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REPORT

Community-Based Technology Transfer in Rural Aquaculture: The Case of Mudcrab *Scylla serrata* Nursery in Ponds in Northern Samar, Central Philippines

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Abstract Finding aquaculture development approaches to open up livelihood opportunities for the rural poor and in mainstreaming smallholder fish farmers to reduce poverty remain a challenge. This paper examines the community-based technology transfer mechanism of mudcrab nursery in ponds and its socioeconomic impacts on smallholder mudcrab growers in Northern Samar, Philippines. Results indicated that the technology is a viable enterprise done by a straight culture system method, which is the rearing of crablets from <1.0 to 4.0 cm for 42 days, or by-phases. However, technology adoption hinges on many factors like area ownership, farm distance from household, and market including the type of strategy needed to enhance technology uptake. Collaboration among research and development institutions and local partners is critical in training and empowering rural communities to adopt aquaculture technologies.

Keywords Rural aquaculture · Mudcrab nursery · Technology transfer · Socioeconomic impact

INTRODUCTION

Fish catch from the wild has dwindled and the remaining main fishing areas in the world have mostly reached its maximum yield (FAO 2006a). Fish producing countries, mostly in Asia, have shifted to aquaculture in search of a more sustainable source of fish for domestic consumption and exports (FAO 2006a; WorldFish 2011). By 2030, the fish food consumption from aquaculture is projected to be 60 % from 42 % in 2006 (World Bank 2013). Aquaculture production worldwide has grown from less than 1 million tons in early 1950s to 48.1 million tons in 2005 valued at USD 1482 per ton, 90 % of which is from Asia. Increasing aquaculture production has, however, been achieved with considerable environmental costs, threatening many aquatic and marine ecosystems (Hugues-Dit-Ciles 2000).

Aquaculture, managed responsibly, has the potential to supply global demand for food fish and support livelihoods in rural communities (FAO 2006a; Subasinghe et al. 2009). Aquaculture is resource-intensive (land and water) and the large-scale operators have had greater access to these resources than small-scale farmers (Lewis 1998; Slater et al. 2013). But some evidence has been found for the Philippines and elsewhere that aquaculture benefits the poor (Irz et al. 2007; Sheriff et al. 2008). Aquaculture represents an inequality-reducing source of income, providing employment to unskilled workers in large communities (Irz et al. 2007). In Asia, aquaculture directly created 12 million fulltime employment opportunities in 2004 (FAO 2006b).

Aquaculture's potential for contributing to rural development has not been fully tapped. The Food and Agriculture Organization (FAO)[1] Code of Conduct for Responsible Fisheries and the Southeast Asian Fisheries Development Center (SEAFDEC) Regional Guidelines for Responsible Fisheries in Southeast Asia provided guidelines for the States in promoting and transferring responsible aquaculture practices to rural communities, producers' organizations, and fish farmers. The Philippine Fisheries Code (Republic Act 8550) grants the fisherfolk and their organizations the priority to exploit municipal and

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[1] See Appendix S1 for list of acronyms (Electronic Supplementary Material).

the demarcated fishery areas for mariculture operation. Moreover, the local government units (LGUs) are mandated to support municipal fisherfolk livelihood through technology and research, training, credit, and marketing assistance. Notwithstanding the encouraging policy environment in international, regional, and national levels, the mainstreaming and sustaining smallholder producers into the aquaculture industry for rural development are still wanting in low-income food-deficient countries like the Philippines. Smallholder refers to a micro enterprise with assets up to USD 75 000 (USD 1 = PhP 40, 29 April 2013) as defined under Small and Medium Enterprise (SME) Development Council Resolution No. 1, Series of 2003 dated 16 January 2003 (DTI 2008). Skills training and empowering the fishing communities are vital to the attainment of the goals for sustainable aquaculture. Thus, a technology transfer mechanism is an important element to SME in technology transfer process (Khabiri et al. 2012). A paradigm shift from the traditional method requires a dynamic research and technology transfer program given that market parameters of aquaculture and fisheries are continually changing (Morrissey and Almonacid 2005).

Institutional Capacity Development for Sustainable Aquaculture

The SEAFDEC Aquaculture Department (SEAFDEC/AQD) has worked with fishing communities, LGUs, non-government organizations (NGOs), business sector, and the academia to promote management and sustainable development of the fishery resources for over two decades. In 2006, SEAFDEC/AQD launched the Institutional Capacity Development for Sustainable Aquaculture (ICDSA) program to hasten the transfer and adoption of aquaculture technologies by fishing communities (Agbayani and Toledo 2008). The program used lessons learned from sectoral collaborations to enhance the productivity of aquatic resources, and minimize environmental impacts. The ICDSA adopted community-based and participatory approaches in transferring appropriate aquaculture technologies in pre-assessed sites done by the interdisciplinary team (a biologist, an aquaculture specialist, and a socioeconomist). It aimed to: (1) build capacities of target beneficiaries on good aquaculture practices; (2) demonstrate technical and financial feasibility of the aquaculture technology on-site; (3) provide stakeholders with scientific information on aquaculture; (4) assess socioeconomic effect on beneficiaries, impacts on environment, and influence on local legislation for effective governance; and (5) evaluate effectiveness of the mechanism of the transfer and adoption of the aquaculture technology.

The ICDSA process took about 3 years and comprised the following:

(1) Season-long training courses (SLTC) consist of lectures and hands-on exercises in one production cycle ranging from 1.5 to 6 months. This enables the trainees to acquire knowledge and skills on all production activities like pond preparation, stocking, feeding and water management, fish health monitoring, harvesting, and marketing.

(2) Demonstration of aquaculture systems of selected species is a twin activity of SLTC. Trainers and trainees set up the fish farm (pond, cage, or pen system) as SLTC progresses. The products are sold and the proceeds are plowed back into operations. Accrued earnings go to participating trainees. SEAFDEC/AQD's socioeconomist prepares the financial analysis of the production cycle to determine its profitability.

(3) At the end of the project, an impact assessment is undertaken to measure the contribution of the technology on the income and food security of the beneficiaries. Results of the research are presented to the beneficiaries and LGUs to encourage support and sustain the aquaculture livelihood.

Through ICDSA, SEAFDEC/AQD transferred the mudcrab *Scylla serrata* pond nursery technology in Northern Samar in 2007 with funding support from the Australian Centre for International Agricultural Research (ACIAR) through the Community Agricultural Technologies Programme (CATP) under the project "Enhancing Adoption of Mudcrab Production Technologies in Northern Samar." The fund support was intended to improve the income of small-scale producers and sustain the mudcrab production in the area through improved adoption of mudcrab technologies. The local partners were the three local NGOs, the LGUs, and the Bureau of Fisheries and Aquatic Resources (BFAR). They spearheaded the revival of aquasilviculture as a supplemental livelihood for coastal dwellers funded by Philippine-Australia Community Assistance Programme (PACAP) in 2004.

The increasing global demand of mudcrabs have resulted in overharvesting of wild mudcrabs, as in Northern Samar, threatening the natural biodiversity and sustainability of mudcrab market (Agbayani et al. 1990; Ewel 2008; Mirera 2011). Harvest included berried crabs and crablets <1 cm carapace width (CW). Moreover, the use of destructive capture methods like push nets caused mangrove habitat degradation affecting ecosystem function and decline in mudcrab abundance (Le Vay et al. 2001; Islam and Haque 2004; Mirera 2011).

A pre-project site assessment in the area showed that the nursery aspect of mudcrab culture was the weakest link in the mudcrab production cycle in the province (Agbayani et al. 2009). Gaillard (2010) also claimed that the limited

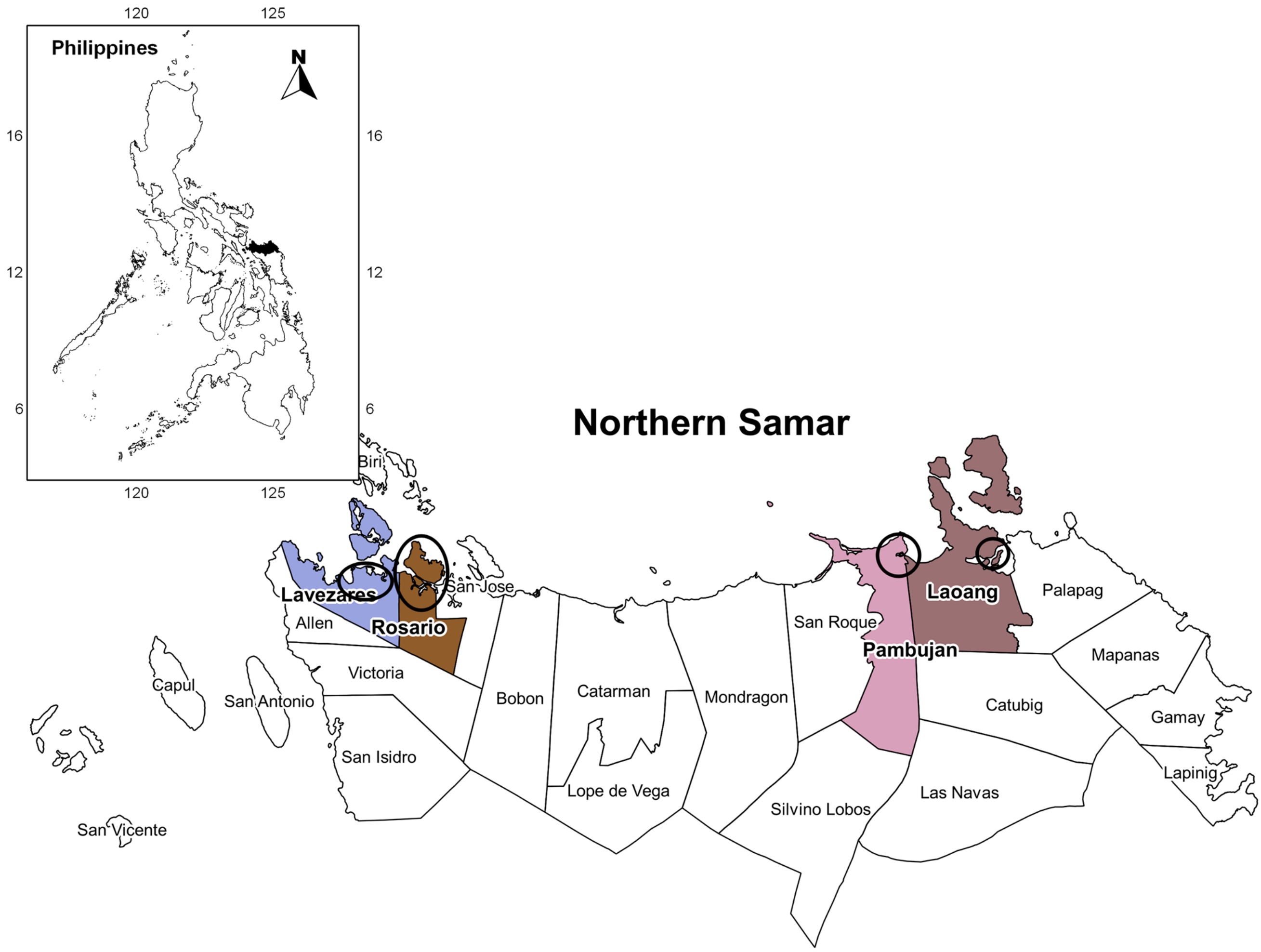

Fig. 1 Map of study sites in Northern Samar, east central Philippines

supply of crablets constrained its mudcrab industry development. Yet about 150 000–200 000 pieces of wild stocks in varying sizes (0.4–1.2 cm CW) were traded outside the province weekly (Muhia and Lutao 2007). A nursery system using the wild crablets from the area was necessary to produce steady supply of stocking materials for culture and fattening. Developing sustainable small-scale mudcrab aquaculture was considered a potential livelihood option for the coastal dwellers (Walton et al. 2006) and mitigates environmental degradation.

This paper examines the socioeconomic impact of mudcrab culture on smallholder mudcrab growers and the technology transfer mechanism of mudcrab pond nursery in Northern Samar. The study determines growers' access rights on the culture area, the viability of the venture, and the constraints of their existing mudcrab business operations. The factors influencing the technology adoption and growers' attitude toward the technology are also identified. Understanding the limiting factors of smallholder growers in technology adoption will help development workers ascertain the type of strategy needed to encourage technology uptake and sustain their livelihood.

MATERIALS AND METHODS

Site Profile

The study covered four Peoples Organizations (POs), each operating in villages of the four municipalities of Northern Samar (12°20′N, 124°40′E), east central Philippines, namely, Lavezares, Rosario, Laoang, and Pambujan (Fig. 1). These were the sites of the PACAP-assisted mudcrab culture livelihood projects. Laoang and Pambujan were listed among the first 5 out of 16 coastal municipalities with the highest number of crablet gatherers (Muhia and Lutao 2007).

Northern Samar estuaries and coastal waters are characterized by an abundance of mudcrab juveniles and is one of the major sources of crablets in the country (Quinitio

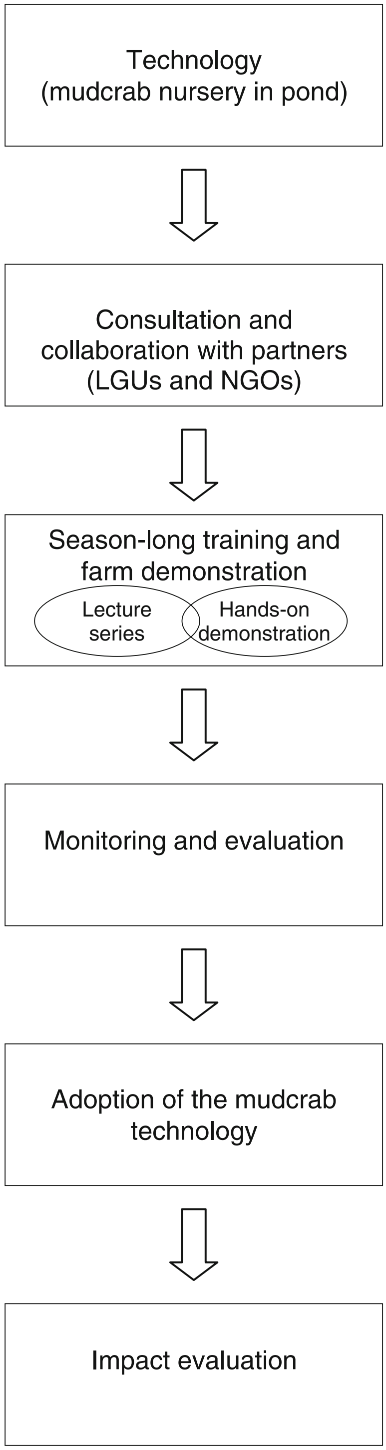

Fig. 2 Adoption pathway of mudcrab nursery in pond for small-scale mudcrab growers

et al. 2011). The province has an estimated 10 720 ha of mangroves (NAMRIA 2003). These are inundated with oceanic water for most of the year and are commonly associated with *Scylla serrata* (Keenan et al. 1998). Gathering of mudcrabs was open access and the gleaners were mostly children ages 7–15 years old. Trading of mudcrabs <50 mm carapace length (CL) outside the province is banned since 2005, but remained unabated due to ineffective enforcement.

The Philippines' 2010 mudcrab production was 14 436 metric tons, mainly from brackishwater ponds (BFAR 2012). Northern Samar belongs to a region that ranked 5th in mudcrab production in the country (BFAR 2012) in spite of about 60 % of all the seedstocks of *S. serrata* come from the province (Muhia and Lutao 2007). The province is the 10th poorest in the country (NSCB 2007).

Mudcrab Pond Nursery

The technology transfer of mudcrab pond nursery involved community training and participation of beneficiaries. It began with the linking of technologists and socio-economists with on-the-ground partners (Fig. 2). A season-long training with five modules was conducted and attended by 12–30 fisher-beneficiaries representing the four POs. The five training modules were: (1) lecture on mudcrab nursery and grow-out; (2) lecture on stock assessment; (3) special training courses on mudcrab culture for teachers and students of a local university; (4) hands-on exercises on farm-based feed preparation; and (5) hands-on exercises on pond preparation and stocking of crablets.

With beneficiaries' participation, suitable demonstration sites were selected and pond designs were made using technical criteria based on land topography and access to water resources. Familiarity of beneficiaries with the area was a big help. The trainees prepared the pond, installed net enclosure, and stocked crablets in their respective sites using SEAFDEC/AQD protocol. A fulltime SEAFDEC/AQD technician was deployed in the area for a year to provide continuous technical support to the beneficiaries. The production data were published in an extension manual prepared by the project team (SEAFDEC/AQD et al. 2010).

Data Collection

Some sixty PO members (15 members per PO) were randomly selected and interviewed in 2009 using a pre-tested interview schedule. The survey instrument contained, inter alia, socioeconomic, and demographic characteristics; technical information, e.g., access right, farm size, nature of operation, and distance of culture farm from household; and attitude toward the technology (Appendix S2). Respondents were also asked on the benefits and difficulties of the venture including their awareness and interest on mudcrab nursery, and future plans. Respondents' reason for joining the PO and their current participation in PO's activities were also gathered. Fattening production data was asked only from a group engaged in a cooperative undertaking that has proven this activity to be profitable.

Focus group discussion was undertaken in one site to clarify issues gathered during the interview. Key informants and available documentary evidence validated some data (e.g., crablets traded, pond ownership, and production data). Direct observations during technology transfer were noted.

Data Analyses

Except for production data, all variables were subjected to statistical analyses using Statistical Packages for Social Science Version 17. Nominal variables like "awareness of technology" were expressed metrically using dummy variables (e.g., yes = 1; no = 2). Multiple regression analysis was used to determine the factors influencing adoption of mudcrab nursery technology (Appendix S3). Correlation test established the degree of relationships between growers' interest and the factors associated with technology adoption.

The profitability of a PO existing fattening operation was examined through simple cost and return analysis. Cost and return analyses of mudcrab nursery operations using the best replicate were culled out from the extension manual prepared by the project team with some modifications to determine its financial viability (SEAFDEC et al. 2010). In Pambujan, only the second run was analyzed due to prolonged rain, adversely affecting the first run.

RESULTS

Respondents, Access Rights, and Nature of Operation

The respondents were predominantly male (60 %). The respondents' average age was 45; the youngest, 23 and the oldest, 66. All respondents had formal education and 93 % were married. A majority (73 %) of Laoang and Pambujan respondents attained elementary education while 86 % of those in Rosario and Lavezares reached secondary and college levels. Except for a few Rosario respondents, all were new into mudcrab culture and fattening.

Table 1 shows the POs' profile, access rights, and nature of mudcrab operations. Smallholder growers gained access to resources (capital and land) through the efforts of NGOs. The NGOs made representation with the LGUs and the Department of Environment and Natural Resources (DENR) on the use of mangrove forests for POs' mudcrab aquasilviculture, and with the donors for funding support. The DENR, a government agency, grants stewardship contracts to qualified individuals or groups for the development and maintenance of mangrove forest so they can sustainably enjoy the benefits from it.

The NGOs varied in strategies in mobilizing fisherfolk communities in the uptake of mudcrab culture and fattening technology. The strategies were either done as: (i) a cooperative endeavor among PO members in a mangrove area; (ii) individual operation (husband and wife) in an allotted mangrove area; or as (iii) individual/family-based operation in their own culture area with soft loan provided by an NGO.

In Rosario, for example, the growers borrowed capital from the NGO for their mudcrab operation, which required submission of a project proposal showing the location and size of area, and the capital needed, among others. About 47 % of Rosario respondents were already into mudcrab culture before their organization was formed. Rosario growers had their own ponds or had informal right on the farmed property, and by local customs, this informal right is respected by fellow resource users. Some of them utilized abandoned ponds, but could not improve the farmed area because ownership remained unresolved. Those engaged in a cooperative endeavor, the profit sharing was based on members' participation in the project implementation. Enterprising members, however, were allowed to venture in the same business, but they have to use their own area. Those with allotted area, they managed their own farm and the NGO helped market their product.

Economic Returns and Constraints

A cost and return analysis of mudcrab fattening in pens in a four-compartment 400 m^2 using only two compartments at Pambujan showed a USD 115 (USD 1 = PhP 40) net income for a 30-day culture period. This indicated that a smallholder grower could earn additional income of USD 2760 per year for 400 m^2 culture area. The area, however, was for 40 PO members participating for only one economic activity. Income was not sufficient if shared among members. The minimum wage was USD 6 per day in the area as of 2012. Consequently, most (63 %) respondents whose livelihood projects were cooperative undertaking were no longer keen with the cooperative-run project (Fig. 3) although 50 % of them liked to venture on their own given capital and culture area. They also encountered some leadership and organizational problems affecting their operation. With a good leader, 13 % of them were still willing to engage in cooperative endeavor. Those who lost interest (30 %) claimed of opportunity lost and wanted a more stable job. Interestingly, those (83 %) who operated their own farm liked to continue and even wanted to expand (26 %), particularly those in Rosario. Others (17 %) expressed hesitation to pursue their venture because the farmed area was ≥2 km away from the household. The growers normally set up small hut near their farm to prevent poaching on their stocks. In some cases, the hut also served as their equity for the project like the case in Lavezares.

Table 1 Profile, access rights, and nature of mudcrab operation of Peoples Organizations in study sites (yearly tenure)

People Organization (PO)	Location	Total member/ year started	Access rights	Nature of operation	Total area
Camparanga Crabs Growers Association	Camparanga, Pambujan	40 2006	PO operates a mudcrab project in 400 m^2 mangrove area; permit given by local government unit (LGU) thru a non-government organization (NGO)	Members manage mudcrab project thru cooperative effort; share of benefit is based on member's participation in project implementation	5 ha
Bayog Valley Farmers' Multi-purpose Cooperative—Canyumanao Mudcrab Project	Canyumanao, Laoang	28 2004[a]	PO operates a mudcrab project in 3775 m^2 mangrove area; permit given by LGU thru an NGO; co-management agreement exists between LGU and Department of Environment and Natural Resources (DENR) on sustainable estuarine resources and silviculture, but not active	Members manages mudcrab project thru cooperative effort; share of benefit is based on member's participation in project implementation	1 ha
San Miguel Mudcrab Association	San Miguel, Lavezares	30[b] 2007	LGU gave permit to NGO for PO to operate mudcrab project in mangrove area; each team allocated with 375 m^2 area for grow-out and fattening	Husband and wife team implement project	5 ha
Mangrove Crab Producers Association in Rosario	Rosario (members spread in six villages)	32[c] 2005	Members have own pond or culture area in mangroves; property rights mostly customary	Household/individual interested to venture on mudcrab culture is granted soft loan (Livelihood Assistance Program) to implement project	Members' area vary from 240 m^2 to 1.8 ha

[a] Started as a pilot project of NGO, LGU, and a government agency

[b] Equivalent to 15 households since husband and wife were listed as individual members of PO though membership increased to 60 later

[c] Members increased because of available funds for loan

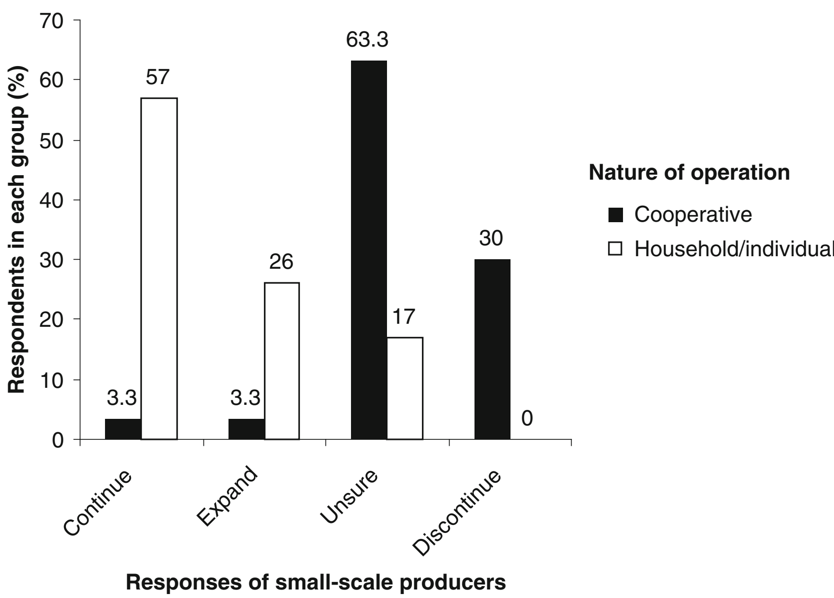

Fig. 3 Attitude of small-scale growers on mudcrab culture technology based on the nature of their culture operation

Generally, economic reasons (source of cash income, 65 % and extra income, 78 %) and the simplicity of technology (67 %) were the major motivations of growers in adopting mudcrab culture and fattening technology. Social factors like sending children to school (37 %), learning new knowledge (13 %), and resource protection (2 %), among others, were secondary considerations for technology adoption. On the downside, the growers claimed that inadequate supply of lean crabs and crablets were their problems in attaining success. The other problems encountered were irregular supply and expensive feeds, climate change (prolonged rain), poaching, and lack of quality product standards. The local traders corroborated these sentiments, particularly the declining crablets validating the importance of regulation in transporting crablets outside of the province. The advocacy to ban the transport of crablets through a municipal ordinance was spearheaded by an NGO in Pambujan and subsequently, adopted by the provincial government.

Mudcrab Pond Nursery

Results of the demonstration in mangrove (Pambujan) and non-mangrove areas (Rosario) indicated that the nursery technology is a viable enterprise (SEAFDEC/AQD et al. 2010). The nursery in Pambujan had a low dike to retain the water, and fenced with 1-mm mesh net size (Fig. 4). Mangrove species such as *Avicennia marina* and

Fig. 4 Mudcrab pond nursery inside the mangrove area in Pambujan, Northern Samar

Fig. 5 View of 700 m^2 mudcrab pond nursery in a non-mangrove area in Rosario, Northern Samar; foreground shows SEAFDEC/AQD technician and a beneficiary broadcasting lime as part of pond preparation while other PO members observed

Sonneratia alba abode in the area. In Rosario, the nursery pond was the usual earthen brackishwater pond without mangroves inside and along the periphery of the pond (Fig. 5).

Straight and "by-phase" production runs were implemented simultaneously. The straight run method is rearing the crablets from <1.0 to 4.0 cm CW for 42 days. "By-phase" nursery comprised of Phase I which involves rearing of crablets from <1.0 to 2.5 cm CW and Phase 2, from 2.5 to 4.0 cm CW for 21 days each. The "by-phase" production runs were developed to provide the industry practitioners options on crablet sizes for grow-out culture that would give them shorter grow-out culture period and higher survival.

In a 200 m^2 pond, the nursery could provide additional income of about USD 1203 in a 6-month straight production runs and by phases (Phase 1—USD 935; Phase 2—USD 193 (Tables 2 and 3). In a 700 m^2, it could earn as much as USD 1635 in straight runs and USD 76 in Phase 1; USD 1162, Phase 2. The six runs are doable from November to March because it is the peak season of wild crablets (<3.0 cm). Comparing the two sites, Pambujan had higher (68 %) survival rate than in Rosario (50 %) for phase 1, but it was reversed in phase 2 (72 %, Pambujan; 83 %, Rosario). For straight run, Pambujan had again higher survival rate (55 %) than in Rosario (43 %).

Table 3 Financial analysis of straight run nursery production (modified from SEAFDEC/AQD et al. 2010)

Item	Open pond[a] (Rosario)	Mangrove area[a] (Pambujan)
A. Technical assumptions		
Area (m^2)	700	200
Stocking	10 000	4000
Stocking density	14	20
Culture period (days)	42	42
Survival rate (%)	43	55
Production/run	4329	2209
B. Cost and returns		
Revenues P10/pc	43 293	16 560
		2520
		19 080
Less: Variable cost	30 807	10 558
Income/run	12 486	8522
Income/year (6 runs)	74 916	51 126
Less: Fixed cost		
Allowance for depreciation	7000	2000
Maintenance	2500	1000
Subtotal	9500	3000
Net income/year	65 416	48 126
Capital investment	70 000	20 000
Return on investment (ROI) (%)	93	241
Payback period	0.97	0.40

[a] One run; USD 1 = PhP 40

Table 2 Comparative cost and return analyses of mudcrab nursery in open pond and in mangrove area by phase 1 and phase 2 (modified from SEAFDEC/AQD et al. 2010)

Items	Phase 1 (1.0–2.5 cm CW)[a]		Phase 2 (2.5–4.0 cm CW)[a]	
	Open pond (Rosario)	Mangrove area (Pambujan)	Open pond (Rosario)	Mangrove area (Pambujan)
A. Technical assumptions				
Area (m^2)	700	200	700	200
Stocking	10 000	4000	5216	2300
Stocking density	14	20	7	12
Culture period (days)	21	21	21	21
Survival rate (%)	50	68	83	72
Production/run	5049	2720	4329	1656
B. Costs and returns				
Revenue/run @ P6/pc	30 294	16 320	43 291	16 560
Less: Variable cost/run	28 206	9587	33 963	14 772
Cost/pc	5.59	4.28	7.84	8.92
Income/run	2088	6733	9330	1788
Income/year (6 runs)	12 529	40 399	55 980	10 730
Less: Fixed cost	9500	3000	9500	3000
Net income/6 runs	3029	37 399	46 480	7730
Capital investment	70 000	20 000	70 000	20 000
Return on investment (ROI) (%)	4	187	66	39
Payback period (year)	4.11	0.39	1.16	0.92

[a] One run; USD 1 = PhP 40

Table 4 Summary of factors showing significant regression coefficients in the multiple regression analysis on growers' interest in technology adoption

Factors	β	α	Adjusted R^2
Awareness of technology	0.42**	0.79	0.13
Farm distance	1.09**	0.0000997	0.24
Culture area ownership	0.77**	0.16	0.31
Feed source	0.17*	0.91	0.14
Market	0.86**	0.14	0.34
Children education	1.91*	−0.46	0.11
Available resource (crablets)	0.50*	0.5	0.18

** $p < 0.01$,* $p < 0.05$; β is regression coefficient; α is the intercept; R^2 is coefficient of determination

The demonstration sites in Laoang and in Lavezares were not continued after initial runs. There was hydrology problem in Laoang. In Lavezares, the beneficiaries claimed that the demonstration site was far, hindering their regular monitoring of the nursery set up. It was noted that only few PO members in Pambujan actively participated during the season-long training. Generally, the NGOs were the ones more actively involved during the season-long training.

Factors Influencing Interest in Mudcrab Nursery

Most (83 %) respondents had positive response to mudcrab nursery intervention. The factors significantly ($p < 0.05$) influencing their interest were awareness of the technology, availability of crablets, distance of farm from household, ownership of culture area, source of feed, market, and education of children (Table 4). The higher coefficient of determination (adjusted R^2) for ownership of area, market, and farm distance from household compared with the other four factors suggests that these are more important considerations in enticing small-scale growers in technology adoption. Correlation test further substantiated this result with the positive and high correlation of nursery interest with ownership of area ($p < 0.01$), farm distance from household ($p < 0.01$), and market ($p < 0.01$) than the other variables. Market ($p < 0.05$) had also positive association with ownership of area. In this study, the market refers to a place where they could sell mudcrab at a high price.

Because of the financial support from the donor agency, capital was not seen as an immediate issue. Respondents believed that while the technology adoption has its advantages, it could also create problems like stiff competition for crablets, insufficient feeds, non-recognition of customary rights upon zoning of the aquasilviculture park, and destruction of mangroves if allocation right is not properly demarcated and monitored.

DISCUSSION

The capacity of aquaculture to meet global demand for food fish consumption has encouraged intergovernmental organizations like FAO to advocate further development of aquaculture through project-based interventions to reduce poverty and ensure food security. The ICDSA community-based and participatory approaches to technology transfer complement this advocacy in the promotion of small-scale aquaculture. Concerns have been raised about the effectiveness of FAO's advocacy, with limited empirical evidence of its applicability (Belton and Little 2011). This study suggests that the impact of technology transfer directed on the resource poor can be far reaching. The ICDSA innovative schemes create awareness among growers the ways to have livelihood regardless of gender. The farm-site demonstration, for example, allows them to examine the technology in a more realistic whole-farm environment (Nyemba 1997). It also gains growers' cooperation and encourages small-sized ventures to be more competitive in the market (Macintosh et al. 1993; Morrissey and Almonacid 2005).

NGOs and LGUs are good channels in transferring technologies to fishing communities. They prepare communities to be self-reliant and help them access resources (capital, culture area, and information), among others. Moreover, they help address community issues even beyond the project life. Nonetheless, lessons have to be learned from the initial technology transfer experience on mudcrab culture and fattening. The economic incentives encourage coastal communities to venture on small-scale aquaculture. Thus, income from the venture must be enough to pay for the opportunity cost in the course of member's involvement in the project, which is unattainable for a small-scale cooperative undertaking with many members. Family-based or individual operations may serve as a better option than the cooperative venture in engaging communities in adopting small-scale aquaculture technology. This makes a member feel that the gain of his/her labor was truly his/her own even if he/she is operating within the ambit of people's organization. However, cooperativism may work well in sourcing common supplies and marketing their products. But it needs good leadership and social preparation (e.g., value formation) of members to make it successful (Gutiérrez et al. 2010; Primavera et al. 2010; Petersen et al. 2011). Own labor is the main asset and source of power of the poor households and the key determinant of household output, income, and food security when access to resources is a limiting factor for them (Smith et al. 2005). Furthermore, engaging women's participation in the venture strengthens women position in the decision-making and control over family's income impacting on household food security and nutritional outcomes (Lewis 1998; Kawarazuka and Béné 2010).

Enforcement of regulations is important to mitigate illegal harvest and regulate dispersion of wild crablets endemic to the locality. If this is coupled with the setting up of mudcrab nurseries, it will provide venue for the gatherers to rear crablets at a size that can be transported legally outside the province. There is also potential for positive add-on effects (e.g., higher income and children can attend school). They will also earn six times more from their current sales (Muhia and Lutao 2007). This, however, requires a dynamic linkage with broad range of stakeholders and technology transfer programs that can respond quickly where innovation and adaptation are keys to successful ventures (Morrissey and Almonacid 2005).

Mudcrab nursery can be profitable if managed properly. It is also beneficial to mudcrab growers for they preferred bigger crablets, though more expensive than smaller crablets, for stocking in grow-out ponds (Ut et al. 2007). Technology adoption by smallholder operators, however, takes time and sustaining the same hinges on many factors. Moreover, innovations are unlikely to be adopted if it would result in a financial loss (Whittemore 2001). Nonetheless, the high survival (68 %) of crablets in a mangrove pond compared to a non-mangrove area (50 %) suggests that mangroves played a role in mudcrabs' endurance. This confirms that mangroves are part of portunid crabs habitat in its life cycle (Walton et al. 2006; Ellison 2008; Primavera et al. 2010). Mangrove habitat provides essential nursery beds, feeding areas, and shelter for a large variety of marine and estuarine biota (Ellison 2008). Rodriguez et al. (2007) also found low survival rate of crablets in a non-mangrove area pond though its growth rate is high. In this study, the high survival rate in non-mangrove area for Phase 2 may be attributed to the use of bigger-sized crablets, hence, it could withstand harsh pond conditions. These imply that the size of the crablets (1.0 or 2.5 cm) and the location of farm should be considered in the culture system. Climate change (prolonged rain) also affects the growth and survival of crablets.

The factors influencing technology adoption are useful criteria in transferring aquaculture technologies to smallholder growers. These also affirm Slater et al. (2013) argument that social and economic drivers affect adoption of aquaculture technologies. Foremost among these is the access rights to land for mudcrab culture. Land ownership among coastal dwellers is nil that mangroves can be utilized for mangrove-friendly aquaculture for it is both compatible with mangroves and amenable to small-scale, family level operations (Primavera 1995). But institutions are critical in determining access rights of different groups over common resources like mangroves (Smith et al. 2005). Co-management may be used as a strategy in allocating access rights to mangrove forest for efficient and equitable system in extracting and distributing resource rents (Pomeroy 1995). Moreover, co-management recognizes the importance of involving locals in the development and implementation of management policies that their participation is necessary considering mangroves multiple uses (Baticados and Agbayani 2000).

Similarly, distance hinders monitoring and makes the stocks vulnerable to poaching. Distance also impeded the community mudcrab culture initiatives in Kenya (Mirera 2011). This connotes fulltime presence in the farm, but less mobility for small fishers to find other livelihood opportunities. The market has to be identified to ensure the product is sold either as a crablet for stocking in grow-out ponds or for growers' own use in their grow-out ponds. The positive association of market with ownership of area implies that growers owning culture areas have more independent options where to market their product, maximizing their profits. To survive a competitive environment, the growers should also consider the economies of scope (e.g., nursery, grow-out, and fattening) instead of economies of scale (Kahen 1996). In aquaculture, however, both scope and scale of operations affect the profitability and sustainability of the venture.

CONCLUSION

While the initial outcomes of the technology transfer of mudcrab nursery showed positive results, the ICDSA strategy has its limitations and lessons to be learned from, as follows:

(1) The insufficient financial and technical resources of the local partners (NGOs and POs) may restrict them to sustain the initial interventions in promoting aquaculture livelihood. External funding is limited and hard to find. LGUs are more stable partners because of the Internal Revenue Allotment from the national government used for livelihood and mangrove conservation programs in the municipality. However, elected officials serve for only 3 years at a time, and the succeeding elected officials may have different priorities in the municipal development program.

(2) Social preparation must be an integral part of rural development, but was not a component of ICDSA process. Social preparation is mainly the responsibility of the LGUs and NGOs as partners.

(3) The uptake of aquaculture technology by smallholders is motivated primarily by short-term financial gains. As most of the target beneficiaries are small-scale fishers, their cash flow is on a daily basis. In contrast, income from aquaculture is realized at harvest time. Micro-finance companies have to make available

low-cost financing to them. However, small-scale fishers are risk-averse especially in new ventures like aquaculture.

(4) Lack of culture area is a limiting factor in enhancing the adoption of mudcrab culture by the rural folks. Abandoned ponds should be replanted with mangroves which may be used for future aquasilviculture.

(5) Effective policies and good science are critical in rural aquaculture. In spite of the international codes and national and local fishery laws, fishery governance can only be effective if local officials have the political will to enforce the law. In many cases, law enforcement has been found wanting. Local power structure plays a significant role in deciding the actual outcome of regulatory measures (Hoq 2007). The efficacy of local ordinances should be continuously reviewed and improved. Research and development institutions like SEAFDEC should disseminate scientific information on good aquaculture practices and the status of the aquatic environment for management and local legislation. Risk analysis in aquaculture should be done to evaluate the dangers and weaknesses of the aquaculture system in adapting to climate change.

Overall, the ICDSA personalized and participatory approaches have created stakeholder awareness on the opportunities and weaknesses of the aquaculture systems. Beneficiaries gain a sense of ownership of the project. These approaches inculcate responsible attitudes toward achieving success in livelihood endeavors and in making them responsible stewards of the aquatic environment.

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