Final Technical Report

Scaling-up Sustainable Aquaculture Development in Sri Lanka

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- Ministry of Fisheries, Eastern Provincial Council
- National Aquatic Resources Research and Development Agency

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This report is presented as received from project recipients. It has not been subjected to peer review or other review process.
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Abbreviations

BMPs – Better Management Practices
BCR – Benefit Cost Ratio
CBF – Culture Based Fisheries
CFP - Cluster Focal Point
EP(C)- Eastern Province (Council)
EUSL – Eastern University Sri Lanka
ICTs – Information and Communication Technologies
KMT – Knowledge Management Technology
MFAR - Ministry of Fisheries and Aquatic Resources
NAQDA – National Aquaculture Development Agency
NARA – National Aquatic Resources Research and Development Agency
NP- Northern Province
NWP(C)- North-Western Province (Council)
PCR – Polymerase Chain Reaction, a biochemical diagnostic technique for pathogen detection
PL – Post-Larvae (Shrimp)
PRA - Participatory Rapid Appraisal
SLADA - Sri Lanka Aquaculture Development Alliance
SMS – Short Message Service
WUSL – Wayamba University of Sri Lanka
Executive Summary

This project aimed to identify strategies and approaches required for scaling-up of promising innovations demonstrated under the CIFSRF (Canadian International Food Security Research Fund) project No. 106342 on Promoting Rural Income from Sustainable Aquaculture through Social Learning implemented jointly by the Wayamba University of Sri Lanka and University of Calgary from August 2010 to December 2012.

The central hypothesis reflected in the primary objective of this project, is that sustainable culture systems, indicated by farmers implementing better practices, achieving higher productivity, and enjoying increased incomes, can be built through interventions that directly focus on improving knowledge connectivity and knowledge sharing. Strengthening these links between farmers and between farmers, government, community and academics would help overcome some of critical challenges faced by aquaculture in Sri Lanka, particularly those of smallholder and community-based fish farms - livelihoods constantly threatened by shrimp disease outbreaks, utilizing seasonal reservoirs and ponds for inland aquaculture constrained by unreliable weather patterns and poor supply of fingerlings for stocking the reservoirs, and lack of knowledge, skills and capacity to develop new opportunities in coastal areas for oyster production using common water resources.

Three main knowledge mobilization strategies were devised and targeted to address critical production constraints identified in each of the three sectors: (a) enhancing the social knowledge-sharing networks including using Information Communication Technologies (ICTs) to boost adoption of better practices, risk reduction, and value chain strengthening tested with shrimp farmers, (b) adopting foundational structures and processes for ‘co-management’, facilitated by knowledge sharing, by both farmer organizations and relevant state agencies in the seasonal reservoirs of the inland aquaculture sector and in the BMPs of the shrimp farming sector, and (c) building capacity for knowledge and technology adoption in resource-poor coastal communities (specifically targeting women as key participants) and integrating them with private sector actors developing markets and state agencies building natural resource management as well as public health and food safety capabilities. These were complemented with critical capacity enhancements including equipping and operationalizing a lab for shrimp pathogen detection, enhancing and operationalizing six nurseries for improving fingerling supply as well as establishing a research and training nursery at WUSL, and strengthening production of oysters, processing them through depuration (purification) systems and monitoring for environment and food safety.

Positive outcomes for small-scale shrimp farmers were significant, particularly in the NWP. Overall, farmers with fewer than 5 ponds in NWP have increased production yields per acre from an average of 740 kilograms in 2010 and 832 kilograms in 2013 to an average of 932 kilograms in 2014, a 26 percent increase over 5 years and a 12 percent increase from the previous year. In the NWP 86 percent of farmers with fewer than 5 ponds achieved the benchmark of 850 kilograms per acre, a significant increase from 31 percent in 2013. Under the project interventions they have also improved individual average weight at harvest from 20.42 grams in the 2013 cycle to 23.2 grams in 2014, an increase of 13.6 percent. Farmers also
improved on average daily weight gain from 0.19 grams in 2013 to 0.21 grams in 2014, also increasing the days in production to an average of 118 in 2014 from 108 days in 2013. The improvement in yields in 2014 combined with strong farm gate prices has resulted in net incomes averaging 382,400 LKR per acre for shrimp farmers compared to 111,375 LKR in 2013. For a household farm with a single pond of 1.12 acres this would translate into 35,690 in monthly income. To put this income into perspective, the official poverty line in Sri Lanka (2010) was 3,028 LKR (about USD $23) real total expenditure per person per month, thus a household of 4 would require an income of over 12,100 LKR per month to reach the poverty line. Hence current small-scale shrimp farming can now lift households beyond the poverty in Sri Lanka. A cost benefit analysis of the project interventions in shrimp farming showed a Benefit Cost Ratio of 2.71 over 5 years as the shrimp farming industry takes on the sustaining of the programs initiated by the project.

Fish harvesting from seasonal reservoirs provided participating communities with fish at farmgate rather than market prices and provided those participating in the aquaculture activity with 8,000 to 15,000 LKR in additional income per household and provided the aquaculture society with revenue amounting to 5% to 12.5% of the total value of fish to invest in aquaculture improvements and fingerling purchase for the next cycle. Communities participating in the oyster culture pilot projects at Gangewadiya and Kandakuliya earned approximately 22,500 LKR per month in the first 4 month cycle of production from the pilot sites, a significant addition of 1,500 per month per household where at least 85 percent of households each earn less than 100,000 LKR per year. Moreover, it is women who are taking the leading role in this emerging area of aquaculture.

The Research Problem

The central hypothesis reflected in the primary objective of this project, is that sustainable culture systems, indicated by farmers implementing better practices, achieving higher productivity, and enjoying increased incomes, can be built through interventions that directly focus on improving knowledge connectivity and knowledge sharing. Strengthening these links between farmers and between farmers, government, community and academics would help overcome some of critical challenges faced by aquaculture in Sri Lanka, particularly those of smallholder and community-based fish farms in Sri Lanka. The goal of the current research project on scaling-up of sustainable aquaculture development in Sri Lanka was to further substantiate the evidence gained from the first phase of the CIFSRF supported aquaculture development project undertaken by collaborating partners the Wayamba University of Sri Lanka (WUSL) and the University of Calgary under project No.106342 from August 2010 to December 2012. The outcomes from that project demonstrated the value of social learning and decision-making based on the concept of co-management as key drivers for scaling-up aquaculture development activities. The innovations tested however, required further validation as well as more clearly identifying the external factors that could influence the adoption of these innovations before a larger scaling up involving expansion and replication could be carried out.

The current project addressed the “Blue Growth” challenge of the government of Sri Lanka, which has recognised the need to increase the contribution from the aquaculture sector to support the goals of ensuring food security in the country and in improving the nutritional status of vulnerable populations. The challenge involved scaling up project innovations that would also
foster inclusive and sustainable development and enable small scale-aquaculture to play a significant part. Knowledge mobilization was taken as the key strategy for piloting and scaling up specific interventions in three distinct sectors that covered the main ecological systems in which aquaculture was developing in Sri Lanka: shrimp farming conducted in brackish water and representing a more mature sector, fish farming in inland seasonal reservoirs and ponds representing an under-developed sector, and oyster farming in marine lagoon areas representing a new emerging sector.

Three main knowledge mobilization strategies were devised and targeted to address critical production constraints identified in each of the three sectors: (a) enhancing the social knowledge-sharing networks including using Information Communication Technologies (ICTs) to boost adoption of better management practices (BMPs), risk reduction, and value chain strengthening tested with shrimp farmers, (b) adopting foundational structures and processes for ‘co-management’, facilitated by knowledge sharing, by both farmer organizations and relevant state agencies in the seasonal reservoirs of the inland aquaculture sector and in the BMPs of the shrimp farming sector, and (c) building capacity for knowledge and technology adoption in resource-poor coastal communities (specifically targeting women as key participants) and integrating them with private sector actors developing markets and state agencies building natural resource management as well as public health and food safety capabilities.

Together, these interlinked knowledge mobilization strategies were focussed as interventions on critical constraints that had been identified in each of the three sectors of Sri Lanka’s aquaculture development, notably inadequate disease diagnosis and health management in shrimp farming, a weak fingerling supply for inland aquaculture, and achieving viability for operating community operations for oyster farming in coastal areas. This combination created “social-technological vectors” of knowledge awareness and adoption which were evaluated in relation to productivity, risk management, income and livelihood, and gender outcomes. The research revealed that the successful application of these interventions along these social-technological vectors was significantly influenced by key variables and determinants including location-specific data, the need to include specific social, economic, and ecological in the components and processes of the knowledge mobilization interventions, and the synergy between knowledge mobilization and building governance processes and structures. Hence, the knowledge mobilization interventions in the project, operating along the distinct social-technological vectors, resulted in positive outcomes in productivity, income, risk reduction and governance in all three sectors of aquaculture in which they were tested. These outcomes are taking root and growing, becoming integral to the planning, policies and practices of Sri Lanka aquaculture. At the same time these outcomes also indicated that more critical factors need to be addressed in moving aquaculture forward in a sustainable and equitable way. For example, impacts of climate change on monsoon rains in Sri Lanka continues to create challenges in predictability for producing fry and fingerlings and for stocking ponds and reservoirs. In other cases, the project found that advancing gender equity is more readily built into aquaculture where there is an emerging opportunity such as oyster farming and establishing new areas for shrimp farming, whereas in more mature areas such as established shrimp farming areas and some inland aquaculture areas, creating the space and opportunity for women is more challenging.
The areas where the applied research was conducted, in the three sectors of aquaculture, included two Provinces, namely, the North Western Province and the Eastern Province (Figure 1). Aquaculture production assumes high significance in these two provinces both because of the resource endowments conducive for aquaculture and also because at present shrimp farming in Sri Lanka is confined only to these two provinces. From these two Provinces three districts were selected to conduct to test the scaling-up interventions: Puttalam and Kurunegala districts from the North Western Province and Batticoloa district from the Eastern Province.

Achievement of milestones

Milestones were established in two stages: Milestones 1 through 9 in the first six months of the project (between 15 July 2013 and 15 January 2014) and milestones 10 through 17 during the final eight months of the project (between 16 January and 15 September 2014).

**Milestone 1.**

*Inception workshop held with all team members in place with clear roles and responsibilities for collaborating partners and participating institutions established. (July 2013)*

An Inception Workshop was held on July 29, 2013. Three participating institutions represented by North Western Provincial Council (NWPC), Eastern Provincial Council (EPC), and the National Aquatic resources Research and Development Agency (NARA) along with 2 private sector
organizations involved in the implementation of the project, namely, the Sri Lanka Aquaculture Development Alliance (SLADA), and the Seafood Alive Pvt. took part at the Inception meeting.

**Milestone 2.**
*MoUs with third party organizations completed and initial financial disbursements made.* *(August – October 2013)*

MOUs with the three participating institutions were completed and initial funds disbursed.

The three partners were:
- North Western Provincial Council Ministry of Agriculture and Fisheries.
- National Aquatic Resources Research and Development Agency (NARA).

**Milestone 3.**
*Baseline survey of all participating shrimp, oyster, and culture based fishery farmers completed.* *(December 2013 – January 2014)*

The assessment of the baseline status with regard to identified attributes in the inland as well as coastal aquaculture sectors was conducted in December 2013 and January 2014 using a participatory process with ten communities representative of the three sectors and different regions of the project were selected for participation and a facilitated process implemented in each with a total of approximately 400 community members participating (Table 1). Between twenty and thirty participants who were engaged or interested in aquaculture were invited to each meeting, with invitations facilitated by a local leader who had good knowledge of and relationships with community members. Equal numbers of men and women were invited where possible, with men and women not necessarily from the same households. Participants were divided into groups for particular activities – women in separate groups from men – and conducted some activities jointly as a community. Additional baseline data was also gathered using short surveys of farmers in the shrimp, CBF and oyster sectors. This process was also used to develop the participatory monitoring and evaluation framework and process for the project (milestones 8). The project is striving towards a ‘performance-based accountability’ with more transparent and inclusive participation and strengthening the likelihood that the project interventions achieve a demonstrated impact that is tangible to the stakeholders.

**Milestone 4.**
*Identification and analysis of gender roles, position and strategic priorities for women engaged in aquaculture.* *(January – March 2014)*

The PRA processes as well as detailed investigations using key informants and focus groups have helped identify various constraints and limitations on gender equity and provided insight into areas for development and policy interventions that are likely to promote gender equity and increase the role of women in contributing to overall productivity enhancement in the three different sectors of aquaculture.
A key result of the gender analysis was that aquaculture sectors require distinct strategies and approaches to gender mainstreaming which will also vary depending on the degree of development in the sector. For example more mature sub-sectors such as shrimp farming require access to resources, capital, and ownership of land, which are factors that often pose a barrier to women’s ownership and management positions. Consequently the position of women in shrimp farming and firms in the value chain such as shrimp processing, is marginalized and often invisible and undervalued. They often provide unpaid labour on family farms and undervalued labour in the “lower end” of the supply chain, for example in processing factories. Strategies to improve the condition and position of women in such value chains requires a focus on addressing equitable access to land and capital for farming and more equitable payment for labour provided in the supply chain. On the other end of the spectrum, sectors that are new or emerging, such as bivalve (oyster, mussel) aquaculture in coastal Sri Lanka, can provide more space to develop in a gender equitable manner because the activity has no prior association with gender-defined roles. In these communities women are involved in supporting the capture fishery activities they usually do so without adequate recognition of the value of their contributions such as net mending, preparing and cleaning fish for sale, and the array of household and livelihood activities for which they usually assume primary responsibility. With a new opportunity such as aquaculture, the role and position of women can be complementary without having to deconstruct the institutions and relationships that were built over time in which women have been marginalized or under-represented.

**Milestone 5.**

*Knowledge mobilization for SMS and web platform prepared and operationalized for shrimp farmers in proposed scaling-up areas. (December 2013 – March 2014)*

The integrated SMS-Web platform to mobilize knowledge for shrimp culture was designed and the initial prototype reviewed and tested prior to the start the 2014 crop cycle that began in the North Western Province in March and in the Eastern province in April. It was progressively implemented in each zone subsequent to stocking of shrimp ponds which is done from area to area according to a crop calendar which is prepared each year in a joint government and farm organization process.

Operationalizing the platform involved thirteen farm clusters, who were provided with computers and devices to access internet through mobile networks, enabling access to the web platform and view knowledge resources and aggregated information. Information uploaded by farm cluster trained personnel was aggregated into data modules. Initially the project aggregated data on PL (Post Larvae) stocking, shrimp production, PCR (Polymerase Chain Reaction) results (at one month), disease outbreaks, and water quality (cluster farms as well as common water bodies). Further modules have been designed and will come online under the joint management of the platform between SLADA and the Provincial Ministries of Fisheries. This will provide a knowledge base over time for the industry to track cluster production performance and progress and benchmarking.

**Milestone 6.**

*Training for shrimp farmers on water quality management completed and testing on various quality parameters initiated. (December 2013 – March 2014)*

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Training of farm clusters was conducted in each cluster one month in advance of the schedule for stocking with PLs while farmers were preparing their ponds (March in NWP and April in EP). Training material for water quality management to assist with shrimp health disease included a manual, instruction cards, and information guides indicating basic concepts and the importance and advantages of water quality management as well as disease diagnostic cards to be used by farmers were distributed. A book on *Health Management in Shrimp Culture Systems of Sri Lanka* was also completed based on field observations of disease incidences collected from lead farmers and farmer societies.

Five people from each of the 10 clusters, including 12 women, received in-depth training on water quality monitoring for ponds and common water bodies, liaising with farmers in the cluster to assist with water quality monitoring, implementing management practices, maintaining records, and ensuring the equipment is kept in working order and calibrated. These people became the cluster focal point persons. Additional follow-up training was provided at one month after stocking with the support of the Provincial Councils and SLADA. These were known as “Crop Clinics” and helped farmers assess their production one month after stocking as well as discuss results of PCR tests on farms and develop and implement collective management strategies. Training in a Certificate Course was completed with 22 officers of the provincial councils. These officers work together with the farm clusters to train more farmers. Course content was prepared with the consultation of lead farmers and technical officers.

**Milestone 7.**

*Nurseries for culture based fisheries initiated and training materials developed and provided to key local resource people in scaling-up sites. (January – February 2014)*

Twenty-four existing mini-nurseries located in the NWP and three in the EP were surveyed for enhancement of fingerling production. A pre-tested questionnaire was carried out to assess nursery production capacity and efficiency of production (e.g. survival rates, growth performance, etc.) with a view to being able to provide a continuous supply of good quality fingerlings of the different species required. However, all required some improvements in infrastructure and water quality to ensure the production of good quality fingerlings with better survival and reduced risk of disease. Five privately held mini-nurseries were selected for improvement in the NWP. In the EP, the Ministry of Agriculture and Fisheries proposed development of a community nursery to serve as a pilot project for training, demonstration and fingerling capacity building. Strategies were devised to improve the technical operation by providing key supplies such as pumps, aeration systems, and nets while at the same time improving the skills and knowledge of the owners through training and sharing knowledge. A training program was prepared and 10 individuals were selected for training. Twelve provincial officers were also selected to receive training in nursery and reservoir production in order to contribute to management and governance.

**Milestone 8.**

*Monitoring indicators and M&E plan for assessing changes in income, food and nutrition security established. (December 2013)*
The project utilized a logic model for monitoring and evaluation consisting of inputs, activities, and outputs, each with a set of data for monitoring progress. A series of indicators were created for the objectives to support monitoring and evaluation of outcomes and impacts. Structure and Process of M&E (Monitoring and Evaluation) is the primary responsibility of the Project Management Committee, which includes members of the research team and representatives of collaborating partners (NARA, NWP, EP). Monthly meetings were held with progress reports provided by team members and collaborating partners. In addition there were sector steering committees established, one for the shrimp sector and one for CBF (Culture Based Fishery)/inland aquaculture which, in addition to research team and collaborating partners, includes representatives of sector stakeholders, including farm societies (SLADA, Aquaculture Committees). The insights from the PRA process were used to develop a participatory monitoring and evaluation framework and process for the project. Together, the ‘performance-based accountability’ process was carried out in the project with transparent and inclusive participation of stakeholders.

**Milestone 9.**

*Project steering committee established with clear management and data sharing protocols for all partners. (October – December 2013)*

A Project Management Committee (PMC) was established at the project outset under the leadership of the Dean of the Faculty of Livestock Fisheries and Nutrition with membership consisting of project co—principal investigators, individuals from senior management positions in the collaborating partners (NMPC, PC, and NARA), the bursar and deputy bursar of Wayamba University, and members of the research team. This served as the primary management body of the project, ensuring progress was achieved, problems solved, expenditures managed and objectives met. In addition, each participating agency established at least one steering committee, headed by the institutional lead, covering the relevant sector activity in their jurisdiction – the NWP formed separate steering committees in shrimp sector and CBF, NARA a steering committee for oyster aquaculture under NARA, and the EP established a steering committee covering both shrimp and inland fresh water aquaculture.

**Milestone 10.**

*Implementation of SMS and web platform for knowledge sharing on Best Management Practices completed through one shrimp production cycle with results and data analyzed. (March – August 2014)*

During the first phase of the project, alerting farmers via SMS for timely action by farmers was mostly related to disease incidences. In the scale-up phase the results of water quality testing, PCR test results, and other events that warranted immediate transmission of information were also integrated, increasing the value and richness of the information but also the complexity of information management.

A standardized procedure was developed and 10 groups of youth from among the farming community clusters were trained to undertake water quality testing and assist farmers with information gathering and implementation. Data on water quality and farm issues was gathered by these trained persons, each cluster equipped with laptop computer, internet access and set
of water quality instruments. Data was entered on into forms and the forms uploaded to the database built on the web platform. These data would then be accessible for reviewing by an expert group comprised of technical experts in the industry and project researchers. Once the group validated information uploaded by clusters, the incoming information was assessed for potential risks and conditions that warranted an advisory or alert to farmers. The web application was also programmed to detect any abnormal readings in water quality parameters and generate automatically an email alert to the experts. These experts would then communicate over the web platform to evaluate the alert levels of water quality parameters and decide on the content development for short messaging. Once messages to farmers were formulated and target farms identified, the message was sent by a team member to designated farmers. Messages sent were also be archived for monitoring and reference. A hotline number, monitored by SLADA, was made available with response person on standby to answer farmer questions or respond to alerts. While 10 cluster groups were initially trained, it was operationalized with four Focal Points who were able to cover the area of the 10 clusters through the first production cycle of 2014. Further training is being provided so that all 10 clusters will be capable of testing water quality, gathering data, and transmitting information from the field level to be used as information for SMS alerts.

Milestone 11.
SMS and web platform knowledge sharing system operationalized for culture based fisheries and oyster culture value chains with initial results and data analyzed. (February – August 2014)

Based on the lessons learnt from the shrimp sector in using ICT for knowledge sharing and using SMS messaging for helping farmers take important decisions about their farming activities, the culture-based fish sector as well as the oyster farming sector stakeholders acknowledged the value of accessibility to knowledge resources using the web and SMS and participated in designing a system for implementation. However, these systems were not able to be fully implemented in the current project cycle. Other critical capacity and production issues such as operationalizing the mini-nurseries and adjusting production schedules in the CBF due to the late arrival of monsoon rains in several project sites, and improving the process in oysters to supply market demands required the full capacity of the project team. These were necessary to be undertaken before interventions for decision-making using SMS and web platform could be formally introduced to these two sectors. However, since the design was prepared, implementation in 2015 has been supported in principle by the government and private sector stakeholders.

Milestone 12.
Knowledge resources and training material published, distributed, and posted on Aquaculture Lanka website (available in local languages). (March – September 2014)

Knowledge resources for the shrimp farming sector were prepared and shared with farmers in print and digital formats. These included the manuals on Best Management Practices, Shrimp Diseases and Health Management, and Water Quality Management. Leaflets on Using Water Quality Testing Equipment, Pond Preparation, Pond Bottom Management, Biosecurity in Shrimp Farming, and Utilisation of Acid Soils for Coastal Aquaculture. Knowledge resources for culture-based fish production were developed as training posters to help farmers understand fish
species, their distribution in different depths in reservoirs, and steps for developing viable farmer organisations and participating in co-management. A Nursery Operations Manual has been prepared for mini-nursery operators. A manual for Oyster Aquaculture has been prepared by NARA. In addition, leaflets on the utilisation and preservation (smoked, dried, frozen, etc) of cultured oyster products, on spat collection, and oyster culture methods, were also developed and shared.

**Milestone 13.**
*Policy brief on models of co-management structures and knowledge mobilization completed. (February – September 2014)*

Based on the policy recommendations, the following administrative changes have been effected thus far.

i. To obtain from the President of Sub-Zonal Shrimp Farmer Societies a certificate of satisfactory pond preparation by the farmer before the farmer is allowed to stock the ponds with post larvae.

ii. Consent in writing by all shrimp farmers at the beginning of every production cycle for strict compliance of BMPs.

iii. Making it mandatory for shrimp farmers to undertake a PCR testing of PLs one month after stocking for White Spot Disease virus.

iv. Preparation of management guidelines by the Department of Agrarian Services of the Ministry of Economic Development for fish farming in seasonal reservoirs used for paddy cultivation.

v. Acceptance in principle by the Provincial Ministry of Fisheries the conduct of regular stakeholder meetings both for shrimp producers as well as for culture-based fish producers to promote and strengthen the co-management processes.

Similarly, the standardisation of procedures and protocols for PCR testing for white spot disease virus was accepted as a priority action by NARA and work on this is planned to continue through 2015.

**Milestone 14.**
*Gender outcome analysis and case studies completed. (March – September 2014)*

A case study on gender in aquaculture and the expectations, constraints, and opportunities in becoming engaged in oyster culture activities was conducted in March 2014 using the communities at Gangewadiya and at Kandakuliya. The results have been documented in a chapter contributed to book with contributions by other CIFSRF projects and gender researchers from around the world. A survey of women stakeholders from the three project districts was also conducted in September 2014 using a structured questionnaire to assess the project outcomes on gender roles and status. The analysis of the data from the questionnaire survey is in progress and will be made available as a separate report.

**Milestone 15.**
*Mini-nurseries operationalized. (March to August 2014)*
Five out of 24 nurseries growing fish from fry to fingerlings were selected for improvement and monitoring of results by the Ministry of Fisheries of the NWP after conducting an evaluation of their past performances. Training programmes were conducted to improve the knowledge and skills of the nursery operators. This specifically helped them reduce losses in the acclimatisation of fry nursery conditions, reduce losses due to predation in nurseries by providing Blue nets for improved the harvesting and packing of fingerlings by providing oxygen cylinders and air blowers. Similarly, in the Eastern Province, the Provincial Ministry has mobilised the farmer community by releasing land and helping to clear other administrative bottlenecks to get the mini-hatchery/nursery at Kadukkamunai operationalized. NAQDA, which is the state agency responsible for aquaculture development in Sri Lanka, is providing technical support for the mini-hatchery/nursery. The mini-hatchery/nursery at the Department of Aquaculture and Fisheries of the Wayamba University was operationalized and is now capable of producing around 150,000 sex-reversed Tilapia per production cycle.

Since operationalizing of the mini-nurseries was carried out during the CBF production cycle during 2014, the full benefit will only be realized in the subsequent production cycle that follows the monsoon rains that begin in November and normally fill seasonal reservoirs. However, for the past 3 years, the onset of the monsoon rains has shifted geographically and temporally, leaving many seasonal reservoirs dry until later in the season and others inundated with water surpluses. This uncertainty, likely related to climate change, requires further investigation and tools for management.

**Milestone 16.**

*Benefit-cost analysis report with recommendations for sustainable implementation in value chain and role of supporting institutions, including private sector. (September 2014)*

A benefit-cost analysis of the use of ICT and SMS messaging to help decision making by farmers and assess the value of the knowledge sharing tools by the value chain actors was undertaken specifically targeting the shrimp sector and oyster production. This study was commissioned as a consultancy under the project in September 2014. However, the study data is still in analysis and the recommendations will be made available as a separate report.

**Milestone 17.**

*Measurable changes in income, food and nutrition security as a result of knowledge mobilization interventions assessed. (September 2014)*

Outcome surveys were conducted in each of the three sectors of project activity. However, in some cases the production schedules, particularly those in the CBF sector, were significantly shifted and delayed due to late arrival of monsoon rains, and harvesting continued beyond the project end date. An evaluation study to assess changes in income, food and nutrition security as a result of knowledge mobilization interventions was undertaken by a group of private consultants. The results of this study will be made available as a separate report.

**Synthesis of research activities and results**
The World Bank has estimated that under current conditions, global food production will need to more than double by 2050 to meet the world’s food and nutrition security requirements. Small-scale farming, providing over 80 per cent of the food consumed in a large part of the developing world, must play a key role in meeting this challenge (IFAD 2013). However, productivity remains chronically low in many of the least developed countries, and productivity-boosting innovative technologies and practices have yet to reach or be taken up by many smallholder farmers – the “awareness to adoption challenge”. Aquaculture will also play an increasingly key role. Nearly half of all seafood is now cultured rather than captured and represents 16 percent of all animal protein consumed globally. Fish provides not only high-value protein but also a wide range of essential micronutrients, including various vitamins, minerals, and polyunsaturated omega-3 fatty acids. Thus, even in small quantities, provision of fish can be effective in addressing food and nutritional security among the poor and vulnerable populations around the globe.

The government of Sri Lanka has recognised the need to increase the contribution aquaculture to ensure food security and improve the nutritional status of vulnerable populations. Fish is important to food and nutrition security in Sri Lanka already providing over 50% of dietary animal protein. The goal is to further increase daily per capita consumption from the present 41.5 grams to 60 grams by the end of 2015. Aquaculture must double its production in this period to meet this goal. Yet aquaculture development in Sri Lanka lags far behind other countries in South and South East Asia. In countries such as Bangladesh and India, aquaculture now accounts for over 40 percent of the total fish supply. In Sri Lanka the contribution of aquaculture is less than 3 percent.

The project addressed the “Blue Growth” challenge in Sri Lanka in foundational ways that would foster inclusive and sustainable development and enable small scale-aquaculture to play a significant part. Knowledge mobilization was taken as the key strategy for piloting and scaling up interventions in three distinct sectors that covered the main ecological systems in which aquaculture was developing in Sri Lanka: shrimp farming conducted in brackish water and representing a more mature sector, fish farming in inland seasonal reservoirs and ponds representing an under-developed sector, and oyster farming in marine lagoon areas representing a new emerging sector.

**Primary Project Objective:** Smallholder aquaculture operations in shrimp farming, culture-based fisheries, and oyster culture sectors will improve productivity and income, in a manner that advances gender-equality, by implementing sustainable practices learned and shared through knowledge mobilization innovations and enabled by a robust governance model for effective management of the aquaculture activities at the Provincial level.

The central hypothesis, reflected in the primary objective of the project, is that sustainable culture systems, indicated by farmers implementing better practices, achieving higher productivity, and enjoying increased incomes, can be built through interventions that directly focus on improving knowledge connectivity and knowledge sharing. Furthermore, interventions of this nature are effective in promoting inclusive and equitable participation of smallholders and women in aquaculture development and lead to better governance structures and processes as a consequence of knowledge and information sharing.
A knowledge mobilization framework was applied to more effectively address the challenge of closing the “awareness to adoption gap”. Knowledge mobilization encompasses the products, processes, and relationships among knowledge creators, users and mediators, both individuals and organizations and attempts to address the spectrum and multi-directionality of knowledge from generation of data, to information and evidence, to knowledge sharing and exchange, to its implementation and application serving the greatest common good. Knowledge mobilization involves analysis and interventions conducted to increase connectivity of all of the participants in the network of particular food production systems. This concept was formulated, adapted and applied to this project owing much to the original definitions and applications developed by the scholars at the Institute for Community Engaged Scholarship at the University of Guelph.

Three main knowledge mobilization strategies were devised and targeted to address critical production constraints identified in each of the three sectors: (a) enhancing the social knowledge-sharing networks including using Information Communication Technologies (ICTs) to boost adoption of better practices, risk reduction, and value chain strengthening tested with shrimp farmers, (b) adopting foundational structures and processes for ‘co-management’, facilitated by knowledge sharing, by both farmer organizations and relevant state agencies in the seasonal reservoirs of the inland aquaculture sector and in the BMPs of the shrimp farming sector, and (c) building capacity for knowledge and technology adoption in resource-poor coastal communities (specifically targeting women as key participants) and integrating them with private sector actors developing markets and state agencies building natural resource management as well as public health and food safety capabilities.

Together, these interlinked knowledge mobilization strategies were focussed as interventions on critical constraints that had been identified in each of the three sectors of Sri Lanka’s aquaculture development. This combination created “social-technological vectors” of knowledge awareness and adoption which were evaluated in relation to productivity, risk management, income and livelihood, and gender outcomes. The research revealed that the successful application of these interventions along these social-technological vectors was significantly influenced by three key variables and determinants: (a) the critical importance of accessing and utilizing local and location-specific data and information, (b) the advantage of creating governance (in our case primarily co-management) structures and processes in harmony with knowledge mobilization interventions, and (c) the degree to which specific social, economic, and ecological factors must be identified and incorporated into the components and processes of the knowledge mobilization interventions. The latter include some emerging phenomena such as climate change impacts (for example variability in rainfall related to more erratic and unpredictable monsoons), natural resource over-exploitations and/or degradation (for example declines in near-shore fishery resources, and contamination of coastal and inland waters), and social and demographic change in rural areas due to migration, urbanization or changing labour opportunities in new rural industries such as vegetable (field or greenhouse) farming.

The knowledge mobilization interventions in the project operating along the distinct social-technological vectors resulted in positive outcomes in productivity, income, risk reduction and governance in all three sectors of aquaculture in which they were tested. The main research activities carried out and the key results in three sectors under study are outlined below under the four specific objectives of the project.
Objective 1. To increase knowledge connectivity among farmers and along the value chain, both women and men, by expanding and evaluating the role of ICTs (Information Communication Technologies) for improving access, sharing, and implementation of information.

The facilitation of knowledge connectivity among farmers and along the value chain in the three sectors required different strategies and approaches tailored to the unique conditions and situations of the communities involved in different aquaculture activities. A “people first” approach was the paramount principle to ensure that interventions were not technology-driven, rather that the technology, and in particular the use of ICT’s, would follow the way in which people approached, utilized and integrated the technologies into the practices of aquaculture.

A key result of applying this approach was that the application and integration of ICTs in the knowledge mobilization strategy achieved the greatest traction in the shrimp sector. The ICT strategy was able to be implemented in all of the means envisioned including aggregating and sharing data on water quality and disease condition, sending alerts and advice to farmers on SMS, and utilizing a web platform to manage the information sharing and prove a point of access for knowledge resources. Several factors are likely to have contributed to this result. First, the “maturity” of this sector, in contrast to new or emerging sectors (CBF and oyster culture), meant that there were firms in different segments of the value chain that were already well established with products, services and customers already linked, albeit very weakly for a large number of the small farmers. Secondly, a geographic concentration of the shrimp industry in Puttalam District of the NWP and Batticaloa District of the EP enabled the knowledge network facilitated by ICTs to more readily take root than in sectors much more widely distributed with weak ties to each other, such as the farming communities of the seasonal reservoirs in CBF.

Third, the production processes and priorities that were most amenable to digital sharing were those required actionable responses for which rapid or near real time information was of critical value. For example, disease outbreaks and alerts to shrimp farmers to modify practices based on water quality changes were recognized to have immediate effect to reduce risks and improve pond and shrimp stock condition. In contrast, the priority process for farmers and hatcheries in CBF was to be able to have available fry and fingerlings at the right time when conditions were right for stocking seasonal reservoirs. In this respect, the delay and uncertainty of rainfall significantly interfered with a smooth implementation of knowledge sharing along the envisioned pathway. In the case of oyster farming, the use case of highest priority was to establish an information link between the market and the producer involving product readiness for harvesting, and the condition of water and potential risk of product contamination. However, with two communities in the trial, the scale warranted only conceptualization and some preliminary testing until larger scales of operation could be achieved. Fourth, the pilot trial of the SMS alerts conducted in the earlier project and its positive outcomes prepared the ground in the industry to expand the ICT applications.

The knowledge intervention strategy was therefore modified according to the conditions of each of the three sectors. Despite the limited application of ICTs in the CBF and the oyster culture sectors positive results in knowledge connectivity were obtained with attendant positive outcomes in risk reduction, increased productivity and income gains.
Knowledge connectivity strategies and results in the shrimp sector

The project interventions in the shrimp sector for knowledge connectivity were aligned with production cycles so that farmers were able to mobilize knowledge from pond preparation through harvest. In the shrimp sector the major production cycle of the industry begins in February following a mandatory shutdown of hatcheries in January. Stocking ponds commences in March and continues through May or June according to the crop calendar set by industry and government stakeholders. A four-month production cycle under good production conditions would normally enable farmers to obtain shrimp with an average weight of over 20 grams, suitable for export markets. Some farmers, however, shorten their production cycle and produce smaller shrimp destined for local markets as a risk management strategy when process offered by local buyers are reasonable.

Location-specific BMP implementation is the foundation for advancing sustainability for shrimp farmers and is the heart of the knowledge mobilization interventions utilized and applied by farmers. These adapted BMPs were formulated with participation of local farmers and local knowledge, to address variations in local conditions such as unique soil composition, distinct water bodies used for culture ponds in different areas, differences in micro-climate (e.g. variability of rainfall), amount of mangrove in farming areas area, proximity of farms to healthy mangroves, density of farms, and facilities used by farmers such as stock tanks to treat water and effluent tanks to treat water post harvest.

Prior to the interventions of the project, none of the small or medium scale farmers (defined as those with 5 or fewer ponds in cultivation) conducted dissolved oxygen monitoring water quality, which is widely recognized as the most important water quality parameter in pond culture of shrimp. The majority of monitoring water quality parameters such as salinity, pH, and alkalinity was done as a service for farmers by the feed suppliers. Yet with little of this knowledge was actually transferred to the farmers. In the surveys of small and medium scale farmers it was found that more than 95 percent did not have the knowledge and skills to adequately monitor the water quality in their culture ponds. Moreover, although feed suppliers provided water quality data directly to the farmers, there was no general sharing of this data among other farmers. Such sharing might have alerted them to conditions common to or emerging in specific areas.

Hence, based on both literature reviews and experimental work, project researchers focused on BMPs related to water quality monitoring and disease surveillance and monitoring as key factors that had the potential to improve production outcomes and reduce risks for farmers. Since outbreaks of WSS outbreaks were clearly the primary cause of losses to shrimp farmers in Sri Lanka, it was discovered that outbreaks were often preceded or coincided with higher pH and higher levels of un-ionized ammonia in culture water. Furthermore, sudden changes in pH or low dissolved oxygen levels were also found to be significant contributors in precipitating an outbreak of WSS. It appeared that physiological stress lowers the immune response of the shrimp, was the most likely explanation for these variables exerting an effect on development of WSS. What was critically necessary therefore was to implement a comprehensive water quality monitoring program linked to BMPs in conjunction with an increased laboratory capacity to diagnose disease (see Specific Objective 3).
Thirteen sets of water quality monitoring equipment were procured through the project and one set distributed to each shrimp farm cluster in the NWP (10) and EP (3). Each kit consisted of a dissolved oxygen meter, a pH meter, a salinity refractometer, and test kits for alkalinity. To enhance lab capacity for disease diagnosis, the North Western Province Ministry of Fisheries provided the infrastructure and personnel to mobilize a laboratory located in Pambala. The project procured critical equipment, the main element of which was a new reliable PCR machine.

Piloting of the programme of integrating data and information to contents for SMS and dissemination using ICTs for BMP implementation was carried out to learn about this approach by doing. For purposes of data gathering ‘Focal Points’ comprising one woman and two men in each cluster were established and they were given in-depth training on handling water quality testing equipment, sampling procedures and in data uploading to the web platform. Each of these groups were given a meter to measure dissolved oxygen, a pH meter, an alkalinity tester and a salinity meter for water quality testing. Also issued was a laptop computer and mobile Internet connection for data uploading. A manual outlining the testing protocols and observance of bio-security measures for use by the Focal Points was prepared.

The knowledge mobilization intervention then consisted of water quality analysis conducted on a regular weekly schedule with farmers, data aggregated on a web platform, reviewed by a group of experts who sent appropriate alerts to farmers’ mobile phones by SMS instructing them to take specific actions or adopt precautionary measures. This was done in combination with a pre-stocking seminar on the new locally adapted Better Management Practices, and a post-stocking (at one month) crop clinic and assessment of disease condition by PCR laboratory analysis. The knowledge mobilization system is illustrated in Figure 3.

Shrimp farmers significantly increased the adoption of more sustainable practices, adapted to local conditions and utilizing local data, to reduce risks from disease outbreaks and reduce environmental impacts. The farmers also adopted a new governance element, in conjunction with support and co-management from both provincial and central government agencies, requiring all shrimp farmers to conduct the one-month PCR test for each pond stocked and follow an enhanced set of Better Management Practices which is monitored through the farmer societies (see Specific Objective 2).

The project therefore has demonstrated the value of knowledge mobilization and the use of ICT thus helping the farmers achieve improved productivity and income outcomes and empowering them to take timely decisions in their farming operations.

**Knowledge connectivity in the Culture Based Fishery**

Lack of knowledge linkages and awareness of farmer communities regarding aquaculture practices, managing reservoirs with fish culture integrated as a new activity, and sourcing fingerlings were identified as critical constraints for the sustainability of CBF and inland aquaculture. Awareness and training conducted in the communities consisted of providing an understanding of the different species used in CBF and their role in the composite culture systems, factors influencing the productivity of the reservoirs, fish harvesting and marketing.
The culture based fishery is conducted in seasonal reservoirs whose primary purpose is for irrigating crop lands. Seasonal reservoirs get filled by monsoonal rains and remain productive for a 6-8 month window during the year when there is sufficient water in the reservoirs. Small seasonal tanks are normally less than 10 hectares in area. Once the reservoir contains sufficient water, fingerlings must be stocked as soon as possible to maximize the culture cycle of the fish. Selection of communities in NWP was affected by an unusually dry monsoon season in November and December 2013.

Eighteen seasonal reservoirs from Puttalam and Kurunegala Districts were selected to form clusters of three or four water bodies based on the administrative divisions of the Department of Agrarian Services (DAS). In addition, two communities, Sangarapurum and Mahiloor were selected in the Batticaloa District of the Eastern Province. The purpose of these “clusters” was to transfer knowledge radially to other farmer communities and facilitate the extension services and marketing of the final production. As such reservoirs were selected to form several clusters in two districts based on the administrative divisions of the Department of Agrarian Services (DAS). Selected reservoirs in the NWP are listed in the Table 2.

Awareness programs were conducted with lectures followed by question sessions and participatory activities by community members in planning CBF for the production season in 2014. Also, at these training sessions all connected government agencies such as the Assistant Commissioner of Agrarian Services and its staff, the provincial irrigation officers, the provincial fishery staff, and the Wayamba University researchers and officers from NAQDA were available and this training and awareness sessions thus facilitated the building of knowledge networks among the farmers and resource persons.

A further training program was prepared for both officers of the Provincial fisheries ministry and the Department of Agrarian Services along with selected members of aquaculture societies. It was a three day residential training and 75 participants from different areas of the province had an opportunity to build collaboration and share knowledge and experiences. The training was conducted by the National Aquaculture Development Authority (NAQDA) at their National Aquaculture Development Centre in Kalawewa.

The fingerling requirement was mainly supplied by the mini-nurseries in NWP (Figure 4) and rest of the fingerlings were obtained from the government hatcheries. Reservoirs were stocked with four fish species including *Catla catla* (Catla) (20 percent), *Labeo rohita* (Rohu) (20 percent), *Oreochromis niloticus* (Nile tilapia) (40 percent) and *Cyprinus carpio* (Common carp) (20 Percent). Stocking density was established at 2500. The mix of species enabled reservoirs to be stocked at densities of 2500 fingerlings per hectare, a significantly higher level than is practiced with single species stocking which is normally 1500 per hectare.

In the middle of the fish culture cycle two additional workshops were organized for the full spectrum of CBF stakeholders. The objectives of the workshops were to improve the coordination among different stakeholders, to share the experiences among different farmer organizations, to identify the solutions for different issues faced by the communities and to identify the improvements for the proposed co-management strategy.

A model for integrated SMS and web platform to support and enhance knowledge mobilization was prepared based on a review of knowledge requirements for supporting production system...
decision-making from seed to market and obtaining a comprehensive picture of capacity and production of inland seasonal reservoirs. However, the system was not successfully operationalized in the 2014 production cycle but is planned for implementation in 2015 and will use the following process and steps of information sharing (Figure 5).

Information from reservoir communities, coordinated by the Aquaculture Subcommittee Leader in each community, would be prepared in advance of the culture season, with the cooperation of the paddy farming society, and Agrarian Services Division, Provincial Ministry of Fisheries and NAQDA Extension Officer, integrating variables by climatic region, province, and local watershed. Information would include records of previous production cycles (reservoir location, reservoir surface area, company / community name, contact, number of fingerlings stocked, species stocked, stocking date, harvest yields, problems encountered) and a plan for the next production cycle – estimated stocking date, number and species of fingerlings required. This would be uploaded to the web platform and aggregated with information for other reservoirs. It is reviewed by an expert group of aquaculture leaders representing members in the stakeholder co-management structure. The aggregated information would be made available on the web platform to hatcheries and nurseries (government and private) and where urgency is required, SMS messages sent. This would provide critical data in advance of hatcheries and nurseries preparing for the breeding cycle of the species required. Aquaculture societies would be informed by SMS of expected fingerling availability so advance orders could be placed. Once reservoirs are stocked, a second report would be completed and uploaded. The web platform also provides knowledge resources for farmers, nurseries and hatcheries to improve production and reduce mortality losses. Geographically linking hatcheries and nurseries more closely with reservoirs will provide better quality fry and fingerlings and reduce transportation inefficiencies. Based on stocking data and expected harvest schedules, aquaculture societies can seek buyers, and prepare for value addition for additional markets. This system can also be adapted to farmers engaged in pond culture.

**Knowledge connectivity in the oyster farming sector**

The coastal communities engaged in oyster production are closely knit communities. The strategy adopted in knowledge dissemination was by way of organizing these communities as production groups with a focal point identified to serve as the link between the community and knowledge sources. As an emerging sector, knowledge mobilization was fostered along the value chain in a market driven manner. Information relating to market demand and quality as well as food safety requirements for oysters was provided by the private sector partner engaged in marketing and processing the oysters. This information was provided to communities culturing oysters via mobile phone and SMS from the buyer.

In order to produce oysters acceptable to the market, Culture systems were set up and oyster growing pouches stocked with oysters and suspended from wooden racks. Regular cleaning and tumbling was being done to ensure shapes and cup depths are optimum. Extensive training and demonstrations in culturing oysters using these techniques were given to community members by NARA as well as the private sector partner. The project created and shared the knowledge of habitat (lagoons and mangroves) and the extent and role of natural oyster beds in ensuring a sustainable supply of seed for culture activities. A manual was produced to help farmers apply the appropriate techniques. As farmers cultured the oysters, performance of the process was
monitored by NARA measuring growth rates in the two community farm locations as well as in two sites monitored for the next stage of development in Puttalam Lagoon. High growth rates indicated that marketable products could be produced in less than twelve months providing an annual cycle of revenue for the community (Figure 6). In addition optimum seed collection times was identified providing a predictive tool that can advise farmers to deploy collectors made from coconut shell, used clay roof tiles, or plastic surface (Figure 7).

In addition to sharing market and technical knowledge, knowledge of production risk factors was investigated and shared along the value chain with NARA taking the leading role in monitoring growing waters and oysters and providing advice on mitigating these risk factors. Firstly, low salinity levels were identified as the most immediate risk for farmers since prolonged exposure to very low salinities can cause mortalities. However this situation was only prevalent in the Gangewadiya area where there is inflow into the estuary from a river, which peaks during periods of heavy rainfall, in particular during October and November, with a secondary peak possible during April and May. An alternate site with lower risk has been identified and utilized for this community. An alternative production option developed for Gangewadiya estuary was to focus the opportunity more on collecting seed (spat). Other sites such as Anawasala, Kandakuliya and Kalpitiya could purchase oyster seed from Gangewadiya.

A second area of risk was identified from microbial contamination of growing waters with a risk of affecting cultured oysters and presenting a potential public health risk of the product enters the market and oysters are not cooked but eaten raw. Water from Gangewadiya and Kandakuliya were often contaminated with high densities of Coliforms, Faecal coliforms, E.coli and Faecal streptococci. On two occasions water samples collected from Gangewadiya were found to contain Salmonella. All water samples tested from Gangewadiya and Kandakuliya were free from Vibrio parahaemolyticus and Vibrio cholera. This risk is managed through an internationally recognized process of purification called depuration which was implemented and tested as standard operating procedure during the course of the project to ensure product was safe for the market.

Additional risk factors were monitored such as heavy metals (e.g Mercury, Cadmium and Lead) but all of these were found to be below the maximum permissible limits. Furthermore no harmful algae containing biotoxins were recorded at any of the sites during the study period.

In order to further advance this risk monitoring and mitigation programme into a comprehensive Molluscan Shellfish Sanitation Program further capacity was identified as essential. The first step was taken by NARA with the support of the project to establish a research and testing depuration system at Kalpitiya, which can then be used to advise and train the private sector in deputation system for shellfish processing.

The first stage of the knowledge mobilization strategy utilizing ICTs has been developed as a web platform now operational for oyster culture. At present it serves primarily as means of sharing knowledge resources. The complete plan of the system envisioned to mobilize and share an array of information related to growing site conditions, risk related alerts and, market information was not fully implemented in the course of the project, but is set to become operational in 2015 as new areas are brought into oyster aquaculture. No critical risk situations, such as Harmful Algal Blooms (HABs), potentially pathogenic bacteria or viruses, or other contamination, occurred during the extensive monitoring conducted in the growing waters and...
depuration process during the course of the production cycle in 2013 and 2014, and the small scale of the new value chain with 2 communities and a single processor and marketer meant that information was shared directly via mobile rather than go through the intermediary step of the web platform.

However, the process of knowledge sharing has been designed for this system (Figure 8). As a scenario, if a harmful algal bloom were detected through the NARA monitoring process, an alert would be generated by NARA and sent by SMS to farmers informing them to temporarily stop harvesting. Information would also be sent by SMS to processors informing them to temporarily stop buying from the affected site, and to check product in the value chain. Farmers and the value chain actors would also have access to this information on the web platform where a library of knowledge resources would also be posted, for example handling techniques for improving oyster quality, and food service customers accessing information on how to open, prepare and present oysters for restaurants and food service customers.

Key results of the biological and culture system research carried out during the project indicated that there is significant opportunity to expand oyster culture in Sri Lanka and in the Puttalam lagoon area in particular. Areas in Mannar (Northern Province) and Trincomalee and Passakuda in the Eastern province are being now targeted by NARA for development based on the success of Puttalam Lagoon pilot cultivation sites. A process was set up with NARA with a framework to identify new sites along the Sri Lankan coast, integrating biophysical, social, geographical, economic, criteria and designate these as suitable and capable for mollusk culture.

Objective 2. Improve governance structures for sustainable aquaculture sector management with an effective model of participatory action for acquiring, interpreting, disseminating, and mobilizing knowledge.

Collectively, the baseline assessments, capacity enhancements and interventions in knowledge sharing have provided a significant opportunity to build and improve governance processes and structures needed in all the sub-sectors for sustainable aquaculture development in Sri Lanka. This has occurred in part through the cooperation required among the project collaborators and participant communities develop effective models for acquiring, interpreting, disseminating and implementing knowledge. This demonstrated a significant synergy between the two objectives of improving governance and mobilizing and sharing knowledge.

In the case of the shrimp sector, creating, adapting, sharing, and adopting knowledge of location-specific BMPs for shrimp farming, for example, has led to farmer societies strengthening their constitutions to enable members to increase adoption rates of specific BMPs and at the same time improve the collective alignment of farm organizations to reduce risks due to disease outbreaks. As part of improving governance, farmer societies have instituted a new system for encouraging and supporting members to improve the application of specific BMPs based on initial project outcomes. Called a “consent form”, the society identifies a series of BMPs that are relevant to the ecological conditions of the sub-zone and which they expect their members to be able to put into practice. Farmers identify their farm characteristics and their production plan (specifically number of ponds stocking and density of post-larvae to be stocked) and sign the form. Farm organizations together with government agencies (NAQDA) are working further with farmers to address non-compliance continue to improve the level of adoption of BMPs.
This process by the farm organizations has also ushered in new and stronger relationships with government agencies, in particular the NWPC and EPC who previously had virtually no structural linkage to the shrimp industry.

Agreement on the purpose, objectives, contributions, roles and responsibilities, protocols and sharing of information, and the confidentiality of certain information is now under discussion by the stakeholder organizations and institutions from industry (SLADA), from government (NWP and EP Ministries of Fisheries; NAQDA), and research institutes (WUSL, Centre for Aquatic Animal Disease Diagnosis and Research [CAADDR] at the University of Peradeniya, and NARA). Formal agreements are being drafted and piloted through the upcoming culture cycle.

From an industry perspective, the farm organizations and SLADA have organized shrimp farmer societies into cluster relationships to build and share capacity, facilitate cooperation, and enable more effective knowledge sharing. This is serving to strengthen linkages within the shrimp value chain by coordinating and harmonizing farmer societies in implementing location-specific BMPs, to improve transactions and learning between hatcheries, feed suppliers and farmers in supplying quality PLs and feeds, and between farmers and markets (buyers / processors) in providing better quality product meeting market demands.

Governance of CBF reservoirs was advanced with the formation of aquaculture sub-committees under the umbrella of the local farmer societies, which is the primary community stakeholder group with respect to the reservoirs. Processes for coordination among stakeholders, organizing the community, collective decision-making and conflict resolution in co-management systems have been initiated and strategies have been developed for effective water management. At the community level, guidelines have been prepared for farmer organizations to undertake financial management of aquaculture in reservoirs, monthly meetings are conducted with representatives from farmer organizations at respective Divisional Agrarian Services Centers, and village level extension offices of the Department of Agrarian Development assist to improve the coordination among farmer organization and stakeholders. Farmer communities, NAQDA, Department of Agrarian Development, Ministry of Fisheries NWPC and fingerling produces are direct partners in the co-management structure. “Grama Niladari” and Ministry of Economic Development were considered as supportive organizations to strengthen the co-management (Figure 9). This structure is now effectively making planning and resource management decisions with respect to utilization of land for crops, allocation and use of water for both irrigation and for fish culture sufficient to complete a culture cycle of 6 months, and improve the supply of fry and fingerlings.

In addition a project steering committee for the sector provides an initial structure for co-management decisions for CBF development in the NWP. Members include Secretary NWP Ministry of Agriculture, Fisheries, Animal Production and Development, Minor Irrigation and Agrarian Development. (NWP-MAF), Assistant Director (NWP-MAF), Director of Fisheries – NWP-MAF, Deputy Commissioner, Department of Agrarian Services (Kurunegala District), Assistant Commissioner, Department of Agrarian Services (Puttalam District), and two leaders from farmer communities (1 each from Kurunegala and Puttalam)

The oyster sector, where food safety and public health issues are crucial in developing the market for this emerging sector, establishing the required infrastructure such as depuration.
plants, laboratories for testing facilities for microbiology and bio toxins are necessary preconditions. As such the engagement of value chain public sector is essential. NARA is serving as the key driver in developing the co-management and governance structures for coastal mollusk culture. As an initial step towards co-management of common resources, user rights for oyster culture, protection and security of oyster farms an awareness meeting was carried out with the stakeholders in Kandakuliya area with the cooperation of the Kalpitiya Divisional Secretary office. The newly formed women’s oyster society and NARA team convened a meeting with local politicians, Kalpitiya Police, the Sri Lanka Navy which operates bases in the area, and local fisheries societies participated. A similar stakeholder program as the first step to co-management was also undertaken in Gangewadiya.

Based on input from this process, further work is now underway to refine the process, invite participation of other stakeholders (e.g. tourism operators) and form a structure for co-management of coastal resources and to ensure protection and sustainability for aquaculture use. This model will then be used as new areas for mollusk culture are identified in scaling up. This is planned by NARA to be scaled-up to an ecosystem-based approach encompassing the Puttalam Lagoon areas as a whole and applied in new areas where mollusk aquaculture will be developed, specifically Mannar in Northern Province.

**Objective 3. To measurably address, through knowledge mobilization and capacity building for women and men, key constraints currently limiting sustainable production practices identified by communities involved in shrimp (disease diagnostic capacity), CBF (supply of fingerlings) and oyster (production system and seed collection feasibility) aquaculture.**

The specific capacity constraints in each of the sectors such as disease monitoring and testing in shrimp, fingerling supply for inland aquaculture, and a feasibility foundation for oyster culture were fundamentally linked to the knowledge mobilization interventions. For example, sharing of shrimp pathogen test results indicating potential outbreaks of disease required immediate and collective action by farmers as well as notification of government agencies and farm organizations. Similarly, knowledge linkages were developed for the supply of fingerlings for inland aquaculture, requiring advance preparation by hatcheries to condition broodstock of different species, monitor rainfall and environment to determine when and where stocking may occur in seasonal reservoirs and ponds and notify nurseries of availability of fry and, through them notify farmers of availability of fingerlings. Likewise quantities and qualities of oysters required in the markets, and monitoring oysters and growing water conditions for health and safety, necessitated reliable and rapid information sharing linking buyers to farmers and both to government agencies.

**Enhancing Capacity for Shrimp Disease Management.**

White spot syndrome virus is the most important pathogen causes high morbidity and mortality resulting in enormous losses in the shrimp production. According to animal health experts, the disease is endemic in Sri Lanka and the best way to mitigate the losses due to white spot disease virus is through the application of Best Management Practices in shrimp farming. The project
was able to demonstrate how losses can be minimised by adopting a PCR test of shrimps one month after stocking of PLs, and by resorting to methods to reduce stress factors, especially maintaining the optimum oxygen concentration in pond water and correct PL density in shrimp ponds.

The shrimp farmers implemented a new measure through farmer societies to require members to have shrimp PLs tested by PCR after one month post-stocking. This strategy was implemented in combination with requirements for farmers to follow a core set of important BMPs. However, the capacity for laboratories in the both the private and government sectors was not adequate to service this new demand. PCR testing must be carried out following rigorous procedures and utilizing approved primers to avoid contamination of samples and ensuring that the test result is consistent and reliable. A problem with PCR test reliability had been growing in the industry and results were often not trusted by the farmers. This exacerbated the problem of managing disease outbreaks as farmers would often delay taking action based upon the test results, believing them to be unreliably and possibly “false positive”. A consequence was that early harvesting was a common practice by farmers, harvesting either at the first signs of disease until shrimp were already dying.

A lab operated by the NWP Ministry of Fisheries at Pambala (near Chilaw) in the shrimp farming district, was provided with a PCR machine funded by the project and the lab operationalized in March 2014. Training was provided to lab personnel by WUSL experienced faculty and the NWP Ministry is contributing the infrastructure, personnel and supplies for this. During the first year of the lab operation, farmers are being supported for 50% of the cost of testing. The new lab has been able to provide a more reliable and trusted procedure which has further assisted the local labs to work together to improve the protocols for disease detection and monitoring. In addition, NARA and NAQDA have both joined the process each with their lab capacities to further provide support for standardizing and improving testing. The farmers rigorous expected to alert farmers to disease so that they can take actions to contain the spread of the disease to neighbouring farms by increasing biosecurity.

The project also evolved a system of testing water quality parameters of individual ponds of farmers regularly and recommending mitigating measures accordingly at what are called ‘Crop Clinics’ which are held at strategic locations and the farmers have accepted this intervention.

Enhancing capacity for fingerling supply with Mini-Nurseries (CBF)

Mini-nurseries are community owned or private fry-to-fingerling rearing small-scale aquaculture farms located in rural areas. Fish post-larvae or fry stages are stocked in earthen ponds and rear them up to fingerling size in these nursery ponds. Nurseries can purchase fry from government hatcheries at Rs 0.20-0.30 each and sold as fingerlings after 2-3 weeks at Rs. 2.0 each. The localized fingerling production units are very close to the reservoirs and therefore, farmers can obtain their fingerlings from nearby, reducing losses from transportation and stocking. There are 21 mini-nurseries located in the NWPC. However, most of them require some improvements in infrastructure to ensure the production of good quality fingerlings and maximize the profit by improving survival, reducing diseases, improving water quality and improving overall standards of the production program.
Five mini-nurseries from the NWP were selected for improvement in capacity and skills and 10 individuals were trained in nursery operations. In addition, 12 Provincial officers were trained in nursery and reservoir production in order to contribute to the management and governance of CBF. In addition to training, facilities were improved at mini nurseries through provision of some critically needed equipment such as submersible pumps, air blowers, oxygen cylinders, stock separation netting and feed grinders for formulating feeds. A research and demonstration mini nursery at WUSL Department of Aquaculture and Fisheries was also improved with recirculation system and nets for containing fry on ponds. The key advance in technology that the nursery here will develop is the production of all male tilapia fingerlings. With mixed male and female stocking of tilapia, the tendency is for the fish to the fish become reproductive at an early stage, significantly limiting productivity. All-male stocking of tilapia will ensure that there is a much higher level of growth and yield. Awareness programs for the nursery owners and farmer organizations are being conducted through the WUSL outreach center and collaborative research done with NAQDA on sex-reversal in tilapia.

Similarly, in the Eastern Province, the Provincial Ministry has mobilised the farmer community by releasing land and helping to clear other administrative bottlenecks to get the mini-hatchery/nursery at Kadukkamunai operationalized. NAQDA which is the state agency responsible for aquaculture development in Sri Lanka is providing technical support for the mini-hatchery/nursery. This has been established as a training and capacity development hub to expand community nurseries in the Eastern Province. Small farmers owning family ponds such as those in Sangarapurum (Figure 10), and communities engaged in CBF in seasonal as well as perennial reservoirs will benefit from these enhanced capacities.

**Development of culture systems for oyster farming**

Through the research and development work of NARA collaborating with the project team and the private sector processor and marketer, the culture of oysters in the two communities has been successfully established following pilot scale operation and investigation of seed collection and grow-out systems. Seed collection was successfully accomplished in several locations of the mangrove system around Kala Oya estuary near Gangewadiya as well as in the lagoon Kandakuliya. Spatfall peaks in November and December respectively, and farmers, with support from NARA will utilize these as the primary seed collection times. The culture system integrates a standardized process based on similar systems used in other areas of the world (North America, Asia, Australia). The process involves removing seed from spat collectors, stocking seed in pouches and hanging them from wood racks constructed in the shallow lagoons. Regular cleaning of pouches and oysters, and size-grading was successfully done by hand. The pouches serve as an intermediate stage for oysters from the 2 cm to 12-15 cm in shell length. Following the pouches, the oysters are transferred to pocket nets for finishing to market size. This process ensures oysters maintain the shape and condition necessary to meet market conditions. Oysters can be grown to a market size in 10-12 months. A small platform boat was developed to assist the farmers and improve the efficiency of the process. To follow will be further efficiency improvements such a mechanical device to simultaneously wash, tumble and grade the oysters, improvements which will be accomplished with the support of the private sector partner (Figure 11). In addition, the future requirements for seed oyster will necessitate the development and application of a hatchery to produce seed reliably. Within two years it is expected that 2-3 million seed oysters will be required.
Purification of oysters in depuration systems was successfully tested by NARA and the buyer/processor, whose system has been monitored and tested by NARA. Depuration is a standard means of placing harvested oysters in tanks with a flow of sand and Ultra-Violet-filtered sea water for a 12-24 hour period to ensuring oysters are purged of any sediments and bacteria. Future scale-up will require a scientifically validated process and design which will be undertaken by NARA, which can also then serve as a certifying organization for quality and safety assurance.

**Objective 4. To improve gender roles and opportunities for women in aquaculture activities and measure positive outcomes of the interventions under the scale-up project.**

**Improving gender roles and opportunities for women**

At the community meetings organized for assessment of the baseline status of the project areas, aquaculture status and the target communities using PRA tools, it was revealed that the contribution of women to aquaculture is not very visible or acknowledged in shrimp farming. Earlier survey work in the project areas carried out in 2011, in which 177 females of 225 small-scale shrimp farm households were interviewed, indicated that women identify and describe their participation differently from men. From the women’s perspective, they contribute to the shrimp farm operation in some way on 80% of small farms in the NWP: However, when male farmers are asked whether the female spouse (wife) is involved in or work in farm activity only 50% respond positively. This gender gap suggests that men and women have differing perceptions of how much and how important the contribution of women is to the farm operation.

A few factors emerged as common themes in the gender analysis of aquaculture in Sri Lanka as well as from a literature survey of women in fisheries and aquaculture. One, women are attracted to aquaculture by the need to earn supplementary income, but this is done in addition to or integrated with existing household and community responsibilities and this constraint largely prescribes their involvement, demanding flexibility. Two, the domestic or reproductive burden limits the ability of women to participate in aquaculture and specifically in traditionally delivered training activities such as workshops, field schools or demonstrations, where being away from home is required. Three, access to productive resources such as land, in cases where land is required for aquaculture activities such as pond or tank construction, and machinery and equipment can significantly constrain the participation of women as enterprise owners or managers. Fourth, women often are less mobile than men and distance from home is an important consideration for women engaging in aquaculture. Fifth, women are often marginalized from traditional forms of extension for knowledge acquisition and training and these must be adapted to women’s situations and context.

The analysis demonstrated that it is also important to understand how the opportunity of aquaculture for women in poverty is embedded in household and social norms, relationships, and practices with respect to access and control of resources and income. This identifies what specific constraints they face, what decisions they make, and whether their decision-making is in fact choice or necessitated by a constraint. The strategy in the project was to consider where
there could be more “space” for women where opportunity could be built such as in areas where they already have some degree of decision-making or control. For example gathering clams or small fish from a lagoon often plays an important role in household food security, and this may be more easily transitioned into women undertaking culture of shellfish or fish in these lagoons than for example, taking over fishing activities normally done by men. While this may be initiated in a way that does not directly challenge social norms and practices, it can also be transformative as women take on new types of responsibilities, decision-making, negotiating and leadership roles.

Of the three sectors under study, the shrimp sector was the one where the role of women is least visible. In terms of labour contribution to the shrimp sector women contribute quite a high proportion of labour hours in tasks such as watch duty in shrimp ponds during nights, feeding shrimps, preparing meals for men working at the farm, and pond cleaning. However, they display less visible roles in the decision making process. This is partly due to cultural reasons, but also due to lack of awareness of technical and economic conditions related to farming and access to training. The project took initiatives to increase the women’s role in the shrimp sector by selecting and training young educated women from shrimp farm families to serve as Focal Points in the shrimp sector. The project interventions for knowledge mobilization also addressed the gender gap by involving women in the training of farmers for BMP implementation, creating awareness about occupational hazards in farming and safe use of farm machinery. In addition, messages and knowledge resources targeting women directly were developed in the sharing of information to women engaged in aquaculture activities. Providing a targeted opportunity for women in shrimp culture was undertaken in the EP.

The contribution of women to income earned through fishing and agriculture is recognized and acknowledged more significantly than in shrimp farming. Yet in some cases men perceive the income contribution by women to be lower than the women themselves perceive. One community, Sangarapuram, is exceptional with a strong women-led aquaculture group and income diversification related to aquaculture. CBF operations are carried out as homestead pond practices where women play a strong role in management and decision-making, including those related to income (Figure 12). In addition, women earn income in supplying nets, supplementary feed and other inputs. This model is being investigated for further integration into other communities involved in inland aquaculture.

In the oyster sector, which is a new value chain Sri Lanka, the focus of interventions related to charting pathways for gender-inclusive aquaculture development in communities dependent primarily on capture fisheries for livelihoods and income. As an emerging sector the project was able to provide some spaces for women to stand in strong and equitable positions as producers in the value chain rather replicate the conditions, roles, and positions of women as they existed in their position in the capture fisheries sector. The results showed some positive indicators of this. By first understanding the context, conditions and positions of women in fishing and livelihood support as well as their position in households, communities and income earning activities, the constraints that women faced were revealed and at the same time activities structured that could be channelled to empower women. This also highlighted the strong interest and motivation displayed by the women involved in the project to supplement income through aquaculture.
Despite the fact that 78 percent of the women in the two communities of Kandakuliya and Gangewadiya had completed education through grade 10, they had been unable to transform this attainment into more equitable positions in the capture fishery value chain and were unable to find opportunities in the villages to undertake employment or engage in entrepreneurial activities that would provide a means to increase their contribution to household income or build a larger asset base. Food security is a high concern among these women since income is episodic and inconsistent. Although they reported spending an average of 39 percent of income on food, 87 percent of them indicated that they needed to borrow to meet household food expenses at some time during the year. There was also a high level of housing insecurity related to ownership of land or fear of loss of housing. Many houses are constructed of cadjan (palm leaf) and one third of the women interviewed in Kandakuliya lived in such homes. Homes are crowded with 70 percent comprised of only 2 rooms. A majority of homes have electricity (72 percent) but this underscores the impact for households with no electricity. Access to clean water and inadequate sanitation facilities were also cited by women as challenges in maintaining households.

Introducing aquaculture to women as an opportunity was also done with sensitivity to ensure that it did not add to the burden of women who also carried responsibilities for household and fishing activities. The women in these fishing communities reported that they were directly involved in many of the activities associated with small-scale fishing, spending a considerable amount of time, often over 7 hours per day during fishing periods. Generally women reported starting their day at 5 AM spending 6-7 hours every day preparing meals and cleaning. Women also took responsibility for care of children before they are old enough to attend school, and also took responsibility for escorting or transporting children to and from school as well as assisting them with homework. Accounting for the daily responsibility of women was a critical consideration in assessing their capacity and willingness to engage in other income earning opportunities such as aquaculture. Women in both villages reported that they would be able to allocate 2-4 hours per day in the fishing season and 3-6 hours per day in the off-season to dedicate to oyster-farming activities. Their reproductive and household burden, however, would not likely to be lighter. Considering this, an important criterion for developing oyster aquaculture was to ensure that the participation by women could be accomplished in ways that they could integrate their household and reproductive responsibilities. One way this was done was to select culture locations close to their home village and develop methods of culture that do not require travel by motorized boats or require tasks for which they would not feel themselves capable. A specialized boat was designed and constructed and provided to the women in the two communities. It was financed through donations from friends and family of one of the co-leaders of the project through a face-book campaign and the NWP Minister of Agriculture and Fisheries matched this amount.

An additional strategy was to share the responsibilities for the aquaculture among a group of women so that oyster farming activities did not mean adding an additional 5 hours to an already long day. In Kandakuliya 20 women took the initiative to form the Kandakuliya Women’s Oyster Society, providing them a vehicle for financial and business management of the aquaculture enterprise, taking on complete management and decision making related to the oyster aquaculture enterprise from seed collection to sales and marketing of oysters. In Gangewadiya 25 families participated in the first phase of the project, but the participation has changed structure to a manager-entrepreneur from the community working directly with the private sector buyer and taking responsibility for the farming operations and hiring and training.
community members who are employed on the farm (presently 20). Although this is a somewhat different path from Kandakuliya, the women participating are gaining in experience, confidence and desire to develop the enterprises on their own.

Based on the survey of their experiences in the project, 92 percent of the women in the two communities believed that oyster farming would help improve their household income. Moreover, 86 percent of them thought that oyster farming is an enterprise that women can do on their own and 89 percent have indicated that they would have enough time to dedicate to oyster farming. In addition, 65 percent of women indicated that they will make the primary financial decisions on commercial oyster culture while 97 percent believe that oyster farming help them take stronger positions of leadership in the community. However they were also realistic in understanding that engaging in aquaculture would entail some restructuring of their domestic and household responsibilities as 88 percent indicated that they would dedicate less time to these activities.

**Measure positive outcomes of the interventions under the scale-up project**

The project key indicators for measuring positive outcomes are productivity improvements and enhancement of income related to implementation of better management practices, adoption of improved techniques and risk reduction. Through the participatory processes conducted as the baseline and the outcome evaluation of the project, these indicators were also embedded in household and community well being indicators including income stability at all times of the year (i.e. the number of months household income was regarded by participants as adequate to meet family needs) and amount of income spent on food as indicators of food (in)security. Women’s contribution to contribution to household income was also considered. Key findings of the participatory baseline assessment related to income, food security and gender contributions to income for households showed that many households spend 50-60 percent of their income on food, an exception being Sangarapurum in the EP, which has built productive agriculture as well as achieved sound pond production of fish, the latter being largely the contribution and management of women. The most vulnerable are the two oyster communities, which, in addition to a high percentage of income spent on food, also obtain 75-80 percent of their food from market purchases rather than being able to rely on their own production. In both of these traditional capture fisheries were identified as the primary means of earning income. Income vulnerability is also high in these communities when measured as number of months in the year when there is seen to be sufficient income to meet household needs. Again the oyster communities are most vulnerable with as few as 2 months of the year when fish capture provides sufficient income. Key data is summarized for seven of the communities in which the PRA for the baseline assessment was conducted in Table 3.

A survey was conducted among shrimp farmers with 5 or fewer ponds (small and medium scale, based on an average pond size of 1.12 acres) at the end of the first production cycle of 2014 (March-September 2014) to assess the outcome of the interventions linked to the knowledge mobilization program along with implementation of BMPs. In addition four shrimp farm community focus group meetings were held at the end of the project to explore outcomes, two in the NWP and 2 in the EP attended by a total of 34 farmers. There were clear and significant beneficial outcomes in productivity, income, and reduction of risk related to disease outbreaks.
There were especially evident in the NWP, where there has been a long history of outbreaks of WSSV. In the EP, in contrast, farmers have not had disease outbreaks resulting in higher overall production rates than in the NWP. However, disease outbreaks began to be observed in 2013. In addition, in the EP, a new private-public partnership was initiated in 2013 with 27 new farmers (12 of whom were women), increasing the number of farmers the existing 60 farmers there. The initial year of production was quite low in this new venture due to late stocking and some exceptionally high salinities. Hence we present the results separately for EP and NWP.

Since the project was undertaken for only 14 months, the interventions were operationalized and results obtained after a singly cycle of production. This was assessed against the most recent production cycle of farmers in 2013 obtained from baseline surveys and to a limited extent from data obtained in a survey of farmers conducted 2011 (obtaining 2010 production data) which was undertaken in the previous project. Productivity improvements were not only measured in yields but also shrimp survival rates, increases in daily weight gain resulting from better management and in the number of farmers that were able to exceed a benchmark level of 850 kilograms per acre (0.453 hectares) established at the beginning of the project.

Production Improvements in the NWP were significant. Farmers with fewer than 5 ponds in NWP have increased production yields per acre from an average of 740 kilograms in 2010 and 832 kilograms in 2013 to an average of 932 kilograms in 2014, a 26 percent increase over 5 years and a 12 percent increase from the previous year. In the NWP 86 percent of farmers with fewer than 5 ponds achieved the benchmark of 850 kilograms per acre, a significant increase from 31 percent in 2013.

### Production Improvements in Small and Medium Scale Shrimp Farms in NWP

- Farmers have increased production yields per acre from an average of 740 kilograms in 2010, and 832 in 2013 to an average of 932 kilograms in 2014, a 26 percent increase over 5 years.
- 86 percent of farmers achieved the benchmark of 850 kilograms per acre, a significant increase from 31 percent in 2013 and 33 percent in 2010.

Outcomes are shown in Table A for shrimp farmers with fewer than 5 ponds in both NWP and EP.

**Table A. Productivity outcomes of shrimp farms in Sri Lanka under project interventions.**

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Yield All Farmers (kg/acre)</td>
<td>880*</td>
<td>825</td>
<td>956</td>
</tr>
<tr>
<td>% Farmers &gt; 850 kg/acre</td>
<td>40</td>
<td>73</td>
<td>88</td>
</tr>
<tr>
<td>Average Yield NWP (kg/acre)</td>
<td>740</td>
<td>832</td>
<td>932</td>
</tr>
<tr>
<td>% Farmers &gt; 850 kg/acre</td>
<td>33</td>
<td>31</td>
<td>86</td>
</tr>
<tr>
<td>Average Yield EP (kg/acre)</td>
<td>1321*</td>
<td>598</td>
<td>1026</td>
</tr>
<tr>
<td>% Farmers &gt; 850 kg/acre</td>
<td>63</td>
<td>42</td>
<td>92</td>
</tr>
</tbody>
</table>

* The 2010 data reflects productivity prior to the initiation of 27 new farmers and the historical absence of WSSV outbreaks in EP.
As shown in Table B, under the project interventions shrimp farmers have improved individual average weight at harvest from 20.42 grams in the 2013 cycle to 23.2 grams in 2014, an increase of 13.6 percent. Farmers also improved on average daily weight gain from 0.19 grams in 2013 to 0.21 grams in 2014, also increasing the days in production to an average of 118 in 2014 from 108 days in 2013. From days in production and shrimp size at harvest, the average daily gain (ADG), recorded in grams per shrimp per day, was calculated. For 2014 ADG was 0.21 grams versus 0.19 grams for 2013 (Figure 13), which was statistically significant. This is an indicator of better production management with higher feed conversion ratios and more farmers achieving an extended production cycle.

Table B. Weight improvements of shrimp in Sri Lanka under project interventions.

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average weight of shrimp at harvest (grams)</td>
<td>20.42</td>
<td>23.2</td>
</tr>
<tr>
<td>Average daily weight gain (grams)</td>
<td>0.19</td>
<td>0.21</td>
</tr>
<tr>
<td>Average length of production cycle (days)</td>
<td>108</td>
<td>118</td>
</tr>
</tbody>
</table>

As complementary evaluation of project outcomes was derived from four focus group meetings with 32 shrimp farmers in both EP and NWP. These farmers represented a spectrum of all farm sizes rather than exclusively the small and medium scale farmers. (Table C)

Table C. Production improvements of shrimp in Sri Lanka under project interventions based on focus group discussions in 4 shrimp farm communities.

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average survival stocking to harvest (Percent)</td>
<td>60.5</td>
<td>75</td>
</tr>
<tr>
<td>Average shrimp weight at harvest</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>Average yield per acre (kilograms)</td>
<td>751</td>
<td>1500</td>
</tr>
</tbody>
</table>

These positive outcomes in shrimp farm productivity were evaluated in terms of income benefits to shrimp farmers. Scenarios for small farmers were prepared and sensitivity analysis applied to present outcomes as interventions are sustained and productivity improves or does not decline over time. In addition, a Benefit-Cost Analysis (BCA) was applied to the interventions combined into knowledge mobilization through SMS and the web platform, the application of the BMPs and the enhancements to disease diagnostics achieved through operationalizing a laboratory under the direction of the NWP Ministry of Agriculture and Fisheries to enable increased testing for shrimp pathogens.

Shrimp prices climbed dramatically in 2014 reflecting a global shortage in supply of shrimp due primarily to disease outbreaks in 2012 and 2013 related to Early Mortality Syndrome which has been more precisely and renamed Acute Hepatopancreatic Necrosis Syndrome (AHPNS). Moreover, Sri Lanka produces exclusively the Black Tiger Shrimp (*Panaeus monodon*), which commands a higher value especially in expert markets, and particularly for larger shrimp.

Table D shows in 2014 shrimp farmers reported farm gate prices per kilogram of 1050 to 1250 LKR, significantly higher than farm gate prices reported in 2013 of 600 to 700 LKR per kilogram. Farmers also increased their cost of production in 2014 due to several factors. One was the longer production cycle they were able to maintain since disease management was improved and there were fewer outbreaks. In fact despite unexpectedly high percentages of samples
testing positive for White Spot Virus, the implementation of the BMPs in combination with the water quality management program, ensured that farmers could continue to culture a full cycle even with the pathogen present in the ponds. The resulted in net profit to farmers in 2014 averaging 400 LKR per kilogram compared to 135 LKR in 2013.

Table D. Net income for shrimp farmers

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median farm gate price per kilogram (LKR)</td>
<td>650</td>
<td>1150</td>
</tr>
<tr>
<td>Production costs per kilogram (LKR)</td>
<td>515</td>
<td>750</td>
</tr>
<tr>
<td>Net profit per kilogram (LKR)</td>
<td>135</td>
<td>400</td>
</tr>
<tr>
<td>Average yield per acre (kilograms)</td>
<td>825</td>
<td>956</td>
</tr>
<tr>
<td>Net Income per acre (LKR)</td>
<td>111,375</td>
<td>382,400</td>
</tr>
</tbody>
</table>

The improvement in yields in 2014 combined with strong farm gate prices has resulted in net incomes averaging 382,400 LKR per acre for shrimp farmers. A scenario for a 2-pond farm with average pond size of 1.12 acres and operated by a single household would provide 856,576 LKR in net income for a single production cycle of 4 months. A single pond farm would achieve a net income of 428,288 LKR. For a household farm with a single pond this would translate into 35,690 in monthly income. If farmers received 950 LKR in future, net income would be 191,200 LKR per acre or 214,144 LKR per pond if cost of production and yields remained the same. For a single pond farm household this would translate into 17,845 LKR as a monthly income. To put this income into perspective, the official poverty line in Sri Lanka (2010) was 3,028 LKR (about USD $23) real total expenditure per person per month, thus a household of 4 would require an income of over 12,100 per month and an annual income of 145,200 per year to achieve that. Hence current small-scale shrimp farming can now lift households beyond the poverty in Sri Lanka.

A Benefit-Cost Analysis of the interventions was also conducted to determine if the value of the investment of the project would provide a positive ration. Intervention investments consisted of the knowledge mobilization program of the SMS and web platform combined with the enhanced water quality analysis and pathogen testing. The costs and benefits were projected over a 5-year period including the project year since benefits accrued to farmers during the project. The benefits were calculated based on an anticipated farm gate price of 1000 LKR per kilogram and cost of production at 750 LKR per kilogram and that the and based on the assumption that production yields would remain stable. With approximately 1680 acres under shrimp farm production in Sri Lanka by farms with 5 or fewer ponds, the net benefit to the industry was estimated. The values of both cost and benefits were discounted using a value of 10 percent. This scenario resulted in a benefit cost ratio of 2.71.

The benefit cost ratio was 2.71 for project interventions that would be maintained by the shrimp farming industry over 5 years.

Communities in the culture based fishery enhancements of the project also realized increased productivity and incomes. However, due to the late date of stocking of a number of the reservoirs due to delayed monsoonal rains in 2014, only four of the reservoirs had been harvested by the project end date. Additional data on the outcomes of the remaining reservoirs is being gathered as harvesting progressing to the end of December 2014. Additional results and
analysis will be made available once this data has been gathered and analysed. The four reservoirs harvested by September 2014 were Tattewa Wewa in Puttalam district (3,000 kg with a value of LKR 450,000), Pahala Talambuwa Wewa (1,100 kg with a value of 115,000 LKR), Mataluwawa Wewa (2,600 kg with a value of 304,000 LKR) and Kumbalporugama Wewa in Kurunegala district (2096.5 kg with a value of 271,835 LKR).

Fish harvested from these reservoirs were largely marketed locally within a 20-30 km radius of the reservoir. Communities conducting CBF were given a certain amount of fish free of charge. Additional fish were then sold in the CBF communities at farm gate prices ranging from Rs. 105 to 150 per kilogram. This provided both a market revenue for households participating in the aquaculture activity as well as lower than open market prices for households in the participating to purchase fish for household consumption. The surplus from each reservoir was then sold to vendors who distributed the fish to other local markets.

The members of the aquaculture management committees in each community earned an income ranging from 8,000 to 15,000 LKR per member. The contribution to the revolving fund of the farmer organizations ranged from 5 percent to 12.5 percent of the total value of fish. Money for purchasing fingerlings for the next culture cycle would be taken from the amount deposited in the revolving fund. Some farmer organizations also utilized the money in the revolving fund for the rehabilitation of the reservoirs and the Kumbalporugama Wewa farmer organization utilized some of the funds to improve the demarcation of the actual area of the reservoir.

The two communities involved in oyster farming initially stocked 20,000 oysters each at Gangewadiya and Kandakuliya of which over 18,000 were sold in local markets from May through August 2014 averaging 4,500 per month. Approximately half of the marketed oysters were sold from each community. At a farmgate price of 10 LKR per oyster, communities earned approximately 22,500 LKR per month in the first cycle of production from the pilot sites. In the context of these communities this income represented a significant improvement and the income will increase as more oysters are stocked in the farms. The baseline assessment showed household income was below the Sri Lanka poverty line (Table 4) for almost all households in both Gangewadiya and Kandakuliya. Based on a survey of women form 36 households in the two communities, it was found that 15 of 20 households in Kandakuliya and 7 of 16 households in Gangewadiya have an annual income of less than 50,000 LKR for an average household size of 4 persons. The remaining 5 households in Kandakuliya reported an annual income of less than 100,000 LKR. A household of 4 with an annual income of 145,200 LKR would be living at the official poverty line in Sri Lanka established in 2010. While still a small amount, adding 1,500 Rs per month to these households added important capacity to support basic necessities and food in these households.

It is important to note that the current limitation is in the production of marketable oysters, while the market demand continues to grow domestically and supply cannot meet the growing demand. Large export markets have also been developed in Thailand and other South East Asian countries such as Taiwan and China (Hong Kong) as well as Saudi Arabia.

The goal is to continue to increase the production at these community sites and add two more in 2015. After 2 years, each community will have a farm unit capable of producing 200,000 oysters per year stocked from locally collected seed (spat collection) and able to be operated by 10 persons on a part time basis. These would be able to eventually increase to 500,000 after 5
years. Income received at the farmgate for oysters is currently Rs. 10, although this is expected to increase for fresh product in domestic markets to LKR 15. At LKR 10 each, 200,000 oysters per year would provide 2,000,000 LKR in gross farm revenue. With production costs estimated at Rs. 4 per oyster, this would provide 1,200,000 in net revenue translating to 120,000 in additional net annual income for each or 10 households participating.

MONITORING AFS EXPECTED OUTCOMES

1. New technologies and/or farming systems and practices. How is the project leading to new and improved agricultural technologies and/or farming systems and practices that increase food production? (e.g. technologies and innovations; staple crops; crop-livestock interactions; agricultural water management; new seeds and plants)

Extensive implementation of Location-specific BMPs supported by farm organizations and government agencies, providing training, water quality analysis and knowledge for decision-making using SMS and web platform increased the number of farmers implementing key practices with an outcome of reducing risks of disease outbreaks and improving sustainability and productivity. Increasing further the capacity of farmers to adopt these practices and add risk-reducing diversification to production systems (with polyculture or integrated multi-trophic culture) would further benefit small-scale shrimp farmers. Multi-species stocking is enhancing productivity of reservoirs and ponds in CBF and is complemented with adding capacity of private and community nurseries to provided fingerlings. Further scaling up will involve integrating data from hundreds of reservoirs and ponds with improved predictability of rainfall events that can enable hatcheries and nurseries to more accurately determine market demand and timing. Addition of giant freshwater prawn to the existing species mix can lead to further advances in productivity as well as provide significantly improved income as this species has a high demand and price particularly for export markets.

Oyster culture systems in 2 communities in Puttalam lagoon using racks and pouches are producing market oysters and are doing so in increasing numbers. Purification of oysters using depuration systems is being piloted. Seed supply from natural spatfall will be come a constraint in the near future, requiring development of small-scale hatchery technology in future scaling up. Additionally, the project is developing systems of production based on a proven process of regular cleaning, tumbling and grading to enhance quality of oysters. To scale up, this will require units of production to be modelled based on minimum production levels (200,000 oysters per year) and developed with equitable opportunity for women and different options for community participation (co-operative, individual entrepreneur, etc).

2. Dietary diversity & nutrition. How is the project contributing to dietary diversity/balanced diets, particularly for women and children? (e.g. food safety practices and regulatory frameworks; food fortification; local nutritional needs)

Development of the oyster culture program has initiated the need for monitoring growing waters and oysters for possible contamination and building awareness of food safety for shellfish for post-harvest handling. This is the foundation of developing a comprehensive
Mollusc and Shellfish Safety program to ensure safe quality products in the market. NARA is taking the lead as government agency to begin development of this program.

3. **Engagement of Canadian researchers with Southern researcher organizations.** Is there increased use of Canadian knowledge and resources to address environmentally sustainable agricultural productivity and nutrition problems in developing countries? Canadian expertise in sustainable aquaculture, aquatic health management, and knowledge mobilization, is contributing to stronger foundations for aquaculture development that are inclusive and sustainable. The BCAFRS is a new Canadian Organization now linked with the project.

4. **Research groups.** How is the project contributing to stronger research groups for improved food security policies and decision-making?
   New clusters of collaboration have emerged from project activities related to research addressing capacity enhancements, knowledge mobilization and governance, linking research organizations with different stakeholder groups in the spheres of both policies and practices. Participation of farmers and industry groups in the research activities has stimulated increasing attention to the knowledge and observational contributions of farmers and served to increase strategic cooperation between farmer groups to harmonize practices and programs. It has also brought together under the knowledge connectivity research umbrella, increasing cooperation among different government organizations – e.g. NARA, Provincial Ministries of Fisheries, Agrarian Services Division and NAQDA.

5. **Food distribution.** How is the project contributing to more equitable food distribution for food security? (e.g. more equitable access to quality food)
   Enhancing productivity and incomes for rural poor communities based on increased fish production from inland resources (new farmer organizations taking on aquaculture as a new opportunity in seasonal reservoirs or ponds) and from coastal resources (fishing communities adding the opportunity of oyster and possibly mussel and clam culture) has increased availability and consumption of fish in rural areas. Creating a local supply of oysters that do not make the urban or export market grade can be added to diets in coastal communities in a variety of forms with recipes and demonstrations of how to prepare oysters.

6. **Food processing and storage.** How is the project contributing to improved post-harvest food processing and storage techniques for food security?
   The project is focusing some efforts on improving post-harvest handling of fish in inland reservoirs and ponds and encouraging means of value-addition and/or preservation (e.g. drying). In the oyster culture activity, the testing of depuration systems for purification of oysters has been introduced with the private sector buyer and NARA is also planning to construct a pilot scale research and demonstration depuration facility at its field station in Kalpitiya at Puttalam Lagoon.

7. **Risk-mitigation.** How is the project contributing to better risk-mitigation for food security? (e.g. mechanisms that cope with the impacts of climate change, and other shocks such as food price volatility)
Aquatic animal disease is a major risk to sustainable aquaculture in Sri Lanka. Shrimp farming is only now beginning to take coordinated and effective measures to reduce risk as a result of project activities. Increasing the reliability and availability of diagnostic capacity (with addition of the PCR lab at Pambala) is helping to improve reliability of results. Farmer groups have all cooperated to institute new measures for disease management in two ways. One is to make mandatory of all farmer members a PCR test on shrimp one month after stocking in ponds. This provided an early warning system for disease outbreaks. A second is the institution by shrimp farm societies of a set of mandatory practices that members are now implementing (using a method called “concern papers” signed by each farmer member), adapted to local capacities and conditions. The operationalizing of nurseries has also brought to the fore greater attention to disease risks of juvenile fish, which will be essential in improving survival in the hatcheries, and ensuring healthy fish are stocked in reservoirs and ponds. The oyster culture activity has also prompted an emerging awareness of the need to develop capacity to monitor and diagnose possible pathogens and parasites that may affect oyster survival.

The increasing uncertainty of monsoonal rainfall has triggered major concern especially for inland aquaculture, but is also impacting coastal oyster and mussel production and brackish water shrimp farming. Lack of sufficient rainfall in the expected monsoonal period has meant that farmers have insufficient water for irrigation and aquaculture. Measures to reduce water usage in irrigation and improve water storage capacity are being considered. Further, these uncertainties have hindered the development of private sector hatcheries and nurseries and led to unpredictable supplies from government hatcheries. Strategies to improve access to rainfall data across geographical are helping fingerling suppliers to target production to areas where rainfall is sufficient and delay for areas with late rainfall.

8. Access to resources. How is the project contributing to improved access to resources for food production and security? (e.g. land tenure, extension and credit, market access)
Access to land and water resources for culturing fish in inland reservoirs is largely assured by farmer societies who have rights to utilize seasonal reservoirs for paddy farm irrigation. For shrimp farmers, around 22% do not own the land on which the pond is farmed and rent ponds for farming. For emerging oyster culture, on the other hand, coastal tenures and licences are obtained from NAQDA, but no system exists in which user rights are assessed relative to other uses and user groups (e.g. fishing, tourism). NARA has developed criteria for suitability and capability of areas for the culture of mollusc shellfish taking into consideration protection of natural resources (mangroves, oyster beds) as well as social-economic conditions of coastal communities. A process to ensure mutual stakeholder recognition of areas and tenure rights is also in development.

9. Income generation. How is the project contributing to improving vulnerable/poor people’s ability to purchase more and better quality food, in particular for the benefit of women and children?
Household expenditure for food in some communities constitutes 60-70% or more of total income. Providing additional income from aquaculture is reducing this vulnerability.
10. **Policy options.** How is the project influencing the development and implementation of food security policies?

Policy implications were formulated together with government and industry stakeholders in each of the 3 sectors, including implementation of BMPs to improve sustainability and reduce disease risks in shrimp farming, access and use of common resources in coastal and lagoon areas for mollusc aquaculture, and harmonizing agriculture and aquaculture use of common resources in CBF. Areas where policy formulation has been recognized by government and farm stakeholders.

11. **Information and Communication Technologies (ICTs).** Has the use of ICTs contributed to increase access to information and improved food security for the most vulnerable? (e.g. equitable use of technologies, such as radio, television, telephones, computers, and the Internet).

The integrated SMS and web platform has been designed for each of the 3 sectors. The project identified women in the value chains and took measures to enable women to participate equally with men in this intervention. For shrimp farming, the integrated SMS-Web platform enables information from farms and common water bodies to be uploaded by the trained cluster persons into a database for reviewing by an expert group comprised of technical experts in the industry and project researchers. Once the group validates information uploaded by clusters, the incoming information is assessed for potential risks and conditions that warrant an advisory or alert to farmers. Several means have been developed to enable communication between the expert group such as chat, email, and SMS alerts. Once messages to farmers are formulated and target farms identified, they are sent by a team member to designated farmers. Farm clusters each have access to a computer with internet to be able to access the web platform and view knowledge resources and aggregated information. Information uploaded by farm cluster trained personnel is aggregated into data modules. Initially the project will aggregate data on PL stocking, Shrimp Production, PCR Results (at one month), Disease Outbreaks, and Water Quality (Cluster Farms, Common Water Bodies). Further modules will come online once the high priority ones are operational. This will provide a knowledge base over time for the industry to track cluster production performance and progress and benchmarking.

For CBF, and oyster culture, the systems have been designed but are not yet fully implemented and this is expected in 2015. However, the fundamental web platform has been prepared for each of these sectors.

12. **Gender.** How is the project considering women’s specific needs in the design of the research, participation of women in the research, and potential impact of research on women? How is the project: a) improving women’s access to and control over income?; b) reducing women’s drudgery or workload (time spent) in agriculture?; and/or c) improving women and children’s access to adequate and diversified diets?

Rendering visible women’s contribution to and position in the farm enterprise as well as value chain required a combination of approaches involving interviews and participatory methods, usually conducted separately between men and women. Conducting participatory processes in which farm and fisher households, represented by both women and men grouped separately for knowledge sharing activities, made explicit in visual and verbal ways gender dynamics and relationships that were previously unacknowledged or even hidden.
For example, women’s and men’s contributions to income, decision making, household food access and availability, responsibility for farm activities, and reproductive responsibilities were sometimes markedly different. Showing this differences in a context and process that was non-threatening and grounded in trust fostered discussion and actions that opened pathways to strengthening the participation and responsibilities for women. The participatory processes also served as a platform for demonstrating women’s leadership abilities and also expanded their horizons and ambitions in being able undertaking activities was an unexpected outcome of the processes. Interventions in the project were consequently directly able to address women’s condition and position in these different value chains. In the shrimp sector women have been recruited from the farm clusters to be trained in water quality management and BMPS, and given responsibility for managing farm cluster information and uploading this as well as facilitating access by other farmers to the web platform. Operating nurseries for fry to fingerling was also developed as new opportunity for women’s entrepreneurship. In oyster culture, female participation is very high and they demonstrated an eagerness to acquire knowledge and experience. In Kandakuliya village an Oyster Culture Women Society was formed to carry out the activities as a direct result.

13. **Environment.** How is the project contributing to environmental sustainability? (e.g. Is the project affecting the environment? If so, are contributions environmentally sustainable?) How is the project testing for environmental sustainability? Reducing risks of disease and BMP implementation has direct consequences for reducing environmental impacts of shrimp farms. In the CBF sector utilization of reservoirs for culturing fish has enabled farmers, together with government stakeholders, to align water use for irrigation with conservation and sue for fish culture. Oyster farming is generally considered to be environmentally friendly, and in fact has noted beneficial effects. Some of these are socio-environmental such as the recognition, once oyster culture is started, of the water quality of growing waters and the risk to production from anthropogenic or natural contaminants. The need for community sanitation, and collection of garbage from beaches is already gaining ground in the communities.

**Project implementation and management**

The project implementation and management has operated relatively smoothly from both the Sri Lanka and Canadian partner sides. The Project Management Committee served as the forum for the research team and third party organizations to come together and ensure the activities planned are undertaken in an effective and timely manner and resources are available. However, there have been a number of incidents in the process of procurement of goods, of contracting consultants, and specific fund allocations to third party organizations that have caused some administrative difficulties, which has impacted to some degree on meeting scheduled deliverables. In certain respects, it is a matter of the administrative structure and requirements of different institutions to come into alignment. For example, hiring a consultant through the university versus hiring a consultant through a government organization (a third party partner) has required in some cases a series of discussions, and agreements for which formal letters between these institutions must be done in the correct manner. Hence there have been some delays in mobilizing these resources for consultants and in some cases extraordinary
delays in making payments. This has caused some frustration among project partners, particularly when one organization or individual does not have the resources at hand to progress with the work and awaits the transactions. Hence we are continuing to look for ways to streamline this process but it still demands a case-by-case approach. We have taken extra steps to understand the administrative structures and protocols of the different partner organizations and align fund transfers and transactions accordingly.

Problems and Challenges

Challenges have been experienced in the project in several dimensions. One is related to the environmental conditions and what appears to be increasingly unpredictable nature of monsoonal rainfall. For example, adequate rainfall to sustain seasonal reservoirs was a necessary condition for community participation in the CBF. Rainfall events also impact coastal environments where oysters are cultured, triggering spawning. However, if the influx of freshwater from rainfall is too great, salinities in coastal lagoons can drop below critical levels resulting in mortalities. The project devised secondary sites where oysters can be moved that are less prone to these influxes. Rainfall (or lack of) also affects salinities in brackish water ponds of shrimp causing stress and susceptibility to pathogens if levels are below or above critical levels.

The PMC and MOU agreements between project partners and stakeholders have maintained a relatively strong alignment of stakeholders towards project objectives. Participatory processes are very helpful for farmer stakeholders to understand the project and provide their knowledge. The project has however experienced some differences in priorities and strategies between the provinces, particularly in CBF activities. The community at Sangarapuram in EP, for example, is a very successful case in which pond culture of fish has provided a space for women to take a leading role including developing their own value chain in which some women have begun micro-enterprises in making nets, feed and other inputs as well as value addition post-harvest. While both provinces require nurseries to address fingerling supply shortages, this model is an important new dimension, which has been incorporated into the project. Ponds are complementary to seasonal reservoirs and this may perhaps also help to address risks associated with dependence on rainfall.

Recommendations

The project is unique in having a 14-month duration to pilot scaling-up. This was valuable to test approaches and strategies and refine what is likely to be most effective. However, the project also experienced a gap of 7 months from the end date of the initial project to start-up of the scaling up. This meant that a season was essentially lost in maintain traction achieved at the end of the project and the farmers went through production in 2013 (the majority of which is from January to June or July for both shrimp and inland aquaculture. While this ground has largely been regained, an opportunity was also to gather data from that period. Furthermore, the production cycles of both CBF and shrimp farming in 2014 meant that the project required completion before all of the production cycles were completed which were part of the project interventions. Hence there is further data to be analyzed and incorporated into subsequent reports.
Annex 1 Tables and Figures

Tables

Table 1. Communities selected for Participatory Rural Appraisal

<table>
<thead>
<tr>
<th></th>
<th>Culture based fisheries sector</th>
<th>Oyster sector</th>
<th>Shrimp sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWP</td>
<td>• Amunukole</td>
<td>• Kandakuliya</td>
<td>• Pinkattiya</td>
</tr>
<tr>
<td></td>
<td>• Attikulam</td>
<td>• Gangewadiya</td>
<td>• Udappuwa</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Puttalam</td>
</tr>
<tr>
<td>EP</td>
<td>• Sangarapuram</td>
<td></td>
<td>• Oddamavadi</td>
</tr>
<tr>
<td></td>
<td>• Mahilurmunai</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Selected reservoirs for the scale up activities of CBF in North Western Province (NWPC) and dates of awareness programmes conducted.

<table>
<thead>
<tr>
<th>Date</th>
<th>Name of the tank</th>
<th>District</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.12.2013</td>
<td>Madawachchiya Maha Wewa</td>
<td>Kurunegala</td>
<td>Madawachchiya</td>
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<tr>
<td>22.12.2013</td>
<td>Andara Wewa</td>
<td>Kurunegala</td>
<td>Siyambalawewa</td>
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<tr>
<td>03.01.2014</td>
<td>Kubalporugama Wewa</td>
<td>Kurunegala</td>
<td>Madagalla</td>
</tr>
<tr>
<td>03.01.2014</td>
<td>Herathgama Ihala Wewa</td>
<td>Kurunegala</td>
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<td>04.01.2014</td>
<td>Thonigala Gala Wewa</td>
<td>Puttlam</td>
<td>Thonigala</td>
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<tr>
<td>05.01.2014</td>
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<td>Attikulama</td>
</tr>
<tr>
<td>05.01.2014</td>
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<td>Puttlam</td>
<td>Naikulama</td>
</tr>
<tr>
<td>09.01.2014</td>
<td>Pupulewatiya Wewa</td>
<td>Kurunegala</td>
<td>Kelegama</td>
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<td>11.01.2014</td>
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<td>Puttlam</td>
<td>Wadaththa</td>
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<td>11.01.2014</td>
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<td>08.02.2014</td>
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<td>Kurunegala</td>
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<td>08.02.2014</td>
<td>Danduwawa wewa</td>
<td>Kurunegala</td>
<td>Dandu Wewa</td>
</tr>
<tr>
<td>Village</td>
<td>Type</td>
<td>%income food</td>
<td>% food purchased</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------</td>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Kandakuliya (NWP)</td>
<td>Oyster</td>
<td>50-60</td>
<td>80</td>
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<td>Gangewadiya (NWP)</td>
<td>Oyster</td>
<td>50</td>
<td>75</td>
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<tr>
<td>Amunukole (NWP)</td>
<td>CBF</td>
<td>55</td>
<td>60-65</td>
</tr>
<tr>
<td>Attikulam (NWP)**</td>
<td>CBF</td>
<td>50</td>
<td>30-50</td>
</tr>
<tr>
<td>Pinakttiya (NWP)</td>
<td>Shrimp</td>
<td>60</td>
<td>60</td>
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<tr>
<td>Sangarapuram (EP)</td>
<td>CBF</td>
<td>20</td>
<td>30-40%</td>
</tr>
<tr>
<td>Mahilurmunai (EP)</td>
<td>CBF</td>
<td>30-40%</td>
<td>60-70%</td>
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</tbody>
</table>

** The range of contribution in Attikulam varies seasonally with female contribution at a high point during the religious Mass season (up to 50%). At other times female contribution ranges from 10-20%
Table 4: Socio-economic characteristics of the participating households in Gangewadiya and Kandakuliya.

<table>
<thead>
<tr>
<th>Socio economic characteristic</th>
<th>Both village n=36</th>
<th>Gangewadiya n=16</th>
<th>Kandakuliya n=20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age (years)</td>
<td>35.2</td>
<td>33.8</td>
<td>36.6</td>
</tr>
<tr>
<td><strong>Respondent (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Educational attainment of the respondents</td>
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<tr>
<td>No schooling</td>
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<td>13</td>
<td>5</td>
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<tr>
<td>Grade 1 -10</td>
<td>78</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>Pass General certificate of education (GCE) Ordinary level (O/L)</td>
<td>12</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Pass General certificate of education (GCE) Advanced level (A/L)</td>
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<td>6</td>
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<tr>
<td>Tertiary education</td>
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<td>0</td>
</tr>
<tr>
<td>Average household size (No.)</td>
<td>3.9</td>
<td>3.8</td>
<td>4</td>
</tr>
<tr>
<td><strong>Household income of the respondent (Rs/ year)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;300,000</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>200,001- 300,000</td>
<td>6</td>
<td>13</td>
<td>0</td>
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<tr>
<td>100,001- 200,000</td>
<td>9</td>
<td>19</td>
<td>0</td>
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<tr>
<td>50,000- 100,000</td>
<td>25</td>
<td>25</td>
<td>26</td>
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<tr>
<td>&lt; 50,000</td>
<td>60</td>
<td>44</td>
<td>74</td>
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<tr>
<td>Women is the main income earner of the family</td>
<td>13</td>
<td>6</td>
<td>20</td>
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<tr>
<td><strong>Household income of the respondent from fishing</strong></td>
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<td></td>
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<tr>
<td>100%</td>
<td>36</td>
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<tr>
<td>50-99 %</td>
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<td>25</td>
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<tr>
<td>1-49 %</td>
<td>19</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>No contribution (%)</td>
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<td>20</td>
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<tr>
<td>Average years of fishing (year)</td>
<td>8.9</td>
<td>10.7</td>
<td>7.2</td>
</tr>
</tbody>
</table>
Figures

Figure 2. Training of farmers on the knowledge mobilization using Short Messaging Service
Figure 3. Schematic of operation of Mobile Knowledge Sharing System For Shrimp Farmers in Sri Lanka

Figure 4. Preparation of fingerlings for transportation from mini nurseries
Figure 5. Schematic of operation of Mobile Knowledge Sharing System For Inland Aquaculture (CBF) Farmers in Sri Lanka
Figure 6. Lengthwise monthly growth increase at four culture sites in Puttalam Lagoon

Figure 7. Spatfall in community farm locations in Puttalam Lagoon. Peaks indicate optimum timing for seed collection. Gangewadiya has several sites for collection with one major peak and two minor peaks. Kandakuliya farm can collect seed during the May-June period.
Figure 8. Schematic of operation of Mobile Knowledge Sharing System For Coastal Mollusk Aquaculture

Data from Growing & Seed Sites – Water Quality, Oyster production and condition, spatfall prediction, HABS, Rainfall, Coastal mapping GIS, Training and knowledge resources. Aggregated on web platform.
Figure 9. Governance structure for co-management of seasonal reservoirs for culture based fishery in NWP.

Figure 10. Culture based fish production in homestead ponds
Figure 11. Oyster culture system in development for Sri Lanka.

Figure 12. Women from Sangarapuram in Eastern Province using PRA tools to articulate their views.
Figure 13. From days in production and shrimp size at harvest, average daily gain (ADG) was calculated which is recorded in grams per shrimp per day. For 2014 ADG 0.21 was grams vs .19 grams for 2013.