Kuroshio Science 12-1, 16-26, 2018

Symposium Proceedings

Status, Challenges and Directions of Rural Fishery in the Philippines: With Focus on Key Riverine and Coastal Fisheries

Raul G. Bradecina
Partido State University, Goa, Camarines Sur, Philippines

ABSTRACT

The Philippine rural fishery, despite its subsistence nature, have recently been attracting attentions because of the government's focus on promoting poverty alleviation and sustainable development. In this presentation, we described the current status of the Philippines' rural fisheries, its challenges and emerging directions with focus on its riverine and coastal ecosystems, their resources and the rural communities that exists adjacent to them. We highlighted the human, ecological and technological dimensions of rural fisheries focusing on the most common resources produced by the aquatic ecosystems covered under the municipal waters defined under existing laws of the Philippines and the related economic activities. Each dimension of the rural fisheries was highlighted using case studies that depict the recent developments and challenges. Strategic directions confronting the challenges discussed in the case studies were articulated in the context of resource management and stock enhancement, social enterprise development, production technology development and modalities for technology transfer to support policies that promote achievement of sustainable communities. The summary and conclusion part of the paper provided overall insights on the challenges and recent directions of the Philippine rural fishery and fish processing industry.

Key words: Rural fisheries, Riverine and Coastal Ecosystems, Human Dimension, Ecological Dimension, Technological Dimension

INTRODUCTION

Under the 1991 Local Government Code of the Philippines, the rural fisheries which covers inland and coastal waters (Book 2, Chapter 1, Section,131 (23)) are part of the municipal waters managed by local government units exercising administrative jurisdiction over them as defined by their respective geographic and political boundaries (1998 Fisheries Code of the Philippines). The inland waters include rivers, lakes and streams; the coastal waters include bays, gulfs, estuaries and marine waters within the 15-kilometer radius perpendicular to the municipal government coastline. The municipalities govern the rural fisheries through Philippine Fishery Law (RA 8550), Executive Orders and Memorandum Circulars issued by government agencies such as the Bureau of Fisheries and Aquatic Resources and the Department of Environment and Natural Resources.

The riverine and coastal fisheries in the Philippines mirrors rural fisheries. The small and native fish species and freshwater shrimps are representative species of the riverine fisheries in municipal waters. The riverine fisheries include handline and pot fishing of native catfish, eel, carps in rivers, stream and lakes and gleaning, pot fishing and net fishing of small freshwater shrimps in lakes, rivers and estuaries. The scallops and mussels are among the representative species of the coastal fisheries. The scallop fishery includes scallop diving in bays; while the mussel fishery includes mussel spat collection and mussel stake and raft farming in coves, swamps and bays.

Rural fishery is the most multifaceted sector of the Philippines fisheries characterized by human, ecological and technological dimensions. The human dimension of the rural fisheries is depicted by the rural fishers who are considered as the poorest of the Philippine society. The ecological

* E-mail: rgbradecina@yahoo.com

dimension is portrayed in its diverse aquatic resources and high endemism. The Philippine coastal and inland fisheries are characterized by multi-species, and multi-gear nature (Bradecina et al. 2012). The multifunctionality of the ecosystem covered by the rural fisheries composed of the various uses ranging from resorts and tourism, navigation, hydropower generation, aquaculture and agriculture use is a source of resource use conflict issues; and the high anthropogenic pressures created threatens its ecological function. The technological dimension is evinced by a low-return economic activity due to the prevalence of low-technology and low-input nature of fishing enterprise. Commonly, rural fisheries is characterized by being small-scale in operation and subsistence in nature.

In this paper, we described the current status of rural fishery in the Philippines with emphasis on riverine and coastal ecosystems and its human communities. Particularly, we highlighted the human, ecological and technological dimensions of rural fisheries focusing on the most common resources produced by the aquatic ecosystems as covered under the municipal waters defined under Philippine laws. These dimensions of the rural fisheries were separately highlighted through case studies depicting recent status, challenges and future directions.

METHODOLOGY

This paper employed multi-case studies on coastal and riverine aquatic ecosystems and communities in Bicol Region and parts of the Philippines adopting standard social, economic and ecological methods and analytical tools. The case studies on the common rural fishery resources and resource utilization which include the freshwater shrimps and small and native fish species in the riverine ecosystems, and the scallops, mussels and tuna in the coastal ecosystems alternately highlighted its human, ecological and technological dimensions. Case studies were contextualized along the analytical frameworks of poverty alleviation, biodiversity conservation, sustainable livelihood, and resource governance.

HUMAN DIMENSION OF RURAL FISHERIES

The case of scallop fishery in Naro Island, Masbate

Scallop fishing is the main source of livelihood of fisherfolks in the island of Naro, in the Municipality of Cawayan, Masbate. It supports more than 200 fishing households in the island. The scallop fishing ground area covers an estimated 28,300 hectares, or barely one tenth of Asid Gulf. Scallops are harvested from sea bottom between 45 to100 feet depth by divers using improvised underwater breathing device known as hookah. It is a long plastic hose brought by a scallop fisher at depth where scallops are collected where he takes in air to breath underwater. The plastic hose is connected to the air compressor machine mounted on the boat which generates the air for the diver. The harvest season of scallops commonly starts from March and extends until June.

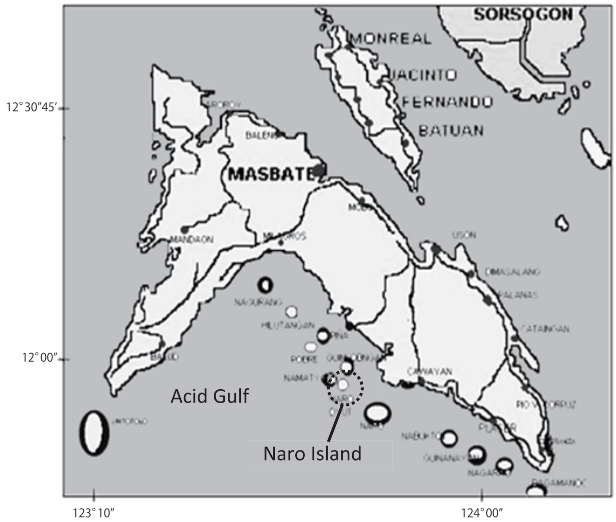

Fig. 1. Location Map showing Naro Island in the Island Province of Masbate, Bicol Philippines.

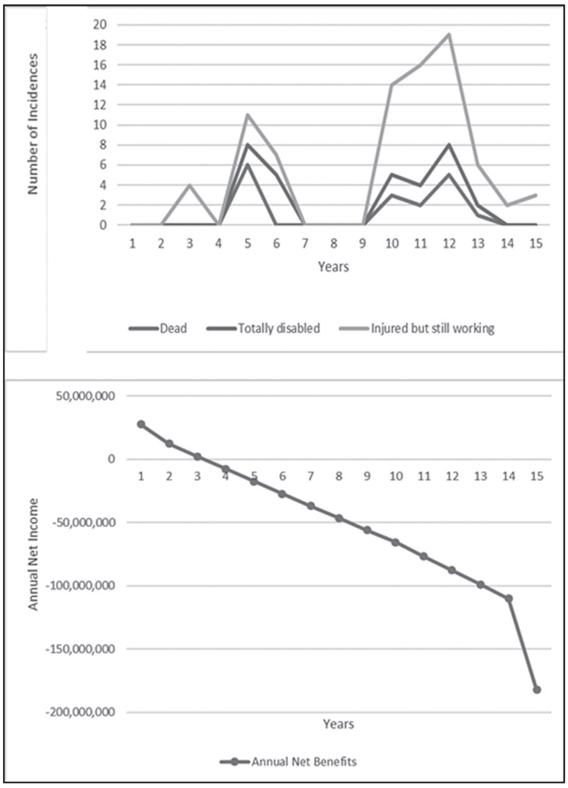

Fig. 2. Annual trend in incidence of fatality in scallop diving fishery and scallop fishery resource degradation over 15 years.

Table 1. Revenue, Costs and Net Income from scallop fishing among Naro Island fishers with and without boats in 1994 and 2008.

Year	Revenue	Fixed Costs	Variable Costs		Total Cost	Net Income
		Depreciation	Opportunity Cost of Labor	Operating Cost		
1994	26,400,000[a]	10,309,200	377,520c	1,161,600	14,520,000	11,880,000
(compounded @5% discount rate ; 15 yrs, Discount Factor = 2.09; @ 200 fishers)						
Pooled WB* & WOB** fishers (Annual)	55,176,000	21,546,228	789,017	2,427,744	30,346,800	24,829,200
Without Boat (WOB) Fisher (Annual)	55,176,000				789,017	54,386,983g
Per WOB fisher (Annual)	275,880				3,945	271,935
Per WOB fisher (Monthly)	27,588				95	27,193
2008						
(Compounded @ 5% discount rate ; 1 yr, Discount Factor = 1.05; @200 fishers						
Pooled With Boat (WB) Fisher & Without Boat (WOB) fishers	16,290,000b	141,128,000	4,752,000	15,704,000d	161,584,000	-182,256,880f
Without Boat (WOB) Fisher (Annual)	16,290,000				4,752,000	11,538,000e
Per WOB fisher (Annual)	81,450				23,760	57,690
Per WOB fisher (Monthly)	8,145				2,376	5,769

a
*WB = with boat; **WOB = without boat

Table 2. Number and Proportion of dead, totally disabled and injured but still working scallop fishers in Naro Island from 1994 until 2008.

Year	Dead	Totally disabled	Injured but still working	Total
1994				
1995				
1996			4	4
1997				
1998	6	2	3	11
1999		5	2	7
2000				
2001				
2002				
2003	3	2	9	14
2004	2	2	12	16
2005	5	3	11	19
2006	1	1	4	6
2007			2	2
2008			3	3
Total	17 (21%)	15 (18%)	50 (61%)	82 (100%)
Mean	6	4	10	6

A team composed of 3-5 divers collect between 10 to 30 sacks (80 kg per sack) of scallops within 4 to 6 hours per diver per day. Production of scallops in Aside Gulf was about 150 mt/month the highest in any single area in the Philippines.

The profitability of scallop dive fishing that earned for each fisher monthly income thrice as much of their counterparts in the country during the early stage of the fishery provided the incentive to mine the resource to depletion. Table 1 presents the average annual net income from scallop fishing among 200 scallop fishing households at PhP 27,193 for non-boat fishers and declined severely by almost three-folds after in 2008, or after almost 15 years of unsustainable extraction.

The profitability of the scallop fishery in the past provided incentives for the fishers to mine the resources to depletion and of late, trade off life and limbs for small wealth. The economic incentive fueled the risk-seeking behavior of fishers to fish at expense of safety to life and limbs. Table 2 shows records of scallop fishery divers who died, were totally disabled or injured but are still working in the area which manifested in the earlier years when scallop resources posted a near collapse, where the untapped populations of the scallop stocks can only be available in the nearly inaccessible depths of the Gulf.

Despite the risk, the open access nature of the common pool scallop resource fueled “race for fish” towards resource rent dissipation. Figure 3 demonstrated the inverse relationship of fatality against resource degradation evidenced by increasing casualties with declining net benefits or resource rent dissipated through time.

The higher price and low supply of scallops means that divers should explore deeper part of the sea, stay longer even at the risk of dying. The absence of fatality under the condition of abundant resource proved the importance of ensuring resource sustainability through resource management. While the real income from fishing appeared to be still profitable today, the net economic benefits, when opportunity cost of labor and other non-expenses were considered posted a negative. Poverty in the island makes the fishers insensitive to the concept whether they are earning no more or even less than their opportunity costs as long as they earn a living (Bradecina and Soliman, 2014).

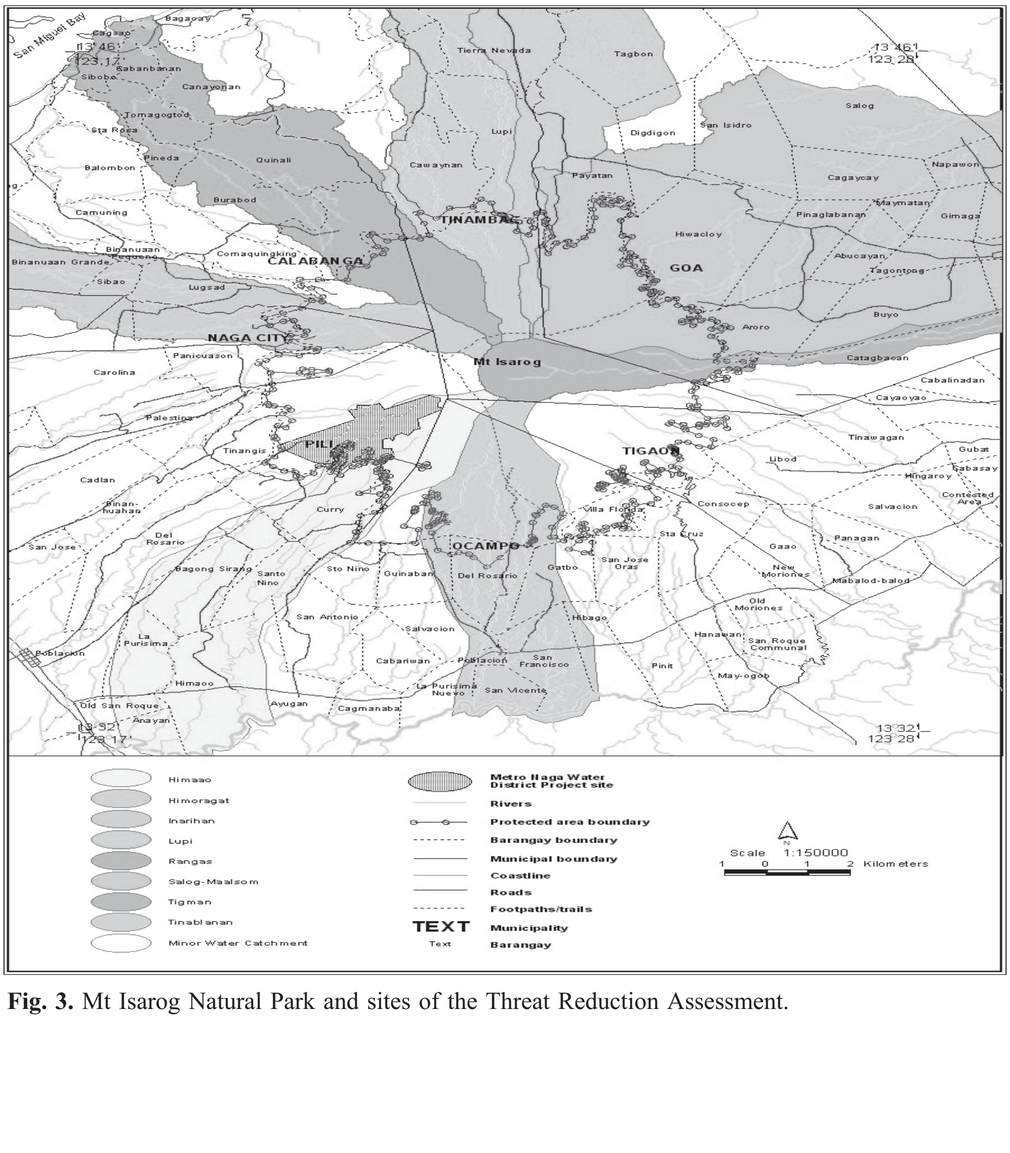

Fig. 3. Mt Isarog Natural Park and sites of the Threat Reduction Assessment.

ECOLOGICAL DIMENSION OF RURAL FISHERIES

The case of small and native fish species and riverine shrimp fishery in Bicol KBAs

Most of the inland aquatic ecosystems in the rural fisheries are fed by mountains in key biodiversity areas. Among these is the Mt Isarog in Bicol Region. Mt. Isarog, is a natural protected area created by virtue of the National Integrated Protected Area System Law of 1992. Considered as a key biodiversity area, there are 28 rivers, 9 springs, 27 creeks, 9 falls and a lakelet within Mt Isarog Natural Park (MINP) that serve as habitat to small and native freshwater fish species (Fig. 3).

The MINP freshwater fishes provide the resources for the subsistence fishery serving the poor fishery-dependent populations within the 6 municipalities and a city that border it. Within Mt Isarog are 22 barangays settled by around 29,819 people or some 5,375 households (2005 data). The average number of person per household is 5.91. It has a total land area of 154.86 km^2, or an average population density of 192.55(n individual per Km^2. The various anthropogenic activities created by these human inhabitants threaten the population of small and native fish species in the riverine ecosystems of MINP. Placing third and ninth among the top-ranking threats were illegal fishing practices of electric fishing and poison-fishing respectively. Table 3 presents the top-ranking threats to Mt Isarog Natural Park biodiversity during the participatory threat reduction assessment in 2004 following the method of Salafsky and Margoluis (1999).

These threats caused the significant decline of SNS in the riverine ecosystems of MINP. Over 15 years the total yield declined from more than 6.6 tons in 1999 to half of a ton in 2004, posting 55% reduction (Bradecina, 2007). Table 4 presents the change in catch of in both introduced and native SNS in riverine ecosystems of MINP showing significant decline.

The riverine ecosystems of Bicol KBAs still contain diverse population of freshwater shrimps. Figure 4 presents the locations of the KBAs in Bicol, Philippines.

Presently, in the riverine ecosystems of Malinao and Mayon in Albay Province, Buhi lake, Mt Isarog, and Caramoan in Camarines Sur province and San Andres watershed in the island province of Catanduanes, there are two families of freshwater shrimps comprising 3 genera and 18

Table 3. Ranking of threats to Mt Isarog Natural Park biodiversity by stakeholders during the threat reduction assessment covering Phase 1 (1995 and 2004.

Threats	Sum of Threat Ranks (Combination of Area, Urgency and Intensity Ranks) Across All Sites	Number of sites the threat was observed	Average	Measure of importance	Rank
Inorganic Farming	471	21	22.43	2.894	1
Wildlife Hunting	341	22	15.5	2.195	2
Electric Fishing	310	21	14.76	1.905	3
Monocropping	356	17	20.94	1.771	4
Timber Poaching	277	21	13.19	1.702	5
Slash and Burn Farming (*Kaingin*)	305	18	16.94	1.606	6
Gathering of NTFP/MFP	235	20	11.75	1.375	7
Improper Waste Disposal	226	11	20.55	0.727	8
Poison Fishing	155	13	11.92	0.59	9
Burning of Wastes	165	9	18.33	0.434	10
Illegal Entry	163	9	18.11	0.429	11
Treasure Hunting	103	7	14.71	0.211	12
Quarrying	81	5	16.2	0.118	13
Permanent Pasturing	52	2	26	0.03	14
Charcoal Making	43	2	21.5	0.025	15
Intro of Exotic Species	19	4	4.75	0.022	16
Infrastructures	24	2	12	0.014	17
Forest Fires	18	2	9	0.011	18
Increase in population of park settlers	34	1	34	0.01	19
Cutting of Coconut Trees	20	1	20	0.006	20
Unchecked Tourism	10	1	10	0.003	21
Firewood collection	10	1	10	0.003	22
Total	3418				

Table 4. Changes in quantity of catch of introduced species and native species of freshwater fishes in the riverine ecosystems of Mt isarog Natural Park in 1999 and 2004.

Year	Introduced Species			Native Species		
1999	Species	Kg	%	Species	Kg	%
	Catfish	781	10	Snakehead	366	5
	Tilapia	639	8	Eel	5426	68
		1420		Native Goby	426	5
				Native Perch	228	3
				Kiskisan	27	0
				Native Catfish	25	0
				Native Carp	19	0
	Total	1420	18		6,517	82
2004	Species	Kg	%	Species	Kg	%
	Catfish	165.5	17	Snakehead	7	1
	Tilapia	272.5	28	Eel	455	47
		438		Native Goby	12	1
				Native Perch	50	5
				Kiskisan	2	0
				Native Catfish	0	0
				Native Carp	5	0
	Total	438	45		530	55
	Increase (Decrease)		(27)			(27)

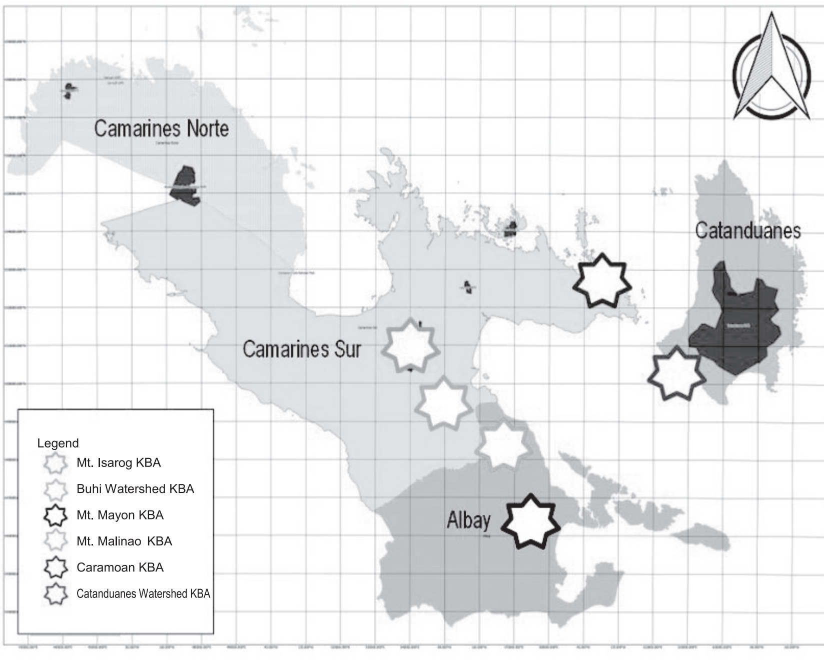

Fig. 4. Locations of the key biodiversity areas of Bicol and riverine ecosystems.

species. Under family *Paleamonidae* (Rafinesque 1815) includes genus *Macrobrachium* (Bate 1868); family Family *Atyidae* (De Haan 1849) includes genus *Atyopsis* and genus *Caridineae.* Figure 5 presents the various species.

However, out of the 18-identified freshwater shrimp species in the riverine ecosystems of Bicol KBAs, only one species was categorized as common species. The single commonly occurring Palaemonid species is *M. latidactylus*. This species can be found in Mt Isarog, Malinao, Caramoan and Catanduanes KBA riverine ecosystems. The rest were categorized as rare species. Table 6 presents the percentage occurrence of each species across the riverine ecosystems in Bicol KBAs and their respective adjectival categories.

The rare occurrence of most species reflected the heavy pressures created by unmanaged extraction by communities within the KBAs on freshwater shrimp assemblages, and the impact of various anthropogenic activities. No riverine

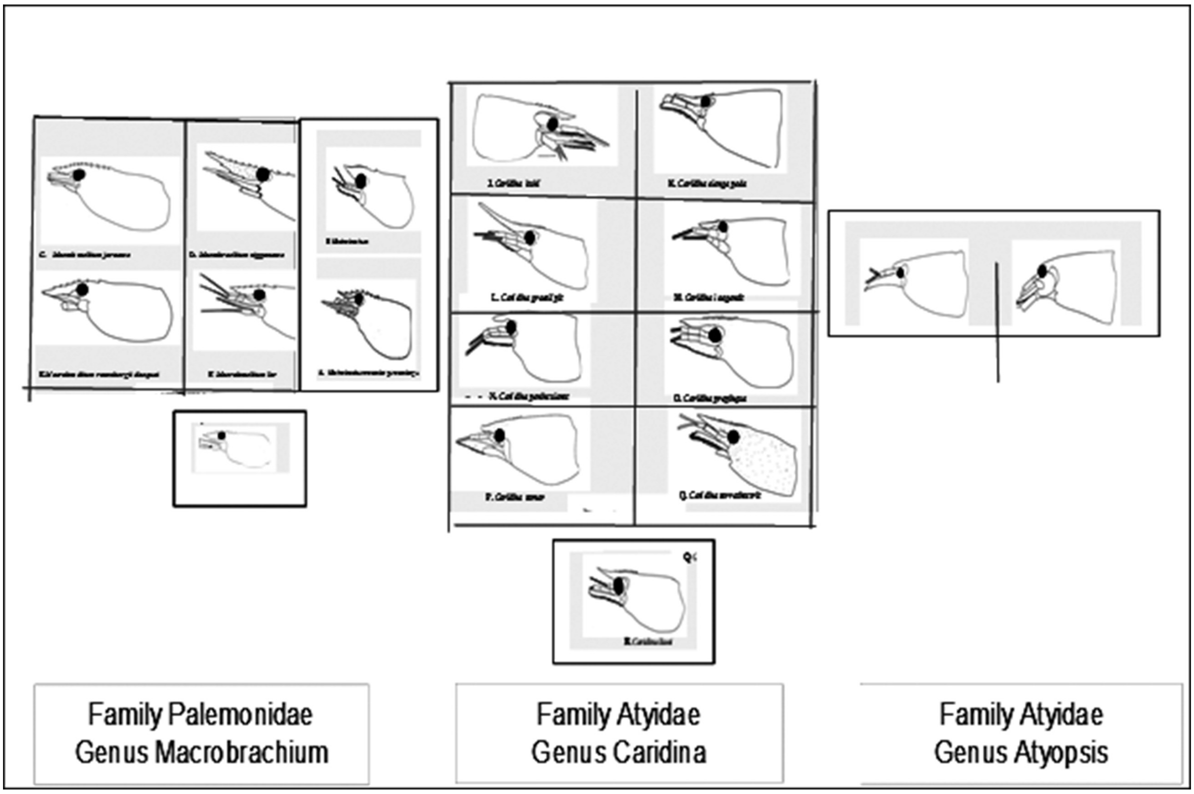

Fig. 5. Illustrated species of freshwater shrimps under the genera of the family *Paleamonidae* and *Atyidae* in the riverine ecosystems of Bicol key biodiversity areas.

Table 6. Occurrence (%OF) and category of freshwater shrimp species in the riverine ecosystems of Bicol key biodiversity areas.

Species	Isarog	Malinao	Buhi	Catanduanes	Caramoan	Mayon	All (Bicol)		
							Total	% OF	Category
M. lar				3			3	17	Rare
M. jaroense		3					3	17	Rare
M. rosenbergii dacqueti				3			3	17	Rare
M. nipponense			3				3	17	Rare
M. lactidactylus	1	1		1	2		5	28	Common
M. leucodactylus		1					1	6	Rare
M. rosenbergii rosenbergii	1						1	6	Rare
A. pelipes		1					1	6	Rare
A. spenipes				3			3	17	Rare
C. elongapoda					1		1	6	Rare
C. gracelipis					3		3	17	Rare
C. buhi			3				3	17	Rare
C. peninsulares	3					1	4	22	Rare
C. propinqua	3	1					4	22	Rare
C. serratirostris	3						3	17	Rare
C. laogensis	2						2	11	Rare
C. samar						1	1	6	Rare
C. liaoi	1	0	0	0	0	0	1	6	Rare

Table 7. Anthropogenic activities identified in the riverine ecosystem of Bicol key biodiversity areas.

Key Biodiversity Areas	Anthropogenic Activities											
	Quarrying	Laundry Public	Gold Panning	Irrigation	Public Bathing	Hydro power generation	Animal tendering	Fishing	Transport and navigation	Dumping of domestic waste	Illegal fishing (electric fishing)	(posion fishing) Illegal fishing
Isarog	X	X			X		X				X	X
Malinao		X			X		X	X			X	X
Buhi	X	X		X	X	X	X	X	X	X	X	X
Catanduanes	X	X			X		X	X		X	X	X
Caramoan					X		X	X			X	X
Mayon							X	X		X	X	X

ecosystem in the Bicol KBAs is spared from these threats to shrimp population and diversity; with illegal fishing practices using electric current and poisonous substances as most prevalent (Bradecina et al, 2015). Table 7 presents the various threats documented across the riverine systems of Bicol KBAs causing their degradation and negatively impacting the abundance and occurrence of freshwater shrimps.

TECHNOLOGICAL DIMENSION OF RURAL FISHERIES

The case of mussel fishery in the coastal communities of Visayas and Luzon areas

On a national basis, there is an estimated total of 4,291 fishing households that depend on mussel industry for livelihood. In the Western Visayas area which include the mussel producing municipalities of Capiz and Aklan, there are more than 2,000 coastal families who are engaged in mussel farming. In Samar area which include the mussel producing municipalities of Borongan and Catbalogan, there are at least 1, 865 households that depend on the mussel industry for livelihood. In the Luzon area such as in the municipality of Cavite, there are 426 registered operators of mussel farms. Around 91% of these mussel farms are operated by fishing households. The total mussel production area of the country is estimated at 900 hectares. In 2013, the annual mussel production was merely 22,894 MT.

There are several technological challenges confronting the industry that explains for its low production. These technological bottlenecks exist along the supply chain of the mussel industry from seedstock production, to grow-out and until the post-harvest. Along seedstock development, the lack of adequate supply of quality seeds or spats for mussel farming is a key constraint. The technological gaps that fuel this constraint are the absence of hatchery technology for mussel, inadequate technology in transporting and transplantation of mussels and the absence of spatfall prediction model and efficient spat collection methods. Along grow-out development, the key constraint is low mussel production. The technology gaps that cause this problem are Inadequate culture technique and the lack of information for potential mussel farmers in non-traditional sites. Along post-harvest and processing the poor quality and unsafe mussels produced by farmers are considered main problems. The technology gaps that fuel these problems are the inadequate cleansing and depuration techniques, the inadequate primary processing techniques and the inaccessibility of the technologies generated among farmers.

To confront the technological challenges posed by the country's low annual mussel production, a mussel industry strategic plan (ISP) has been pursued by the national government through the DOST-PCARRD in collaboration with academic and research institutions such as the UP Visayas and Partido State University. Along seedstock development the gaps were addressed through the development of S and T interventions for the mass production of quality seeds, brood stock conditioning, larval and spat rearing, development of remote setting and nursery technologies and transplantation and spatfall determination. Along low mussel production, the gaps were addressed through the development of S & T interventions of raft and long-line culture of green mussel. Along the main problems of poor quality and unsafe mussels produced by farmers, the gaps were addressed through S and T interventions on the development of mussel relaying protocol, and development of depuration protocol.

Despite the plan for the transfer and formal roll-off of the technology in the field, already, less than one half or 42% of mussel famers in the key mussel farming areas of the country expressed willingness to adopt longline method for mussel farming. Mussel farmers with higher monthly household income, have bigger farm areas, and have been innovating on non-traditional mussel farming methods are more likely to adopt the longline technology. This reflect the significant influence of economy of scale, the familiarization and prior knowledge and skills on the upscaled level of farming system by the would-be adopters, and the complexity or simplicity of the method as the factors that will greatly influence adoption of the generated technology for mussel yield improvement. Table 8 presents the results of the regression analysis of mussel farmers' willingness to adopt with key independent variables.

Each of the mussel ISP technology bundle is composed of technology packages addressing a specific outcome and targeting a defined group of adopters and mussel producing areas. From the S and T interventions developed along the technology chain, three technology bundles were packaged namely: Bundle 1 (Mussel Yield Improvement Technology); Bundle 2 (Mussel Product Quality and Safety Improvement Technology) and Bundle 3 (Mussel Seedstock Production Area Expansion and Supply Stabilization Technology).

Bundle 1 (Mussel Yield Improvement Technology) is composed of technologies that will help improve yield in mussel farms by increasing the capacity of the production system to accommodate more number of seedstocks for grow-out (i.e increasing the number of pieces of mussels per kilo produced), increasing the number of cropping per year through stable supply of seedstocks, increasing the survival and the recovery rate of seeded mussels. The technologies that comprise Project Bundle 1 include longline, nursery, hatchery, spat prediction model and effective spat collector technologies.

Bundle 2 (Mussel Product Quality and Safety Improvement Technology) is composed of technologies that will help improve the quality of marketed mussel by reducing their microbial loads thus commanding premium on selling price by considerable percentage due to the increased assurance of food safety. The technologies that comprise Bundle 2 include relaying and depuration protocol and longline farming technology for mussel.

Bundle 3 (Mussel Seedstock Production Area Expansion and Supply Stabilization Technology) is composed of technologies that will help increase the current mussel production area through translocation in areas with existing mussel stocks or by extending the coverage of mussel farms in coastal provinces or municipalities with large areas for expansion. The technologies that comprise Bundle 3 include hatchery, nursery and longline technologies.

Mussel farmers are keen at adopting a combination of technologies developed to increase production. Treating adoption of bundled technologies as a simultaneous decision by mussel farmers, the bigger is the farm size and the higher is the disposable income of the mussel farmer, the more likely that they will likely adopt longline technology and use hatchery-raised spats in their farms. Table 9 presents result of the bivariate probit analysis on the mussel farmer respondent's simultaneous response to a decision to adopt the mussel longline grow-out method and to utilize the hatchery-raised spats together with select independent variables (Bradecina et al, 2016).

Table 8. Results of the regression analysis between mussel fishers' willingness to adopt longline technology and key sociodemographic and mussel farm production variables.

Variable	Coefficient	Standard Error	|b/St.Er.	P[|Z| > z]
Constant	-1.94507999	1.47943486	-1.315	.1886
SEX	-1.08115450	.52285548	-2.068	.0387**
CIVST	.36834404	.6519115	.565	.5721
EDUC	.02958661	.06376532	.464	.6427
YFARM	.02048732	.01901245	1.078	.2812
MINC	.00021044	.647218D-04	3.251	.0011 **
FSIZE	.00012076	401371D-04	3.009	.0026**
MAJOC	.46835153	.43363915	1.080	.2801
FMETH	-.55341299	.27291343	-2.028	.042**
No Obs				169
Mc Fadden Pseudo R-squared				.2817365
Chi squared				64.78575
Degrees of freedom				8

Table 9. Results of the bivariate probit regression analysis of mussel farmer respondent's simultaneous decision to adopt the mussel longline grow-out method and to utilize the hatchery-raised spats together.

Variable	Coefficient	Standard Error	B/St. Error	P{|Z| > z]
Index Equation for WTALL*				
Constant	-.8575618	.98658740	-.869	.3847
SEX	-.72510177	.32044079	-2.263	.0236**
CIVIST	.11841647	.42570508	.278	.7809
EDUC	.00896195	.04809458	.186	.8522
YFARM	.01440094	.01186129	1.214	.2247
MINC	.00012790	.473487D-04	2.701	.0069**
MAJOC	.12230664	.28503504	.429	.6679
FSIZE	.705617D-04	.227605D-04	3.100	.0019**
FMETH	-.22516326	.16523281	-1.363	.1730
HARV	.195398D-04	.532647D-04	.367	.7137
Index Equation for WTAHATC**				
SEX	-.32286548	.38271136	-.844	.3989
CIVIST	.22030099	.46599669	.473	.6364
EDUC	-.05671426	.04197763	-1.351	.1767
YFARM	-.00755123	.01358807	-.556	.5784
MINC	.00014309	.443278D-04	3.228	.0012**
MAJOC	-.37000155	.26243148	-1.410	.1586
FSIZE	.00012258	.570792D-04	2.148	.0317**
FMETH	-.04840468	.17479339	-.277	.7818
HARV	-.893910D-06	.355109D-04	-.025	.9799
Constant	-.42528813	.98420824	-.432	.6657
Disturbance correlation				
RHO(1,2)	.76723692	.09364419	8.193	.0000
No. Obs.	169			

*WTALL = willingness to adopt longline technology; ** WTAHATCH = willingness to adopt mussel hatchery-raised spats as seedstocks for mussel grow-out operation using longline method

CONCLUSION AND WAY FORWARD

The rural fisheries of the Philippines is a complex system. The interplay of human, ecological and technological dimensions is most profound in the country's rural fisheries sector. Its human face is reflected on the development of a risky economic behavior of fishers as resource users in a common pool fishery resource. The declining fishery resource creates premium for rare catch and provides the incentive for each fisher to trade lives and limbs in a fishery whose economic rent has been dissipating over time. Its ecological dimension is gleaned from the declining population of SNS and diversity of freshwater shrimps in the riverine ecosystems. Riverine ecosystems and their resources are sensitive to ecological perturbations which are caused by anthropogenic activities. Among rural communities commonly characterized by dense population, a combination of unsustainable fishing practices and human activities impact the rivers and their living resources altering ecosystem soundness and biodiversity. The technological aspect is manifested in the concerted effort of various stakeholders to address both the challenges related to the ecological and social dimensions of the rural fishery particularly by enhancing natural production, promoting safe environment and ensuring healthy food fishes. While technology holds the promise to address ecological and social issues of rural fisheries, its success is also defined to a large extent by human behavior and ecosystem dynamics. The biology and ecology of a species determines its reproductive success and growth in an altered environment. The level of awareness and perceptions of utility determine fish farmers' binary decision to adopt or not a new technology. In rural communities of the Philippines, fishers response to a new technology mimics the natural adoption curve in the literature which follows a lower adoption rate in the initial phase that peaks in the middle of the adoption period until its natural decline in the later phase.

Because rural fishery rhymes with poverty (Bene,2003), the development of rural fishery should be pursued in the larger context of rural development that aims to promote sustainable communities. Promoting sustainable communities means achieving happiness for the individual and the fisheries sector as a whole. Poverty is not only the root cause of unhappiness but also the key driver of irrational use of resources and ecosystems in many of these communities that threaten their sustainability. At any rate, there are recent impetus towards pursuing social innovations in the rural fisheries sector that need to be conscientiously pursued to promote and achieve sustainable communities. These include innovative livelihood approaches, tools for resource governance, extension modalities and product value adding.

A community-based coastal resource management as an innovative option for the use of property rights to mitigate the tragedy of the commons has proven successful in a number of different natural resource environments in the Philippines. Aside from increasing economic efficiency, a community-managed fishery regime can substantially reduce the incentive to race and the inherent risks within the fishery. The declining population of SNS and the rareness in occurrence of most riverine shrimps underscore the need for conservation efforts if not the enhancement of stocks through artificial and natural propagation. Ecological and population restoration action need to be implemented within inter and intra-KBA system. These would include the establishment of riverine managed areas or freshwater protected areas and stock enhancement activities in riverine ecosystems of KBAs. For KBAs with higher diversity indices and high endemism but subjected to intense anthropological riverine protected areas should be established selecting the river sections or sites where the most stable patch of the microhabitat is located and where suspect endemic, and accidental shrimp species inhabit. For KBAs with riverine ecosystems that are small, with relatively less diverse shrimp community but harbor rare and endemic species stock enhancement efforts should be initiated. Stock enhancement should use native and endemic shrimp species. Appropriate stock enhancement techniques for riverine ecosystems such as the potential of brushparks should be developed and piloted to ensure viability and success.

A social enterprise in the form of a community-managed ecotourism will be an effective livelihood approach to incentivize biodiversity conservation and fisheries resource management efforts in the rural fishery sector. Poverty in small-scale fisheries is caused by its open access nature and remote location. The remote locations of many fishing communities isolates them from the opportunities afforded by economic hubs in urban areas. The geographical barrier makes it difficult and costly for remote rural communities to bring products their products to the market. Ecotourism brings the market to the product. The market merely enjoys the biodiversity and the beauty of the natural base in the rural fishery sector communities while fueling the engine of the rural economy through their recreational expenditures. Marrying ecotourism with coastal resource management will not only promote social resiliency through livelihood diversification but ecological resiliency as well.

Creative technology transfer modalities composed of a mix of pilot demonstration, technology roll-out, trainers' training and microcredit assistance could address the slow rate of technology adoption in rural fisheries which depicts the peculiar rural Filipino culture of wait and see. These modalities should be aggressively implemented in the first five years which appeared to be the critical years for introducing the technologies where intention to adopt appears incipient. The popular appeal of low-cost, low-tech but high return fish production and stock enhancement techniques in the rural fishery sector would require the downscaling of more complex and high investment S and T interventions. Social innovations and science and technology enhances rural fisheries by promoting sustainable utilization and value adding.

REFERENCES

Bene C.2003.When fishery rhymes with poverty: A first step beyond the old paradigm on poverty in small-scale fishery. World Development 31(6): 949-975.

Bradecina RG and Soliman VS. 2014. Peril and profit in a scallop fishery. Bicol Science Journal 1(2): 26-35.

Bradecina RG, Candelaria PM and JMA Dela Vega. 2016. Ex-ante analysis of PCAARRD industry strategic S&T Plan for mussel, Department of Science and Technology-Philippine Council for Aquatic and Agricultural Resources Research and Development (DOST-PCAARRD), Terminal Report, 155 pp.

Bradecina RG, Ocampo PP and LM Lanciso. 2015. Abundance and occurrence of freshwater shrimps in the riverine ecosystems of key biodiversity areas of Bicol. Bicol Science Journal 2(1): 35-48.

Bradecina RG. 2007. Decline of small and native species (SNS) in Mt Isarog Natural Park: impacts of illegal fishing and introduced exotic species. Journal of Environmental Science and Management 10(3): 24-33.

Salafsky N. and Margoluis R. 1999. Threat Reduction Assessment: a Practical and Cost-Effective Approach to Evaluating Conservation and Development Projects. Conservation Biology 13:830-841.