.ecologyandsociety.org/vol9/iss2/art5/).

White, H. & Masset, E. 2003. The importance of household size and composition in constructing poverty profiles: an illustration from Vietnam. *Development and Change*, 34(1): 105–126.

White, S. & Petit, J. 2004. Participatory methods and the measurement of well-being. *Participatory Learning and Action 50: Critical reflections, future directions.* pp. 88–96.

Wiggins, S. & Proctor, S. 2004. How special are rural areas? The economic implications of location for rural development. *Development Policy Review*, 19(4): 427–436.

Wood, G. 2003. Staying secure, staying poor: the "Faustian bargain". *World Development,* 32(3): 455–471.

Woolley, J., Cook, S.E. & Molden, D. 2009. Water, food and development: the CGIAR Challenge Program on Water and Food. *Water International,* 34(1): 4–12.

World Bank. 2006. *Aquaculture: changing the face of the waters: meeting the promise and challenge of sustainable aquaculture*. Washington, D.C., World Bank. 136 pp.

World Bank, 2001. *Attacking poverty*.World Development report 2000/2001. World Bank, Oxford University Press 335pp.

World Bank. 2007. *Agriculture for development.* World Bank Development Report 2008. Washington, D.C., World Bank. 365 pp.

Wyban, C. 1992. *Tide and current: fishponds in Hawai'i.* Honolulu, University of Hawai'i Press. 208 pp.

Zhao, J., Luo, Q., Deng, H. & Yan, Y. 2008. Opportunities and challenges of sustainable agricultural development in China. *Philosophical Transactions of the Royal Society,B, Biological Sciences,* 363: 893–904.