Small-scale aquaculture, development and poverty: a reassessment

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ABSTRACT

The potential of small-scale aquaculture (SSA) to contribute to development goals including poverty reduction and improved food security has been widely discussed. These accounts emphasize the following characteristics of SSA: the relative poverty of practising households; the subsistence or semi-subsistence nature of the activity; its role as a means of agricultural diversification; its contribution to food security; family ownership and operation of production or reliance on predominantly family labour; and utilization of small areas of land and/or water. This paper presents case studies of four systems of Asian aquaculture, all of which possess more than one of the commonly identified characteristics of SSA. Analysis of these cases suggests that conventional representations SSA have overemphasizsed certain characteristics with respect to its potential to meet development goals. At the same time, these accounts have tended to overlook other positive contributions that aquaculture can make to development, particularly through employment generation in associated value chains.

Keywords: poverty, food security, land ownership, value chain, non-farm employment.

INTRODUCTION

The term 'small-scale aquaculture' (SSA) has been used to refer to a range of production systems with very variable characteristics. The aim of this paper is to lend greater clarity to discussions surrounding SSA and its implications for poverty, development and food security among producers, consumers and actors in associated value chains in a range of geographical locations. This is achieved by reference to empirical data drawn from four case studies of inland aquaculture production in South and Southeast Asia. The author has conducted extensive research on these systems over the past seven years, and the case studies draw primarily on survey data relating to each. The systems described span a broad spectrum in terms of physical size, capital investment and operating costs, management strategies, productivity and output, ownership patterns and employment generation, their role in producer livelihood portfolios, and their impact on economic growth. The function of presenting data in this manner is to highlight the complexity of Asian inland aquaculture, catalyze clearer understandings

of the activity, and encourage reconsideration of conventional characterizations of SSA and its implications for human development.

The following section of the paper gives a brief summary of the arguments advanced in favour of extending support to SSA and an overview of six of the main features identified in previous work on SSA. The third section briefly describes four Asian pond-based fish culture systems, all of which display at least some features generally understood to be indicative of SSA. These are: carp polyculture in homestead ponds in Bangladesh; Nile tilapia culture in Central Thailand; Pangasius catfish culture in Mymensingh district, Bangladesh; and Pangasius catfish culture in the Mekong Delta, Viet Nam. In the fourth section, selected empirical data derived from studies of these systems are presented with reference to each of the six features of SSA identified in section three. The final section of the paper then offers some interpretations of the role of inland Asian aquaculture in alleviating poverty, providing food security and contributing toward socioeconomic development.

CONVENTIONAL PERSPECTIVES ON SMALL-SCALE AQUACULTURE

Small-scale forms of aquaculture have received considerable attention and institutional support over the years as a means of alleviating rural poverty, improving household food security, and contributing to socioeconomic development more generally. In its most basic form, the logic for believing that SSA can accomplish these goals proceeds as follows: Aquaculture is an activity which produces food-fish and can generate cash incomes. Small-scale farmers are generally poor. Therefore, if small-scale farmers are able to adopt fish culture or to increase the technical efficiency of existing fish production, concurrent increases in levels of income and fish consumption should result and, consequently, their poverty and food insecurity should be reduced. In addition, the poor may also benefit from aquaculture through employment on the farms of better-off households or companies and in value chain activities such as seed supply and fish harvesting (Edwards, 1999). Because this argument has such a coherent logical structure, it is rarely ever questioned.

Various authors have attempted to define SSA or have written about its characteristics. These include: the relative poverty of those who practice it; its subsistence or semi-subsistence nature; its potential as a means of agricultural diversification; family ownership and operation of production; a reliance on predominantly family labour; it's potential contribution to food security and logically, given the name, utilization of small areas of land and/or water. These features and their sources are summarized in Table 1. Some of the authors listed in the table, e.g. Martinez-Espinoza (1995) and Edwards *et al.* (2002), use the alternative descriptor 'rural aquaculture', but there is much overlap between the two categories and all the authors listed have a shared interest in the potential of aquaculture of this type to generate positive development outcomes.

Most recently, an FAO workshop (Bondad-Reantaso and Prein, 2010) reworked Martinez-Espinoza's original typology (1995), concluding that SSA is a continuum

TABLE1
Characteristics of small-scale aquaculture

Characteristic	Source
Relative poverty of practising households	Edwards *et al.,* 2002; Edwards, 2000; Martinez-Espinoza, 1995; Friend and Funge-Smith, 2002
Subsistence or semi-subsistence activity	Martinez-Espinoza, 1995; Prein, 2002; Edwards and Demaine, 1997
Potential means of agricultural diversification	Martinez-Espinoza, 1995; Friend and Funge-Smith, 2002; Prein, 2002
Contributes to food security	Prein, 2002; Ahmed and Lorica, 2002; FAO, 2003
Family ownership and operation of production or reliance on predominantly family labour	De Silva and Davy, 2010; Subasinghe and Phillips, 2008
Utilization of small areas of land and/or water	Subasinghe and Phillips, 2008; Bondad-Reantaso and Prein, 2010

from, 'Type 1' systems 'involving limited investment in assets, some small investment in operational costs, including largely family labour and in which aquaculture is just one of several enterprises', to 'Type 2' systems 'in which aquaculture is the principal source of livelihood, in which the operator has invested substantial livelihood assets in terms of time, labour, infrastructure and capital' (Bondad-Reantaso and Prein, 2010). This is indicative of a recent shift under which the definition of 'small scale' has broadened to include a range of systems displaying features not previously consistent with the traditional view of what constituted rural aquaculture. De Silva and Davy's (2010) definition of SSA as 'family owned, managed and operated' also reflects this change in emphasis as it is broad enough to include nearly all operations except those owned by corporate agribusiness.

POND-BASED AQUACULTURE IN SOUTH AND SOUTHEAST ASIA: FOUR CASE STUDIES

This section briefly describes salient technical, financial and social dimensions of the four fish culture systems listed above, all of which have features which appear qualify them as either Type 1 or Type 2 SSA.

Homestead pond carp polyculture in Bangladesh

Extensive fish culture is a traditional activity in Bangladesh. Ponds were originally constructed close to homesteads for multiple purposes including drinking, bathing and other domestic uses, irrigation, watering livestock and providing earth to elevate houses above the level of flood waters. Declining availability of wild fish coincided with increasing availability of hatchery produced seed, improving transport links and market access, and promotional efforts by a number of institutions and projects during the 1980s and 1990s. These factors have contributed to a general increase in the numbers of such ponds brought under fish culture, and their deliberate management for this purpose. The uptake of improved management strategies such as regular application of feeds and fertilizers and the stocking of fish species in complementary combinations and at optimal densities and sizes remains somewhat patchy however, with producers adopting a variety of strategies depending to their knowledge, resources and inclinations.

Belton *et al*. (2012) report the median area of ponds devoted to homestead carp culture in Mymensingh to be 0.08ha. Table 2, which contains data on fish ponds from various areas of Bangladesh indicates similar findings. Ponds of this size can be adequately managed by the owner in approximately an hour or less each day, as a result of which, homestead carp culture generates no primary on-farm employment. Operating costs are comprised mainly of fingerlings and, if improved management techniques are used, small quantities of inorganic fertilizers and 'raw' feeds, most commonly rice bran and mustard oil cake purchased from off-farm. Rent is rarely incurred since ponds are normally borrow pits dug on homestead land and pond construction costs are therefore usually also incidental. Table 3 provides approximate budgets for homestead carp culture in Mymensingh. Rice cultivation usually represents the most important livelihood activity of rural households producing carp in homestead ponds (see Table 2). The activity is normally practiced for either partially or completely subsistence purposes (as opposed to being entirely commercially oriented), and therefore usually contributes only a minor, albeit potentially important, portion of household income among those who practice it. Carps produced in these systems which are not consumed at home are sold primarily through local auction markets. Despite the fact that quantities produced by individual households are small, aggregate production is very substantial because of the large numbers of producers involved. Total recorded carp production in Bangladesh in 2008 was 696 053 tonnes (FAOstat, 2010), of which a large portion would have originated from homestead pond systems.

TABLE 2
Characteristics of homestead carp culture in Bangladesh

Average pond size (ha)	Aquaculture as a % of income	Fish consumed at home (%)	Source
0.1	2.8	41	Thompson *et al.* (2006)
0.09	3	37	Thompson *et al.* (2006)
0.08	13.2	–	Winrock International (2004)
0.1	10	26	Khondker *et al.* (2010)
0.1 - 0.2	15.5	47	Karim (2006)
0.04	10	29	Hossain *et al.* (2010)
0.06	–	–	Belton *et al.* (2011a)

TABLE 3
Approximate budgets for homestead pond carp culture, Phulpur Upazila, Mymensingh

Item	Extensive	Improved-extensive	Semi-intensive
Extrapolated yield (kg/ha)	527	1860	2890
Actual yield (kg/household)	42	149	231
Per unit farmgate value ($/kg)	1.44	1.44	1.44
Operating costs ($/household)	58	163	216
Actual cash equivalent gross income ($/household)	66	215	337
Net cash income ($/household)	0	52	121
Net fish consumption (kg/household)	42	75	116

Source: Belton *et al.*, 2012.

Tilapia culture in Central Thailand

Nile tilapia was introduced to Thailand in 1965 and has since become the most important cultured fish species, accounting for 41 percent of total freshwater aquaculture production in 2007 (DOF, 2009). A large portion of this takes place in ponds located in the provinces of Central Thailand, where a suitable agroecology, good market access and a ready supply of low cost agro-industrial byproducts for use as feeds and fertilizers make for ideal culture conditions (Belton and Little, 2008). Virtually all tilapia producers in Central Thailand have a very strong commercial orientation. Management regimes are extremely diverse, but production systems falling under the semi-intensive umbrella dominate output, accounting for perhaps 75–80 percent of tilapia produced. These are managed as polycultures in which tilapia comprise the greatest percentage of stocked fish, and are fertilized, normally with pig or chicken manure. Supplementary feeds including a diverse range of cheap food processing byproducts and wastes, are widely used, but intensified production using manufactured feeds including pig pellets and formulated fish feeds for part of the growout cycle in conjunction with greenwater have emerged in the last decade in response to increasing demand for large live tilapia which command a higher value than small dead ones (Table 4). Farms span a range of sizes which reflect the resources and aims of their owners, from operations around 1ha to much larger enterprises of over 100 ha. Farms in the order of around 2–3 ha are most commonplace, with a pond area of approximately 3ha being the minimum required to maintain a reasonable standard of living for a household if fish culture represents its main source of income. The labour effort required to manage farms at the smaller end of the spectrum is quite low, being in the order of several hours per day. Larger farms employ permanent workers, often families of Burmese migrants who live on site, but overall primary employment intensity is low. Most of the fish produced is destined for urban and peri-urban markets in the Greater Bangkok Metropolitan Area. These are now quite diversified, with small (300–400 g) dead tilapia with providing cheap food for low-income-bracket consumers, and larger fish selling to a somewhat different set of customers (Belton *et al.*, 2009).

TABLE 4
Partial budgets for semi-intensive and intensified pond-based tilapia culture in Central Thailand

Item	System Type	
	Semi-intensive pond	Intensified pond
Farm area (ha)	1	10
Yield/ha (t)	6.25	7.5
Actual yield/farm (t)	6.25	75
Per unit farmgate value ($/kg)	0.47	0.73
Total costs/farm ($)	1681	37,998
Net farm income ($)	1257	16,752

Source: modified from Belton *et al.*, 2009.

Pangasius catfish culture in Mymensingh district, Bangladesh

Commercial production of non-native Pangasius catfish (*Pangasianodon hypothalamus*) began in Mymensingh in 1993, and has expanded rapidly, with estimated annual production reaching 300 000 tonnes in 2008 (Belton *et al.*, 2011b). This has caused the fish's value to decline to a present level approximately 40-50 percent lower than that typically obtained by the traditionally popular Indian major carps, and makes it the cheapest widely available fish species in Bangladesh (Little *et al.*, 2009). Pangasius are cultured intensively using artificial diets comprised of sinking pelleted feed, manufactured either in commercial feed mills or by farmers themselves using purchased machinery. Carps are also stocked in Pangasius ponds to exploit algal blooms which occur in the nutrient rich water, and account for around 15 percent of the total weight of fish harvested, thereby insulating production of the main crop of catfish against downward fluctuations in market value. Yields of Pangasius range from 15-65 tonnes/ha depending on the stocking density and length of growout cycle, which may be strategically adjusted by farmers in line with available operating capital, averaging 36.9 t/ha (Ali *et al.*, 2012) . Carps are harvested regularly during the course of grading Pangasius and are sold in local auction markets from which they are distributed both locally and throughout the country to urban centres such as Dhaka. Regular harvest of carps in this manner by netting teams provides a source of operating capital with which farm owners may purchase additional Pangasius feed. Pangasius farms create approximately two permanent on-farm jobs per hectare, and generate a great deal of additional work in ancillary activities such as pond harvesting, soil cutting and transport of feed by trishaw (three wheeled cycles). One study in a village with just 17 Pangasius farms reported the main source of income of one third of household heads to be associated with Pangasius culture in some way (Belton *et al.*, 2012). Mean pond area is 1.37 ha, although farms up to 30 ha in size exist. Fish culture almost always represents the first or second most important income stream for Pangasius farm operators, with agricultural activities often absent from, or comprising a minor component of, livelihood portfolios. The high input demands of Pangasius culture are reflected in average per hectare production costs of USD 23 790 (Haque, 2009). Per hectare net profits are USD 8 025 (see Table 5).

TABLE 5
Comparative partial budgets of Pangasius culture in Bangladesh and Vietnam

	Vietnam	Bangladesh
Mean farm area (ha)	1	1.37
Farm size range (ha)	0.1-50	0.1-30
Yield/crop/ha^{-1} (t)	370	36.9
Farmgate value/kg ($)	0.82	0.84
Production cost/crop/ha^{-1} ($)	250,000	23,790
Net return/crop/ha^{-1} ($)	45,000	8025

Source: Belton *et al.*, 2011b.

Pangasius catfish culture in the Mekong Delta, Viet Nam

Pangasius catfish have been farmed in the Mekong Delta since the 1960's. Pond-based production, of which more than 90 percent is for export (Loc *et al.*, 2009), has expanded dramatically since 2003, and has become a significant source of export earnings for Vietnam. Production now approaches the total global output of farmed Atlantic salmon, with an estimated 1.2 million tonnes with an export value of approximately USD 1.45 billion recorded for 2008 (Dung, 2008). The industry reportedly supports the livelihoods (directly and indirectly) of 105 535 individuals and provides an additional 116 000 jobs in the processing sector (Lam *et al.*, 2009). It is of particular economic importance to the Mekong Delta Region due to its geographical concentration there. Primary employment intensity generated by Vietnamese Pangasius farms is approximately 2.75 jobs per hectare. Extremely high per unit area yields of Pangasius can be obtained due to its ability to breath air, coupled to production in deep ponds (≈4m) located close to major branches of the Mekong River which allow for water exchange of around 20-30 percent daily. The average yield per crop from farms located in inland provinces of the Mekong Delta is 369.7 tonnes/ha (Sinh and Hien, 2009). If market conditions favour the production of two crops in a year it is therefore entirely feasible for a single farmer to produce well in excess of 600 tonnes of catfish per annum from a single hectare of ponds (Wilkinson, 2008). Achieving such high productivity depends upon the use of massive quantities of fish feeds, and results in operating costs of approximately USD250 000/crop/ha^{-1} (see Table 4). Margins are very slim, but the scale of investment is so great that it is still possible to achieve net returns averaging ≈ USD45 500/crop/ha^{-1}. Large losses are frequently incurred however as a result of very low per unit margins. The mean size of Pangasius farms in the Mekong Delta is variously reported at between 1 ha and 2.67 ha (Sinh and Hein, 2009; Lam *et al.*, 2009) but covers a huge range from <0.1ha to 50 ha or more. Data from the Department for Agriculture and Rural Development of An Giang Province published in Loc *et al.* (2010) suggest that very small farms predominate, with 94 percent sized less than 0.5 ha, 3 percent sized 0.5^{-1} ha, and only 3 percent of more than 1 ha. However, many of these very small farms (less than 0.1ha) produce largely or partly for domestic markets and are subject to somewhat different production economics than the export-led operations, and farms of less than 0.5 ha cumulatively contribute just 10.3 percent of total output (Loc *et al.*, 2010). Loc *et al.* (2010) also showed a 61 percent reduction in the number of farms under 0.1 ha in size between 2006 and 2008, and a 247 percent increase in those over 2 ha for the same period in An Giang Province (2010), and recent evidence suggests that the industry is undergoing a major period of consolidation in which small producers are increasingly switching to production of other species or being forced to abandon aquaculture altogether (Kheim *et al.*, 2010).

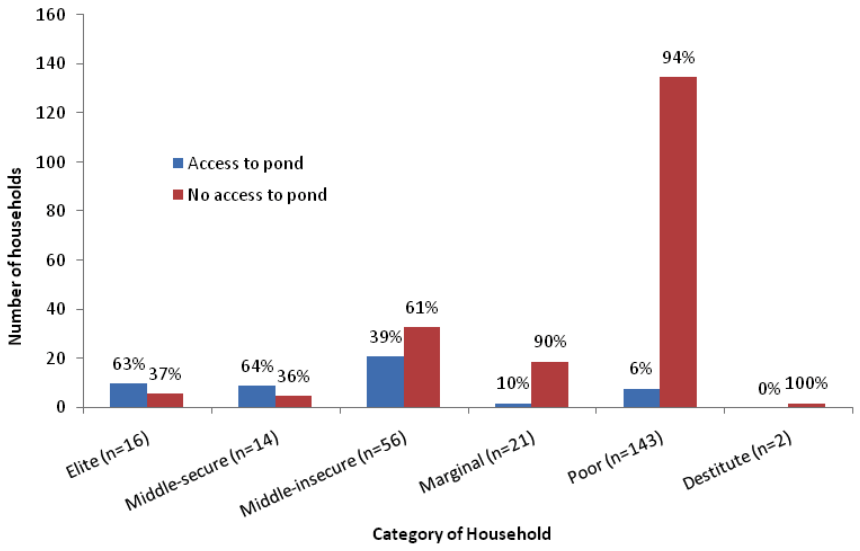
DO THE CASE STUDY SYSTEMS MATCH THE CHARACTERISTICS OF SSA?

This section addresses each of the features identified in the second section of the paper as characteristic of SSA in turn, with reference to features of each of the production systems described above.

Relative poverty of practising households

Carp polyculture in homestead ponds has been widely promoted by development agencies in Bangladesh as a means of providing food and income to the rural poor. However, close to 60 percent of population is functionally landless (defined as owning <0.2 ha land). As a result, many of the poorest households own insufficient land to construct even very small ponds. This tendency is indicated in Figure 1 which details homestead pond ownership for all the households in a single village, disaggregated by wellbeing status. This shows clearly that a majority of those in higher wellbeing groups own homestead ponds, as compared to only a small proportion of those in the

FIGURE 1
Distribution by wellbeing group of households with access to a homestead pond in a Mymensingh village (n=252)

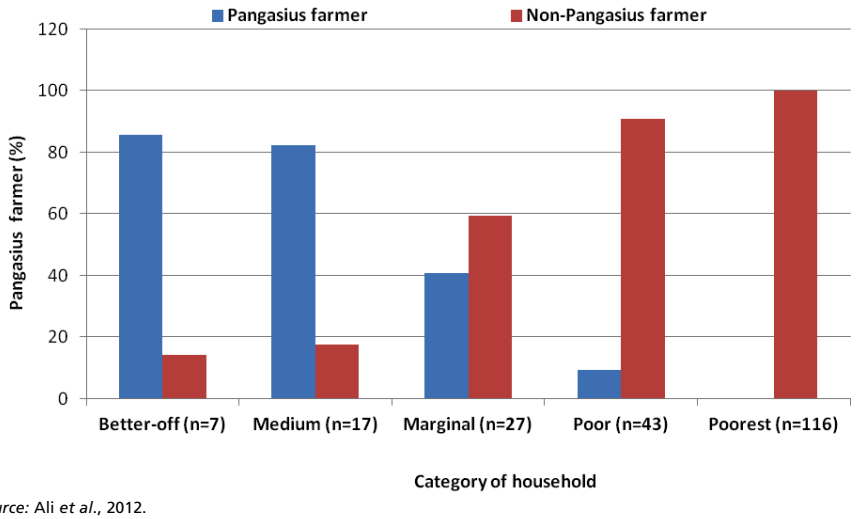


Source: Belton *et al.*, 2012.

more populous low-income groups. Thus, for the most part, conventional pond based aquaculture practiced on even this very small scale cannot be generally be considered the preserve of the "poorest of the poor".

Given that the poor in Bangladesh have difficulty in participating in even very low input homestead pond based aquaculture, they have even fewer options for direct participation as producers in Pangasius aquaculture due to the larger areas of ponds and much higher input costs involved. This is clear when one considers that the average cash equivalent net annual income from 1ha of double cropped rice would be in the order of just USD 400, as compared to per hectare operating costs of USD23 790 per crop of Pangasius. Data from one study of a village in Mymensingh shows that no households considered 'poorest', and less than 10 percent of those considered 'poor' practice Pangasius culture, whereas more than 80 percent of those in the 'better-off' and 'medium' categories do so (Ali *et al.*, 2012; see Figure 2). In Vietnam, extreme stocking

FIGURE 2
Well-being category of Pangasius and non Pangasius-farming households in Moddhovatipara village, Mymensingh, Bangladesh



Source: Ali *et al.*, 2012.

densities and associated levels of feed use mean that operating costs per ha are in the region of USD 250 000. These costs are clearly sufficient to preclude direct participation in Pangasius aquaculture by any poor households. This has led Mantingh and Dung (2008) to state that, 'Pangasius farmers cannot be considered as poor smallholders'.

The range of management options employed by tilapia farmers in Central Thailand is much more varied, ranging from small low-input ditch/dyke systems integrated with fruit production or horticulture and directly-integrated livestock/fish operations, to intensified monoculture practiced on a very large scale. General standards of living are higher than in either Bangladesh or Viet Nam, as is the availability of agricultural land. Thus there is some scope for households in relatively low income brackets to engage in fish culture, for instance for elderly former crop farmers who find it easier to manage ponds of around a hectare than to continue with more labour intensive forms of agriculture. Larger and more intensive tilapia culture tends to be practiced by moderately well-off households, although in some cases these have been able to expand from a small initial base by reinvesting profits.

All these cases tend to suggest that, contrary to one of the key assumptions in the SSA literature, in many instances only those who are at least relatively moderately well off stand a reasonable chance of participating in conventional pond based aquaculture as producers. However, for those who do participate, the benefits may be substantial. Even the lowest intensity forms of Thai tilapia culture provide average per unit area incomes approximately twice as high as those possible from rice cultivation, and Pangasius culture in Bangladesh and Vietnam generates net incomes approximately 20 times and 100 times greater than those possible from paddy.

A subsistence or semi-subsistence activity

Tilapia culture in Central Thailand and Pangasius culture in Bangladesh and Viet Nam are practiced for entirely commercial purposes, with the majority of product destined for urban and international markets in the two first and final cases respectively. In contrast, production of carp in homestead ponds in Bangladesh may range from completely subsistence to largely commercial, but the household consumption of around one quarter to one half of the fish produced is probably most common (Table 3). Contributions to household incomes of this type of aquaculture are generally rather limited, amounting to less than 15 percent of the total (Table 3). Even these relatively small sums may play an important role in smoothing seasonal cash shortages associated with rice cultivation however, and can act as a form of insurance for moderately well resourced families that may reduce the likelihood of their slipping into transient poverty (Belton et al, 2012). Subsistence consumption of fish is also attractive to relatively comfortably off households in rural Bangladesh who often prefer to consume a large portion of the fish they produce for reasons of convenience and taste. This suggests that production for entirely subsistence purposes is not necessarily indicative of aquaculture practiced by the very poor as some accounts propose (e.g. Martinez-Espinoza, 1995). In fact, some evidence from Bangladesh suggests that the very poorest adopters of very small scale forms of aquaculture such as tilapia seed production in rice fields are more likely sell the fish they produce in order to generate cash incomes with which to purchase more essential items (Haque, 2007).

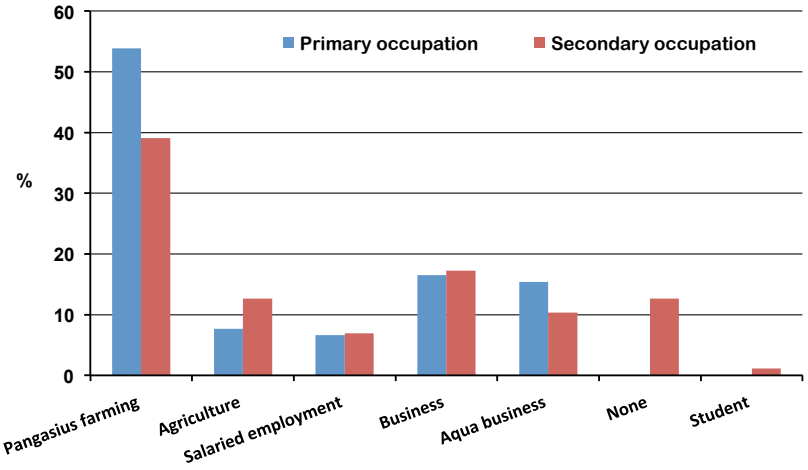
A potential means of agricultural diversification

A very substantial majority of homestead carp pond operators in rural areas of Bangladesh practice rice cultivation as their primary livelihood activity. For these households, the addition of aquaculture as a new activity offers a means of agricultural diversification which has the potential to increase resilience to seasonal pressures (e.g. through sales of fish to cover part of the costs of irrigated rice cultivation) and, perhaps, to other less predictable forms of stress such as the illness of a family

member. Graduation from semi-subsistence homestead pond based aquaculture to more commercial forms practiced on a larger scale is relatively rare however due both to constraints (most importantly limited land and capital), and disincentives to intensification (the limited opportunity costs and risk associated with low-input homestead pond aquaculture and complementary role that this plays in rice dominated livelihood portfolios) (Belton *et al*., 2012).

For the farmers operating each of the three other production systems discussed here, engaging in aquaculture typically represents a form of 'upgrading' in which a lower value livelihood activity is exchanged for a more profitable one, rather than a form of horizontal diversification. Contrary to what might be expected, the case studies show that many fish producers did not practice any form of agricultural activity prior to entering into aquaculture. Figure 3 suggests the relatively low importance of agriculture in the livelihood portfolios of Pangasius farmers in Bangladesh. A similar pattern also exists in Vietnam, where only 37 percent of Pangasius farmers surveyed by Belton *et al*. (2011c) had engaged in any kind of aquaculture or agriculture prior to starting catfish culture; the substantial majority of market entrants being engaged in either entrepreneurial activities or managerial positions before hand. For many of these, aquaculture represented an opportunity to expand a portfolio of business activities. In Central Thailand, shifting from rice cultivation or other types of agriculture into tilapia culture was a common pathway, but even here close to 40 percent of all market entrants had non-agrarian livelihoods before taking up fish culture, with some opting to do so as a lifestyle choice in preference to office work, or following unemployment during the financial crisis of the late 1990s. This suggests that commercial forms of aquaculture are often either entered into as entrepreneurial business opportunities, or as a form of upgrading in which one activity is deliberately exchanged for another, rather than as a means of diversifying a limited on-farm resource base. It is noteworthy that aquaculture usually occupies an important place in producer livelihood portfolios for all three of these commercial fish culture systems. Pangasius culture in Bangladesh is indicative of this tendency, representing the primary income generating activity for 54 percent of producers, and the second most important activity for 38 percent (Figure 3).

FIGURE 3
Primary and secondary occupations of Pangasius farmers in two villages in Mymensingh, Bangladesh (n=90)

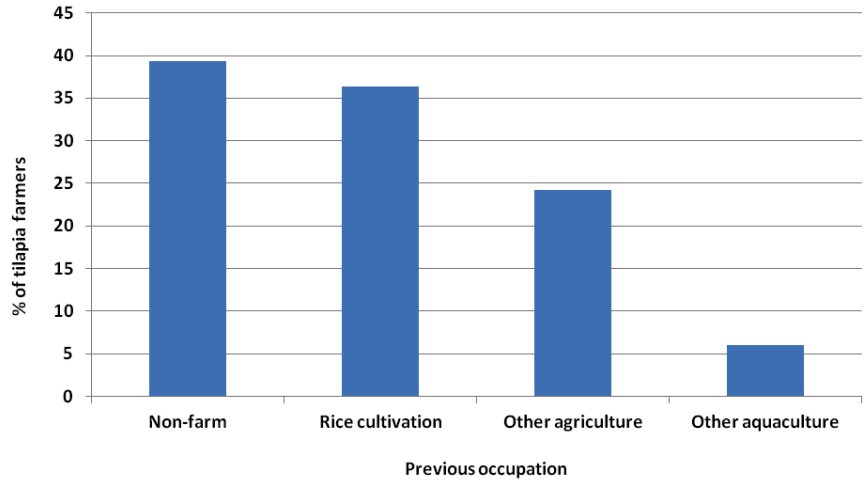


Source: Modified from Haque, 2009.

Contributes to food security

The homestead carp culture practiced in Bangladesh produces only limited marketable surpluses of fish per producing household, estimated at between 0 and 116 kg for a

FIGURE 4
Previous occupations of tilapia producers in Central Thailand



Source: Modified from data in Belton, 2006.

typical household depending on management and consumption strategies employed (see Table 2). Despite this, aggregate production is extremely large due to the huge number of borrow pits brought under fish culture. Fish produced in these systems is typically marketed locally however, possibly in part due to difficulties associated with assembling the large quantities of product required to cost-effectively export to distant urban markets from so many dispersed producers with small individual amounts of fish. Furthermore, with the exception of silver carp, the large major carps which dominate homestead polycultures are highly priced relative to other cultured fish species (although as Table 6 shows, species of wild origin now tend to be even more expensive due to diminishing supplies). This suggests that the observation of Lewis (1997) that under most circumstances the carp species produced in homestead ponds are too expensive for poor consumers to afford remains valid.

In each of the three other case studies presented here virtually 100 percent of output is produced for commercial purposes, and farms are often located in highly concentrated geographical clusters. Figure 5 indicates a downward trend in the real value of tilapia in Thailand in almost every year in which production increased. This

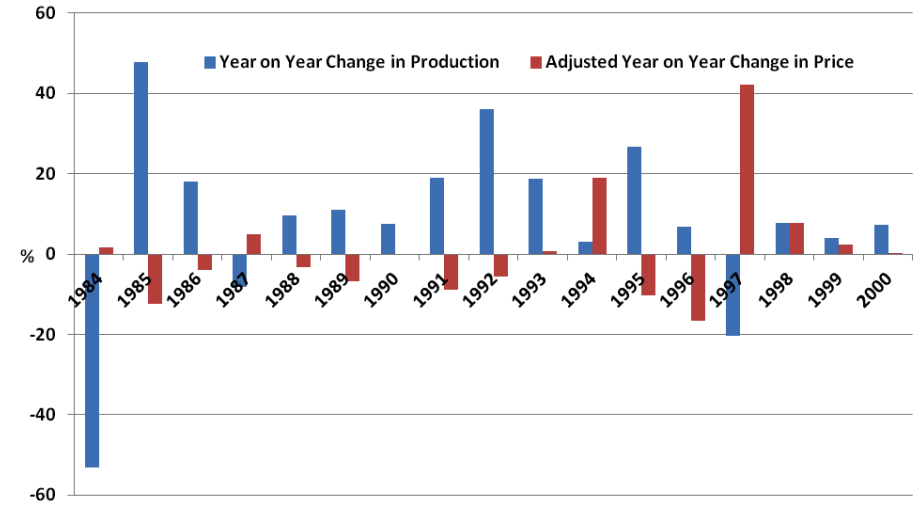
TABLE 6
Origin and average price of farmed and wild fish species from 15 markets across Bangladesh

Source*	Species	Average price (USD/kg)
Wild	Walking catfish	3.76
Wild	Stinging catfish	3.24
Wild	Climbing perch	2.85
Wild	Striped snakehead	1.77
Farm	Rohu	1.73
Wild	*Mystus tengara*	1.65
Farm	Catla	1.58
Wild	Indigenous barbs	1.19
Wild	Spotted snakehead	1.19
Farm	Mrigal	1.18
Farm	Tilapia	1.01
Farm	Silver carp	0.92
Farm	Pangasius	0.85

* Although some species reported of wild origin are also farmed (and vice versa) the designation reflects the common source in each case.

Source: adapted from Little *et al.*, 2009.

FIGURE 5
Year on year change in Thai tilapia production and inflation adjusted price/kg (1984-2000)



Source: Adapted from Belton *et al.*, 2005.

has resulted in declining real farmgate values and retail prices, greater production efficiencies on the part of producers (Belton and Little, 2008), and rising consumer demand because demand for fish is highly price elastic (Dey *et al.*, 2008). As a result, fish such as small dead tilapia in Thailand and Pangasius in Bangladesh are now among the cheapest and most widely available products nationally (Table 6), and are destined primarily for urban markets where they provide 'fuel' for workers in the productive sectors which make major contributions to GDP growth and may therefore contribute indirectly to the livelihoods and wellbeing of families of urban migrants from rural areas who receive remittances. At the same time, Vietnamese Pangasius has become the cheapest internationally traded whitefish, and has now diversified beyond traditional European and American markets to supply, among others, Latin America, the Middle-East, and the former Eastern Bloc countries, with the result that it thus now arguably contributes to global food security.

Family ownership and operation of production and reliance on family labour

Homestead carp culture in Bangladesh, is almost by definition, exclusively family owned and operated. The vast majority of tilapia farms in Central Thailand are also family managed, though Belton (2006) reports that it is quite common for tilapia farm owners in some in land-constrained areas close to Bangkok to construct ponds on large parcels of rented land in more distant Central Region provinces and to install live-in labourers to take care of day-to-day management activities. Ownership and management oversight by household members is also the predominant pattern for Pangasius producers in Vietnam and Bangladesh. Large operations belonging to absentee investors occur in both countries however, particularly in Viet Nam where there is a clear tendency towards greater levels of absentee ownership on larger farms, as indicated in Table 7. There is also an increasing trend toward the establishment of

TABLE 7
System of Vietnamese Pangasius farm management by size of farm (n=33)

Farm size	System of farm management		
	Self-managed (%)	Absentee owner (%)	Operated by company (%)
<1ha	79	14	7
1-3ha	50	50	0
>3ha	0	71	29

Source: Belton *et al.*, 2011c.

vertically integrated catfish farms by seafood processing companies. Although the majority of farms are owner operated, current trends suggest that large corporately owned or professionally managed farms are on the increase in Vietnam, whilst the smallest purely family operated farms are in sharp decline (Kheim *et al.*, 2010).

With the exception of harvesting, all the labour inputs into homestead carp ponds in Bangladesh are provided by household members. This is also true of smaller Thai tilapia farms, with only those farms sized 15 ha or more typically needing to employ permanent hired labour. The management intensive nature of the Pangasius culture practised in Bangladesh and Vietnam means that operations of 0.5 ha typically employ at least one permanent worker to supplement the labour of the farm owner, while larger farms employ considerably more, generating approximately 730 and 1000 man days of labour per hectare per year respectively, with family labour deployed less frequently as farm size increases.

Utilization of small areas of land

The size of homestead ponds used for carp aquaculture in Bangladesh is typically less than 0.1ha. Whilst this is certainly small in absolute terms, it must be remembered that well over half of the population possesses landholdings of 0.2 ha or less. As a result, even owners of ponds in this size class tend to possess larger total landholdings than the average for the communities where they reside. There is a great deal more variability in the areas devoted to Thai tilapia, and Vietnamese and Bangladeshi Pangasius culture, making mean farm sizes potentially misleading, and median area is a more reliable indicator of what is typical. Table 8 shows both the mean and median size of Central Thai tilapia farms and Bangladeshi Pangasius farms to be considerably larger than average agricultural landholdings in the areas where they take place. Vietnam is the exception in this regard. Productivity varies very widely between the four systems, from less than one tonne per hectare for extensive homestead carp polyculture, to around 7 tonnes/ha/yr^{-1} for Thai tilapia, and up to a possible maximum of 700 tonnes/ha/yr^{-1} for Vietnamese Pangasius. This makes physical area a poor indicator of the scale of investment and level of production if it is considered alone.

TABLE 8
Areas under agriculture and aquaculture in three case study locations

Species and location	Mean agricultural landholding (ha)	Mean fish farm area (ha)	Median fish farm area (ha)	Fish farm area range (ha)
Tilapia, Central Thailand	3.8	21	6.2	0.2-160
Pangasius, Mymensingh	0.6	3.7[1]	1.2	0.1-50
Pangasius, Mekong Delta	1.2	1	-	<0.1-50

[*] This figure differs from that given in Table 5 because it includes figures from a sub-district of Mymensingh in which production takes place in large natural water bodies (beel), as well as from other sub-districts where, as is more typical, production takes place in ponds.

Source: BBS, 2002; NSO, 2004; own survey data.

DISCUSSION: TOWARD A CLEARER UNDERSTANDING OF ASIAN AQUACULTURE

The four case studies presented above give an indication of the diversity of Asian inland aquaculture, both within and between systems and in relation to a variety of technical and economic characteristics. Despite this diversity, a number of general lessons may be drawn with respect to the degree of fit between characterizations of SSA outlined in the second section of the paper, and the empirical descriptions provided in the third and fourth sections.

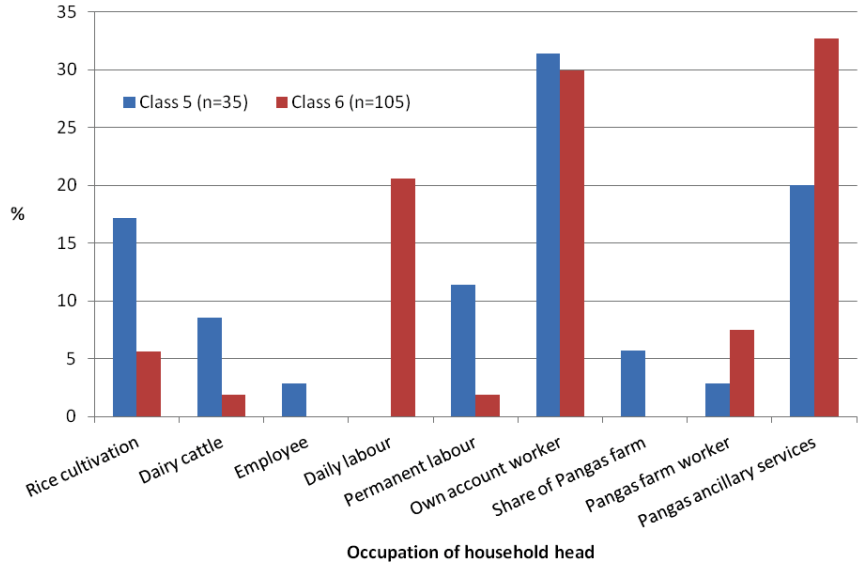
One important observation arising from the four case studies is that direct entry into conventional pond-based aquaculture as producers is rarely feasible for the poor. Fish culture does not therefore usually offer a means for people to escape poverty, but rather way in which already moderately well-off or wealthy households are able to accumulate additional wealth, to maintain their position in the face of seasonal stresses,

or to enhance levels of well-being conceived of in terms of satisfaction as well as in purely monetary or calorific terms. This is not to suggest that engaging in aquaculture cannot have a transformative effect on a household's socioeconomic status and security, but rather that it is most likely to leverage significant improvements for those who start from a better than average asset base.

Given that this is the case, far greater potential for the poor to benefit from aquaculture is to be found by providing services or gaining employment in associated value chains. It should be noted however that direct primary employment opportunities generated by aquaculture (i.e. on-farm labour) are generally somewhat limited. Whilst this feature makes aquaculture particularly attractive to adopters it also means that on-farm employment generation is cumulatively quite low; the entire Vietnamese Pangasius industry generating probably less than 20 000 paid farm jobs. Multiple employment opportunities are created elsewhere in the value chains of highly commercial forms of aquaculture such as the three described in this paper however, especially where farms have been established in dense geographical clusters. Figure 6 presents data on the poorest (Class 6) and second poorest (Class 5) groups of inhabitants of a village in Mymensingh in which only 17 households farm Pangasius. There is almost no participation in catfish culture as farm operators among members of Classes 5 and 6, and quite limited employment on catfish farms. However, approximately one third of all members of the poorest (and most populous) group in the community (Class 6), and 20 percent of those in Class 5 derive a significant portion of their income by providing ancillary services to Pangasius farm owners.

The size of fish culture operations documented in the four case studies that inform this paper is highly variable but, where aquaculture represents a major livelihood strategy, landholdings devoted to the activity are often larger than average agricultural landholdings. Per unit area productivity and operating costs of ponds under different systems of management also span a wide spectrum. These factors indicate that farm or pond area is a poor analog for scale of production if considered in isolation from contextual factors. The case studies presented here also show that entrants into commercial aquaculture come from a variety of backgrounds including both agriculture and the non-farm sectors, and that it is usually adopted as means to upgrade

FIGURE 6
Occupation of household heads from the two poorest well-being groups in a Mymensingh village



Source: Belton *et al.*, 2012.

existing livelihood activities, or is a form of entrepreneurial investment. Contrary to what might be expected, the expansion and intensification of low intensity or semi-subsistence forms aquaculture by households already devoting small areas of land to the activity is not one of the main routes by which commercially oriented fish farmers enter into production.

Management oversight of farm operation by the farm owner and/or family members is common for all the systems described in this paper, and in many instances labour will be provided by the farming family or some of its members. However Pangasius farms of 0.5ha or more in both Bangladesh and Vietnam typically also employ hired workers; in part due to the fact that households wealthy enough to participate in this form of aquaculture can also afford to educate their children to a level where higher status forms of off-farm employment become available. It should also be noted that absentee ownership is common on larger farms for each of the three commercial systems described here. These commercial systems all produce large volumes of relatively affordable fish in areas that are well connected to urban and, in the Vietnamese case, international markets. Fish produced in these systems therefore contributes to food security at the national level. In contrast, homestead pond aquaculture in Bangladesh (which is in many respects the quintessential 'small-scale' production system) is dominated by higher value carp species. Because both consumers and producers of these species tend to be relatively better-off the impacts on wider food security may actually be somewhat limited despite very high aggregate production volumes. It is also ironic that the latter system has received substantial donor support and promotion on the basis of its theoretical capacity to alleviate poverty, whereas development of the three commercial production systems described here has occurred with limited external assistance but appears to bring a range of more significant and wider reaching societal benefits.

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