

Final Technical Report

Promoting rural income from sustainable aquaculture through social learning in Sri Lanka

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Study carried out in Sri Lanka with emphasis on Northwest Province and Eastern Province, and in Canada at the University of Calgary and Centre for Coastal Health, Nanaimo, BC

Collaborating Institutions

- Wayamba University of Sri Lanka – Faculty of Livestock Fisheries and Nutrition
- University of Calgary – Faculty of Veterinary Medicine

Participating Institutions and other Project Partners

- North Western Provincial Council - Ministry of Road Development, Electricity, Housing & Construction, and Fisheries
- Eastern University of Sri Lanka -
- Eastern Provincial Council Ministry of Agriculture, Livestock Development, Rural Industries and Fisheries
- National Aquatic Resources Research and Development Agency, Sri Lanka
- Small Fishers Federation, Sri Lanka

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List of Abbreviations

BMP – Better Management Practices

CBF – Culture Based Fisheries

EP(C)- Eastern Province (Council)

EUSL – Eastern University Sri Lanka

ICT – Information and Communication Technology

KMT – Knowledge Management Technology

MCDA – Multi-Criteria Decision Analysis

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)

SLADA - Sri Lanka Aquaculture Development Alliance

SMS – Short Message Service

WUSL – Wayamba University of Sri Lanka

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I. Executive Summary

The government of Sri Lanka is viewing aquaculture expansion as a means to foster rural development for poverty reduction and income stabilization – both of which are critical for food security. With the end of the civil conflict, new areas have opened up for aquaculture development. Refugees from war torn areas and other rural poor are benefiting from aquaculture. The purpose of this project was to provide evidence for facilitating and enabling change towards implementing sustainable practices that would provide human development benefits from the growth of aquaculture in Sri Lanka. Our goal was to help identify strategic priorities to promote sustainable aquaculture development and build knowledge-based capacity for farm-level practices and local, regional and national policies. Lack of knowledge and poor knowledge connectivity rather than resource or technology limitations were the principle impediments to implementation of practices and policy. This research focused on how farmers, government decision makers, and academics used and shared knowledge and how strategic insights into enablers and impediments to knowledge mobilization could open pathways to promote sustainable rural aquaculture. Multiple approaches and methods were used: scoping and systematic literature reviews; policy review; surveys of farmer and farm households; on-farm observational studies; multi-criteria decision analysis; pilot projects in new methods of aquaculture for smallholder farmers; application of models for selecting production sites; network analysis; and knowledge mobilization interventions.

A literature review of the promise of aquaculture to achieve human development goals revealed a mixed experience, which in part reflected a lack of critical assessment, different approaches to assessment (for example, private sector versus development agency supported, and shrimp versus freshwater fish) and variation in the outcomes measured. Overall, 60% of papers reported positive benefits on human development outcomes, with more positive reports for freshwater finfish aquaculture than for shrimp farming. This international experience was supplemented by undertaking a survey of 225 shrimp farming households in the NWP and Eastern Province (EP), finding that 60-80% of the households declared themselves food secure (varying by province and by accounts made by men versus women). There were more food insecure households in the NWP than in the EP. For the most part, shrimp farming enhanced food security by providing income rather than contributing directly to food for household consumption. Work with 11 communities in the NWP involved in enhancing fish production from seasonal reservoirs addressed constraints in optimizing stocking of fingerlings and demonstrated that local fish availability as well as supplying wider local markets can contribute to food security as well as rural income. The oyster production pilot project with a community of 35 families in Puttalam Lagoon demonstrated significant potential to generate local income for coastal communities faced with a declining capture fishery resource. The project's work with communities conducting lobster fishery showed considerable income promise to shift toward "fattening" of undersize animals and eventually to full culture. Small scale ornamental fish farming has also been developed in Sri Lanka with significant contributions to rural income. Aquaculture in Sri Lanka is, therefore, showing the promise for rural development.

Perhaps the most important insight of the project was the significant role of fish and shrimp diseases as a prevailing source of instability in production and farm failure. This was most intensely examined in the shrimp industry and this discovery informed much of the subsequent project work. The lack of capacity to assess, diagnose, manage and prevent diseases was common across all sectors of aquaculture in Sri Lanka. Inability to control disease and disincentives to implement proper practices lead to shrimp farmers feeling disempowered to control the fate of their farm and causes significant farm-level instability in production. Hence interventions must address this as a priority area in shrimp farming. Though less directly impacted by disease at present, the expansion of seasonal reservoirs for culture based fisheries (CBF) requires greater consideration for fish and ecosystem health. Models for selecting

reservoirs and optimizing stocking to minimize negative impacts and improve yields were explored with communities in the NWP.

Knowledge sources and expertise were poorly connected, limiting the diffusion to farmers of knowledge on techniques, structures, and strategies for sustainable production. Regions for new aquaculture development, like the EP, were disconnected from the experience in the NWP, which has a longer history of aquaculture. Farmers relied largely on neighbours and other farmers rather than government sources and universities. Few farmers and industry members had formal aquaculture education, an important factor since farmers with some formal education tended to report more sustainable practices. Ongoing analysis is examining whether farmers with larger social networks also reported more sustainable practices. Lack of trusting relationships and market pressures created conflicting forces that prevented farmers from adopting better management practices (BMP) intended to help them survive a production cycle. Project work using participatory BMP development and enhanced knowledge connectivity by delivery of timely information for farmers through mobile SMS were able to overcome some of the barriers to knowledge sharing. Adaptive BMPs were developed and distributed to all of the shrimp farm societies in Sri Lanka, potentially reaching as many as 700 farmers. A pilot SMS trial with 60 farmers showed an increase in farmer awareness and self-efficacy to change practices and increase cooperative actions in response to emerging problems. These strategies are being adapted in the NWP and EP for application in other sectors of aquaculture, notably CBF, but also in emerging opportunities such as oyster farming.

Although embraced in principle, strategies for sustainable aquaculture were either non-existent or sparse in Sri Lankan legislation. No policy implementation, monitoring or enforcement plans existed. The shrimp industry has evolved under the constant barrage of disease, leading to unstable and crisis focussed organizational structures in the value chain. Strategies to more fully engage women in aquaculture were lacking. This was reflected in the small number of female-headed farms found in the surveys. The policy review identified key considerations for policy assessment and provided a gap analysis which was shared with government. Foundational research was undertaken to identify and assess a series of indicators for sustainable shrimp farming that can be adapted by industry and government to identify policy priorities and assess progress in meeting on-farm sustainability goals. Participatory policy development was not found to be the norm. This resulted in problems in adoption of BMPs for disease because of the lack of consideration of local constraints to implementing BMPs and lack of ownership by the farmers of the BMPs. A multi-stakeholder participatory process was conducted to examine a critical bottleneck for culture based fisheries (CBF). The process was able to find an agreeable set of development options for this sector in the EP and it was so successful that the NWP government plans to replicate the process in the NWP.

Aquaculture holds promise to be a reliable source of stable income and thus an underlying component of rural food security in Sri Lanka. But, that promise will not be realized until (1) An enabling policy environment, which emphasizes co-management, creates specific plans and actions focussed on fostering sustainable aquaculture; (2) the spectre of disease is addressed; and (3) knowledge is better connected and mobilized along the value chain with government and university. The lessons from developing the industry in the NWP must be more effectively synthesized and communicated to the EP and Northern Province as aquaculture is emerging in those sectors or the risk of repeating the failures and mistakes of the NWP are very real.

II. The Research Problem

Aquaculture has significant potential to contribute to food security, rural economic development, and poverty reduction, but at the same time struggles with sustainability and in many cases has been the source of social and environmental harm. Sri Lanka has recently emerged from a civil conflict affecting a large percentage of the most important areas with aquaculture development potential, particularly in coastal ecosystems of the Northern Province, Eastern Province, as well as the Northwestern Province through displacement with a significant number of Tamils settling in the Puttalam district. The promise that aquaculture can reduce the primary impediment to rural food security (i.e. low income) makes it an attractive development option, particularly in the North and East where new income sources are desperately needed.

To gain the advantages of aquaculture development, government policy and farm practices must avoid the pitfalls to date experienced in Sri Lanka and elsewhere that affect the short-medium term sustainability of this food production sector. This requires effective access and exchange of knowledge that leads to sustainable production. Farmer's knowledge of production and management options is critical to ensure individual's aquaculture operations are productive and sustainable. The Sri Lankan government recognizes the need to redesign and strengthen aquaculture extension services to increase the likelihood of developing sustainable human development benefits from this sector, but there is a lack of locally relevant research to inform program development. Supportive and effective policies, be they on-farm management policies or national policies, are critical to creating an enabling environment that will promote industry sustainable development and thus multiple aquaculture benefits beyond individual farms. Past experiences have shown disconnects between local needs and aquaculture policies. Assessing and linking policy within a local socio-ecological lens had not been undertaken before this project. If the factors that enable decision makers, including farmers, to put knowledge into action are known and if the conditions to actualize these factors are realizable within the local context and circumstances, impacts on aquaculture sustainability in terms of production, income and environmental impact can be expected.

The central hypothesis of the research was that enhancing the social knowledge links between farmers and between farmers, government, community and academics can remedy some of the obstacles impeding the use of management practices to foster sustainable aquaculture for rural development in Sri Lanka. The project focused on research to inform strategic development of a connected functional knowledge exchange system linking policy, development, extension and smallholder farmers, to underpin a Sri Lankan strategy to develop sustainable aquaculture for poverty reduction and food security. The project contributed to an area that remains a major gap in food security research- aquaculture. The emphasis of the project was knowledge *implementation research* - how knowledge can be mobilized to ensure informed actions are taken.

The project focussed on shrimp farming and inland culture based fisheries as examples of sectors with a few decades experience as well as nascent aquaculture activities (e.g. mollusc and lobster farms and ornamental fish farms) in order to find key variables affecting sustainability of the industry and hence its ability to provide rural income and access to food.

III. Progress Towards Milestones

Details on major projects related to each milestone

The following provides a narrative on progress of the activities linked to the milestones that were foundational to success. Additional outcomes are not described here due to space. Results for most are

described in Section IV. Summary of progress on specific milestones are presented in a table at the end of this section.

Analyze the current knowledge network used to inform practices:

Data about the knowledge and functional networks used by Sri Lankan smallholder shrimp farmers were collected in two ways. First, as part of a larger survey on indices of farm sustainability and management practices, farmers were queried about sources of management knowledge. The study included the EP and NWP involving 225 farmers. Data was collected from June through August, 2011. Overall knowledge degree was calculated by counting the number of unique individuals farmers named when prompted by a list of expert titles. Supplemental data from shrimp society leaders and industry experts was collected by in person interviews using a structured questionnaire evaluating what topics experts communicated about, with whom they communicated and what communication method they used. The results have been submitted to a peer-reviewed journal in a paper titled: “A comparison of knowledge networks for shrimp farming from the perspectives of smallholder shrimp farmers, shrimp-farmer society leaders and industry experts in Sri Lanka” and shared in scientific conferences and workshops.

Second, development and application of a set of guiding questions based on theories of social learning and behaviour change to gain insights into enablers and obstacles to BMP implementation on Sri Lankan shrimp farms was done. Concepts were reviewed in the literature on social learning and behaviour change within a food production and natural resource context to develop a framework to identify enablers and impediments to the implementation of BMPs. This framework was used in face-to-face interviews with key informants in the NWP and EP using an unstructured questionnaire. This was further supplemented by meetings with 13 sub-zone shrimp farmer societies to discuss local enablers and impediments to implementing BMPs. Clusters were also identified that facilitated BMP application and could be venues for sharing information and advocating for, or assisting with, BMP implementation. The results of this project are summarized in a paper titled: “Using theories of behaviour change as a framework to examine the implementation of disease better management practices on Sri Lankan shrimp farms” submitted to the journal *Development in Practice*. Lessons from both projects were shared at workshops and in fact sheets.

Early in the project a review of the Sri Lankan policy context for sustainable aquaculture was completed. Lacking a validated aquaculture policy evaluation tool, a framework was developed for policy evaluation based on three core concepts: 1) critical policy elements; 2) sustainable aquaculture goals; and 3) sustainable development principles. Results are presented in Section IV. Results of this review were presented to government in a technical report as well as in workshops. A fact sheet on this topic was prepared and a paper based on this work titled: “Does the national policy environment support development of sustainable freshwater ornamental fish aquaculture in Sri Lanka?” has been submitted for publication.

The examination of the role for women in Sri Lankan aquaculture is ongoing and the subject of part of Dr. J Wu’s PhD (estimated completion late 2013). She undertook specific targeted interviews with female aquaculture owners as well as examined differences in perceptions of food security between men and women on shrimp farms. Preliminary findings have been presented as scientific posters and in a fact sheet.

Status: These activities successfully meet this milestone.

Develop improved systems for government and industry to deliver knowledge:

It was important to systematically examine the case in support of/against a strategy of using aquaculture for human development to ensure Sri Lankan policy makers had an evidence-based foundation to advocate for/against its use for rural development. A scoping review was undertaken of the English language peer-reviewed literature (566 papers retrieved) to evaluate how the research community has examined the impacts of aquaculture on human health and development. The results are discussed below in Section IV and have been submitted as a peer-reviewed paper titled: “A scoping analysis of peer reviewed literature about linkages between aquaculture and human development outcomes.” A fact sheet summarizing the findings was made available to stakeholders and partners and results have been presented at scientific conferences.

The completion of an MSc by Dr. Trisha Westers within the project timeframe was a significant contribution to this milestone. Dr. Westers worked collaboratively with other team members in our survey of farmers in the NW and EP. She examined the implications of using different “lens” to measure sustainability and recognized early to add a 4th pillar (disease) to the usual 3-pillar approach. A comprehensive questionnaire consisting of approximately 200 questions was used for assessing shrimp farm status. The results of the questionnaire were compiled into indices for 18 indicators identified. These indices were verified using factor analysis, and used to identify potential obstacles to sustainable shrimp farming at both the national and regional scales. A composite index was created to facilitate analysis to highlight farms and/or regions that may be particularly unsustainable. A set of indices that can guide development of best management plans has been developed and can serve as a first step in development of policy monitoring indices. The outputs provide a baseline farm-level sustainability index to identify similarities and differences in farm-level sustainability between the more established NWP and the newly developing areas such as the EP. The results help inform strategies for assessing and supporting sustainable development, suggesting that strategies need to be targeted at a farm rather than regional level. Supplemental inquiries were made into farmer’s perceptions, demographics and sustainability status with respect to disease outcomes and BMP application (details in Section IV). Dr. Westers has been accepted into a PhD program (University of Guelph) and is dedicated to transforming her three chapters on sustainability and on BMP implementation into peer-reviewed papers in the next 4-6 months.

A series of meetings were held with each of the shrimp farm societies in the NWP and the EP to incorporate local knowledge of farming problems and issues, identify the most pressing risk factors, and analyze local environmental conditions. This provided the social and ecological insights to develop locally adapted BMPs that were more accessible and applicable to farmer’s situations.

The work on linking household food security and position in the knowledge network is ongoing. Delays in assembling the local team (interviewers and translators) to finish the network analysis delayed an association of food security with the knowledge network. Dr. Jessica Wu is analysing these data currently and aims to have the analysis complete in the next 3-5 months. Her interviews provided some insights into household food security (discussed below). She partnered with other team members, supplementing the farm survey tool with household food security assessments for this phase of the project.

Status: All data have been collected and analyses finished or underway to meet the expectations for this milestone; all elements of this milestone will be completed with the defence of Dr. Wu’s PhD in 2013.

Evaluate alternative means to connect people to exchange information and experiences to improve sustainable practices

The milestone experienced delays in implementation for two main reasons: (1) delayed fund transfers to WUSL and; (2) disease outbreaks in the shrimp industry. Progress in financial management and transfer of funds from the central government enabled WUSL to allocate funds by October 2012 to hire staff, purchase equipment, and contract services. Disease outbreaks and financial challenges facing the industry prevented implementation of the planned SMS trial according to the original project time lines. The establishment of a project steering committee in January 2012 comprised of members of the provincial council (Ministry of Fisheries), Shrimp Hatchery Association, Sri Lanka Aquaculture Development Alliance (SLADA), shrimp farm zonal leaders, Aquaculture Technologists Society (ATS), central government (National Aquatic Resources Research and Development Agency – NARA), and members of the research team was instrumental to launching the SMS project in the February 2012 production cycle. The research team modified the SMS trial design to accommodate these changes and focussed on assessing the additive value of mobile phone communications in extension connected with the implementation of locally adapted BMPs. We were able to obtain results from a trial extended with participants from all five zones rather than two, as was the initial plan.

The implementation of SMS trial was linked to the analysis of the knowledge network of the shrimp farming industry using social network analysis. The initial survey of 225 smallholder shrimp farmers, plus a second survey of 34 leaders of farmer organizations and 34 shrimp farming experts in the NWP and EP was used to examine how knowledge was accessed and shared (details of findings presented below). The trial was launched with two workshops with farmers and industry participants in February and March 2012 to provide orientation to the trial, identify critical information needs of the farmers, and identify high priority target for managing disease threats and improving production outcomes. A response team comprised of technical experts prepared and sent over 180 messages to farmers. A feed supply company was recruited to provide water quality analysis from a number of key intake sites as well as pond water quality data for use as real time environmental information to farmers. While we were unable to do our originally planned follow-up on impacts of SMS messaging on production, we were able to document that farmers used the system to make management decisions via a post trial evaluation, leave a legacy of extension material and provide sufficient material for a paper tentatively titled “Potential of mobile SMS to evaluate knowledge connectivity and improve shrimp health in Sri Lanka” (to be submitted for publication in April, 2013).

Multi Criteria Decision Analysis (MCDA) was another technique examined as a means to enhance knowledge connectivity. Through a peer reviewed literature search and expert consultation, a preliminary MCDA performance matrix was developed to identify existing and potential opportunities for seed to fingerling production systems (alternatives) and provide criteria which could be used to distinguish decision options. Overarching objectives for criteria decision making were “sustainable development”, “social learning”, and “food security”. Workshops were held to conduct the MCDA involving a participatory decision making process to identify preferred carp and tilapia fingerling production systems to support culture based fisheries in Batticaloa. Results are presented in Section IV. Our approach and outcomes were well received by policy makers and culture based fisheries stakeholders. The participatory nature of the MCDA provided an important opportunity for culture based fisheries community members and farmers to engage with each other and with provincial and national government agents involved in policy making and planning. A MCDA “how-to” manual was prepared and presented to stakeholders. It has defined the process for ranking and weighing of preferences for policy trade-offs in relation to sustainability. A paper titled; “Using Multi-Criteria Decision Analysis to identify fish fingerling production options for culture based fisheries in Sri Lanka” has been submitted for publication.

Status: This milestone has met its goal of exploring and assessing a novel means to enhance connectivity as well as to inform new extension strategies.

Foster new capacity for research and support for sustainable aquaculture:

The MCDA had two objectives. The first, described above, was to test and assess this approach as a means to enhance connectivity between multiple stakeholders and knowledge sources to affect more transparent and locally relevant decision-making. The second was to address a pressing limitation to the expansion of culture-based fisheries. Our preliminary interviews with experts and stakeholders found that production of fingerlings was a production bottleneck limiting local access to an aquatic protein and income source. The MCDA produced a prioritized list of preference options for improved fingerling production and access that has buy-in from the participants. The outcomes were ground-truthed by conducting subsequent informal interviews with stakeholders to ensure the products of the MCDA met their priorities. The process was so effective that the NWP Council aims to replicate it in its jurisdiction. The results were provided to stakeholders and decision makers at the final dissemination workshop, in person to the NWP Fisheries Secretary and the EP Fisheries Director, and will be forwarded to participants as the final scientific paper.

WUSL researchers developed a decision support model for selecting optimal reservoirs for CBF. Model development preceded project implementation. This project allowed the researchers to take this model to communities and make them aware of this tool. This work touched over 700 community members in 11 communities, allowing the team to not only train many community members in CBF but also to document the variation in governance of CBF (which varies between communities) seeking markers of success in social structure and decision making features.

WUSL researchers worked with communities to develop new methods, policies and markets for oyster and lobster aquaculture. Oysters are not traditionally consumed foods, but there is a growing market for the tourist trade. A pilot project was conducted to investigate parameters for culture methods as well as develop market relations for farmers in the NWP and the Northern Province. For lobster culture, new policies were created to regulate harvest size and thus support a lobster fattening industry (see ASF outcomes for further details). These projects are examples of `classic` animal science research that have helped WUSL build relationships with communities and provide production relevant research and expertise. These aquaculture development projects have provided data for 1 PhD, 1MPhil and 2 undergraduate research projects at WUSL. One MPhil and 1 undergraduate trainee projects provided additional information to inform local BMP development.

Canadian trainees (1PhD, 1MSc, 1 post-doctoral fellow and 1 professional skills retraining) were directly involved in this work. Lessons from the research were routinely integrated into a course at the University of Calgary on animal, health and society interactions. Faculty at WUSL were provided with time to work on this project in partnership with University of Calgary, learning new research skills and perspectives. University of Calgary faculty were brought in as graduate student supervisors, gaining new insights into food security and global health research via mentorship by the project PI's and senior faculty

Status: The milestone was met through implementation of new opportunities for community aquaculture, contributions to local decision making for aquaculture development, and inclusion of trainees and junior faculty.

Table 1: Summary of progress on detailed milestone activities:

Milestone Activities	Status	Comments
Baseline of smallholder aquaculturists involved in knowledge studies and interventions	Completed	Used in farmer survey, KMT intervention and MCDA
Inventory and select venues and mechanisms for KMT	Completed	As above
Indicators selected to assess productivity, income and food security	Completed	Used in farm level surveys and included in MCDA
Policy gap analysis	Completed	
Gender and poverty analysis	Partially completed – expected completion late 2013	Assessment of role of women in aquaculture and household food security assessment in analysis phase for PhD project
Knowledge flow network map	Completed	
Sustainability audit tool	Completed	
Repeat assessment of KMT strategy and measure change	Modified to met revised time lines (Completed)	Post implementation assessment of utility conducted
Rank and weigh preferences for policy trade-offs (MCDA)	Completed	
Disseminate MCDA policy results/recommendations	Completed	
Analysis of KMT results against baseline and gender equity	Modified to met revised time lines (Completed)	Post implementation assessment of KMT utility conducted; qualitative study using social learning theory on BMP implementation
Report of MCDA policy options	Completed	
Conduct MCDA and communicate implications	Completed	
Policy, technical briefs and extension materials	Completed with more ongoing	Ongoing translation of some notes, publications under review and in preparation

IV. Synthesis of Research Results

Research Objectives

The primary project objective was to improve aquaculture in Sri Lanka for economic diversification and food production through innovations in the delivery of knowledge and information to smallholders emerging from a conflict situation. Three specific research objectives were formulated to achieve the primary goal.

1. Conduct a gender sensitive analysis of the current knowledge network used to inform aquaculture practices and develop improved delivery systems for government programs and policies.
2. Evaluate alternative means to connect people to exchange information and experiences that will inform practices necessary for sustainable development in the aquaculture sector.

3. Foster new and sustainable capacities for ongoing research and support of sustainable aquaculture through training, collaboration and production of extension materials

Research activities directed toward these objectives were implemented by focusing on shrimp farming and culture based fisheries as sectors with history of development and which contribute most to the country's aquaculture production. The project's activity in emerging opportunities for growth of aquaculture, such as oyster culture and lobster and crab "fattening" provided evidence and strategies for culture practices as well as policy and management.

A number of research tools were used to obtain data and develop and implement interventions in Sri Lanka aquaculture:

- A scoping literature review of 566 English language peer-reviewed papers was carried out to examine the impacts of aquaculture on human well-being and food security globally, with implications for aquaculture development in Sri Lanka.
- A detailed survey of shrimp 225 farming households in the Puttalm and Batticaloa districts, with female and male members interviewed separately, on their farming practices, income and expenses, housing, food security, and how and with whom farmers communicate on shrimp farming.
- In depth interviews were done with all female shrimp farm owners focusing on their experience in the industry. Only five women were identified as shrimp farm owners in Sri Lanka, all in the Puttalam district, accounting for less than 1% of shrimp farms in Sri Lanka.
- A baseline farm-level sustainability index was created to identify similarities and differences in farm-level sustainability between the more established NWP and the newly developing EP, and to explore the implications of those similarities and differences.
- Social network analysis was utilized to examine how shrimp farmers shared knowledge with experts and organizations in the cluster and value chain. Data was obtained from the primary survey of 225 smallholder shrimp farmers and subsequent interviews with 34 leaders of farmer organizations and 34 shrimp farming experts from in the NWP and EP.
- Workshops and farm society meetings were held with 13 different sub-zone shrimp farm societies to gather farmer, industry leader, and local knowledge on constraints and issues affecting implementation of BMPs. Local perceptions were integrated with data collected from the surveys of 225 farms (see above) and used to review existing BMPs. Gaps or additions were addressed in existing BMPs to help tailor BMPs to local needs and conditions. A new BMP manual, produced in local language was created and distributed.
- A purposive sample of 60 farmers, including the 5 zonal leaders, participated in a trial to evaluate the effectiveness of mobile SMS as a means of enhancing knowledge connectivity. An exit survey was conducted to determine perception of value and response to information.
- An investigation of the potential for enhancing and optimizing fish production in seasonal reservoirs was carried out in eleven communities in the NWP. Stocking trials with hatchery-reared fingerlings of catla, rohu, genetically improved farm tilapia (GIFT), and common carp and post-harvest data were collected and analysed.
- A survey was conducted with the 11 communities involved in the culture-based fisheries stocking trials to gather data regarding knowledge sharing mechanisms, communication among different institutions, different management strategies used, and factors affecting the sustainability.
- Multi-criteria decision analysis (MCDA) was used as a participatory decision making process to identify preferred carp and tilapia fingerling production systems to support culture based fisheries in Batticaloa. Seven alternative production systems were compared and ranked according to their perceived performance and efficiency to reach sustainable development and food security objectives.

- A pilot project in oyster culture was carried out with 35 families in the Kala-oya estuary of the Puttalam Lagoon area to explore the potential to initiate new opportunities for communities reliant on diminishing capture fisheries and develop market channels for products.
- An investigation of policy and management requirements to develop the lobster “fattening”, i.e. on-growing of small lobsters to attain market size, was conducted in EP and NWP.

A summary of the research carried out in the project to achieve the objectives is summarized in Table 2. The researcher responsible for each sub-projects is identified in brackets following the description. (A full list and details of team members can be seen in Annex 1).

Table 2: Summary of projects conducted to achieve research objectives

Research Objectives	Sub-projects conducted to achieve objectives (Lead research team member[s])
OB 1a. Analyze the current knowledge network used to inform practices	<ol style="list-style-type: none"> 1. Sri Lanka aquaculture policy review to determine if there is an enabling environment to support knowledge flow and industry development. (J. Dawson) 2. Farm survey and analysis of sustainability in relation to BMPs and food security (T. Westers) 3. Network analysis of information flow to identify connectivity and targets for improvement (T. Burns) 4. Assess perceptions on obstacles and enablers for BMP implementation to inform extension strategies (T. DeJager) 5. Examine the role for women in shrimp farming to determine the need to improve their connection with benefits from aquaculture (T.Wu)
OB 1b. Developed improved systems for government and industry to deliver knowledge	<ol style="list-style-type: none"> 1. Associate better management practice (BMP) use with reported disease outcomes to guide improvements in BMPs (S Jayakody) 2. Assess the association of shrimp farm household food security and knowledge connectivity (J. Wu) 3. Develop and apply farm-level sustainable aquaculture indicators (T. Westers) 4. Develop locally adapted BMPs based on participatory process (J.M.P.K. Jayasinghe) 5. Synthesis of evidence for aquaculture as a human development tool to review if aquaculture development is a wise strategy (T. Burns)
OB 2. Evaluate alternative means to connect people to exchange information and experiences to improve sustainable practices	<ol style="list-style-type: none"> 1. Test multi-criteria decision analysis (MCDA) as a participatory policy development (J. Dawson / W.M.H.K. Wijenayake) 2. Use of mobile phones and SMS to enhance real time farmer-to-farmer and expert knowledge connections (T. DeJager)
OB 3. Foster new capacity for research and support for sustainable aquaculture	<ol style="list-style-type: none"> 1. Pilot alternative production systems in oysters and lobsters new local aquaculture development (W.M.T.B. Wanninayake; Sunil Jayakody) 2. Develop models to identify good sites optimize stocking for culture-based fisheries development (W.M.H.K. Wijenayake) 3. Support training of new highly qualified personnel in Sri Lanka and Canada 4. Identify options to remove a production bottleneck from culture-based fisheries through MCDA (J. Dawson)

The project carried out its research is study sites in the NWP and EP (Figure 1). The shrimp farming areas of Sri Lanka are located in the Puttalam District where there are an estimated 650 farms and in the Batticaloa area in the EP where a cluster of 65 farmers are located. Culture based fisheries study sites were located in the Kurunagela and Puttalam districts of NWP and the Batticaloa district of EP. The oyster culture pilot project was primarily conducted in Kala-Oya estuary of the Puttalam lagoon in NWP.

Promoting Rural Income from Sustainable Aquaculture
through Social Learning in Sri Lanka Map

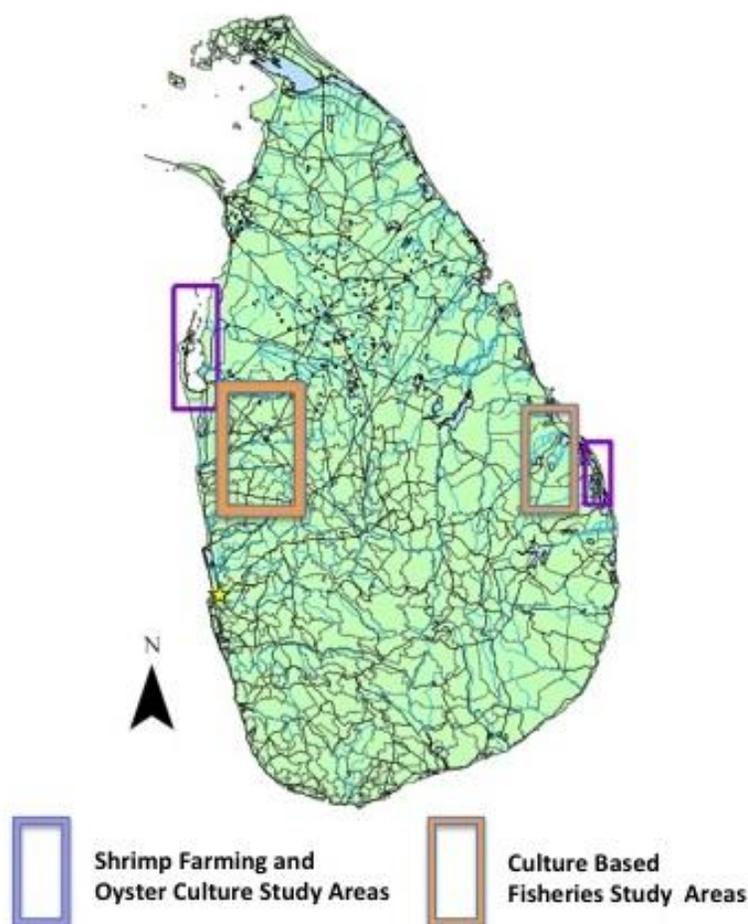


Figure 1: Map of Sri Lanka showing project study areas for shrimp farming, culture based fisheries and oyster culture.

The research conducted in this project provides evidence to support selection of priorities for aquaculture development, has created a more enabling environment for the industry by fostering new connections and has strengthened support for and attitudes toward collaboration and co-management. Three significant outcomes emerged after we examined research outcomes *in toto*:

1. The successful expansion of aquaculture in the north and east and creation of a sustainable industry for rural development will require systematic integrated development plans and policy.

Sri Lanka lacks a specific policy for aquaculture development and management. The reliance on fisheries legislation and reactive program development in response to crisis has resulted in conflicts and/or lack of clarity in goals and responsibilities, which in turn result in management inefficiencies and risks replicating past mistakes as the industry develops in new areas. Opportunities for co-management, linking national, provincial, and industry stakeholders were under-developed and venues and mechanisms for participatory decision-making were lacking.

2. The rural development and food security advantages of aquaculture will not be realized until animal disease can be more effectively managed.

Health management is the primary constraint for sustainable aquaculture development in Sri Lanka. The shrimp sector is constrained by lack of access to health management expertise and services, limiting the ability of farmers to effectively implement practices necessary to avoid disease and survive a production cycle. The NWP continues to be devastated by disease but the EP has not yet been affected. However, farmers in the EP are not acting proactively to protect against disease, thus increasing their vulnerability. The lack of diagnostic support required ornamental fish farmers to use harmful chemicals (causing economic loss and environmental impact) on an ongoing basis in the hopes of controlling disease and parasites. The role of disease in the culture based fishery is unknown and has been unexamined due to lack of capacity, but, based on international experience, can be expected to be causing losses of food and protein for the community. Management practices for disease prevention and control have not benefited from on-farm evaluation or consideration of the reality of smallholder farm capacity.

3. There is a greater need to connect existing expertise and information sources than to invest in creating new expertise and information.

Significant gaps and breakdowns in the flow of information between farmers, academics and government have created inefficiencies in use of current knowledge and capacity. The transitory nature of key knowledge brokers in government, lack of trust, and lack of history of farm level knowledge extension have resulted in many farmers being isolated and thus not benefiting from the expertise and experience of others. A lack of connection between experienced farmers in the NWP and new farmers in the EP or north increases the likelihood that aquaculture development in new areas will suffer the adverse impacts experienced when the industry developed in the NWP. This project helped to identify key opportunities to improve knowledge flow and created knowledge mobilization tools and collaborative process to better connect farmers with the knowledge they need to succeed.

Implications of the Major Findings

Connectivity

Through analysis of knowledge sharing relationships, we showed that Sri Lankan aquaculture was hampered by gaps and breakdowns in social knowledge networks. As the ultimate knowledge end users, knowledge is most critical for farmers but farmers tended to have the weakest links to knowledge sources they need to make management decisions. Farmers relied primarily on other farmers for knowledge. Lack of trust and conflicting market forces weakened the knowledge connection with some key industry knowledge brokers. The transitoriness of government agents and the lack of a capacity for and history of farm extension services through colleges and universities further isolated farmers. **Therefore building bridges between the stakeholder groups in the industry “ecosystem”, with farmers as the first focus, by introducing mechanisms to establish and maintain knowledge sharing connections should be a strategic priority.** With network disconnects, it is very likely that one group of farmers is getting different information than other farmers (especially when we compare the NWP, EP and Northern Province). We found relatively low cost means of bringing people together for decision making that can yield rapid improvements in knowledge sharing and planning. Our MCDA connected EP and NWP farmers, government and academics to collaborate on defining criteria and selecting options for fingerling production for culture based fisheries in the EP. Our SMS network effectively communicated ongoing variability of conditions and disease related information and built a bridge between stakeholders that enhanced responsiveness to disease.

Disease

Disease is causing considerable losses to many farmers every production cycle and unless the occurrence of disease outbreaks is tackled directly and significantly, first and foremost in the shrimp industry, development and growth cannot occur in a sustainable manner. We showed that health is itself was a pillar of sustainability for the industry but there remains several social disincentives to implement disease management plans despite the recognition of its pervasive threat to farm sustainability. In the EP, there is a somewhat laissez faire attitude towards disease given its lack of detected impact to date in this relatively new area for industry development. The lack of connection to the experience in the NWP and lack of access to international experience reduces disease preparedness in the EP and North. Similarly, the culture-base fisheries are not examining the role for disease, in contradiction to international experience, and thus are discounting disease impacts. **Therefore, the critical shortage of capacity and expertise to provide animal health services and undertake research to identify better management practices applicable to local socio-ecological constraints is an urgent development need.** Farmers and consultants need access to the best knowledge and information from within and external to Sri Lanka in a timely manner to avoid repeating past devastating outbreaks and to reduce the high rate of economic failure due to existing problems. We conducted the first on-farm examination of BMP impacts and identified key obstacles to implementing disease BMPs. The project's participatory development of adaptive BMPs helped bring farmers to a common understanding as well as brought provincial government and industry supplier into dialogue with farmers.

Common plan for development

While sustainable development of aquaculture for rural poverty reduction was an oft-stated goal, there was no central plan for its development. Explicit policy plans and actions were absent, making it difficult to link policy goals with decision-making. The industry development has historically been reactive to crises and opportunities rather than strategically unfolding. Decision-making has been centralized, leading to some practices and requirements that are insensitivity to local social and ecological realities. There was no explicit short or long term vision for sustainable aquaculture development: This has prevented the development of consistent rules and regulations across sectors and geographic regions. The lack of a coordinated approach has resulted in (i) inconsistencies and gaps in combating major impediments to growth and sustainability (e.g. disease), (ii) industry expansion happening almost de novo in new areas as opposed being built from past lessons, (iii) lack of trust and acceptance of required management activities, and (iv) different support and attention to different sectors. **Therefore: Co-management – with key stakeholders working towards the same goals and each playing their appropriate role – is a reasonable and necessary step in Sri Lanka's aquaculture development to ensure a strategic approach to developing locally acceptable and effective plans to use this sector for rural development and food security.** A knowledge mobilization focus can unify the players to cooperate and create the structures needed for moving toward co-management. Cross-stakeholder cooperation on the project implementation and management activities has led to formation of new cooperative multi-stakeholder mechanisms that can now be used as the foundation for developing stronger and more enduring structures for co-management – encompassing knowledge mobilization as well as governance and regulatory functions. Our research identified policy priorities and created new structures to support co-management and shared decision-making that can be applied in the future.

This project was focused on the theme of “facilitating and enabling change” in stakeholder relationships and knowledge mobilization such that future development and performance of aquaculture in Sri Lanka yields improvements in sustainable income for rural communities engaged in aquaculture production. The primary research issues, as outlined in the Memorandum of Grant Conditions (MGC),

were explored by a series of interrelated activities as illustrated in the following table. Details of achievement of milestones and challenges encountered are described in this section and Section IV and illustrate the project’s success in addressing all project milestones.

V. Research Highlights Supporting our Key Findings

What does the global scientific literature reveal about aquaculture’s impacts on human wellbeing and food security?

A scoping literature review of 566 English language peer-reviewed papers was undertaken to examine the impacts of aquaculture on human wellbeing and food security globally. Sri Lanka was grossly under-represented in the literature. The literature was unable to provide consensus for or against aquaculture as a tool for human development. This is because there were inadequate numbers of studies done within the same context (e.g. county, species, and production type) with similar methods examining the same outcomes to provide an adequate case series to confidently determine impacts. While the challenge of evaluating and integrating research is not unique to aquaculture, the problem seemed especially acute in this case due to the lack of consistent measurements and widely varying context for assessing the contributions of aquaculture. This study suggests that context is a very important determinant of aquaculture impacts and that it would be inappropriate to lump all production types and settings together (Fig. 2). Nevertheless, the review provided some insights into research into aquaculture and human development including: (1) Local participatory approaches are likely to be more useful planning tools than international or regional studies; (2) Local ownership and extensive production are more often associated with positive outcomes when compared to non-local ownership and intensive production; (3) Within freshwater finfish aquaculture, polyculture of multiple aquatic species and integrated rice fish and rice-fish-crop farming are more often associated with positive impacts and (4) Polyculture and integrated farming for shrimp aquaculture appears to have more positive impacts than monoculture.

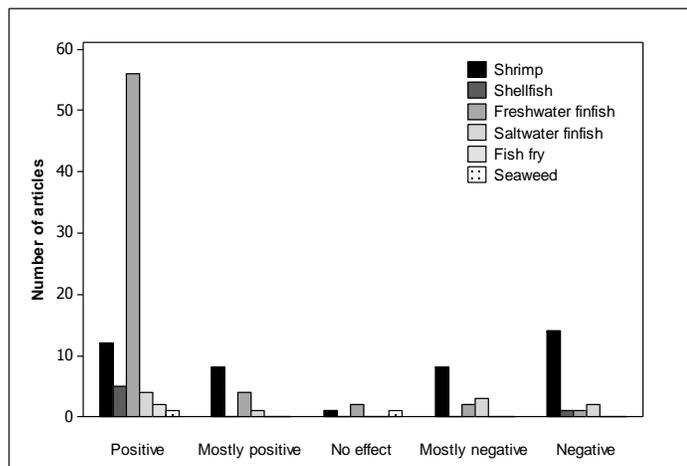


Figure 2: Stated impact of aquaculture on human health and development from peer-reviewed papers.

Food Security in the Sri Lankan Shrimp Farming Industry

Between June and August, 2011, shrimp farming household members were interviewed about their farming practices, income and expenses, housing, food security and who farmer’s talk to regarding shrimp farming. Farms were surveyed in the Puttalam district of NWP (n=165) and in the Batticaloa

district EP (n=60). The majority of shrimp farming households were food secure in Sri Lanka, but there was higher prevalence of food insecurity in the Puttalam district. (Figure 2)

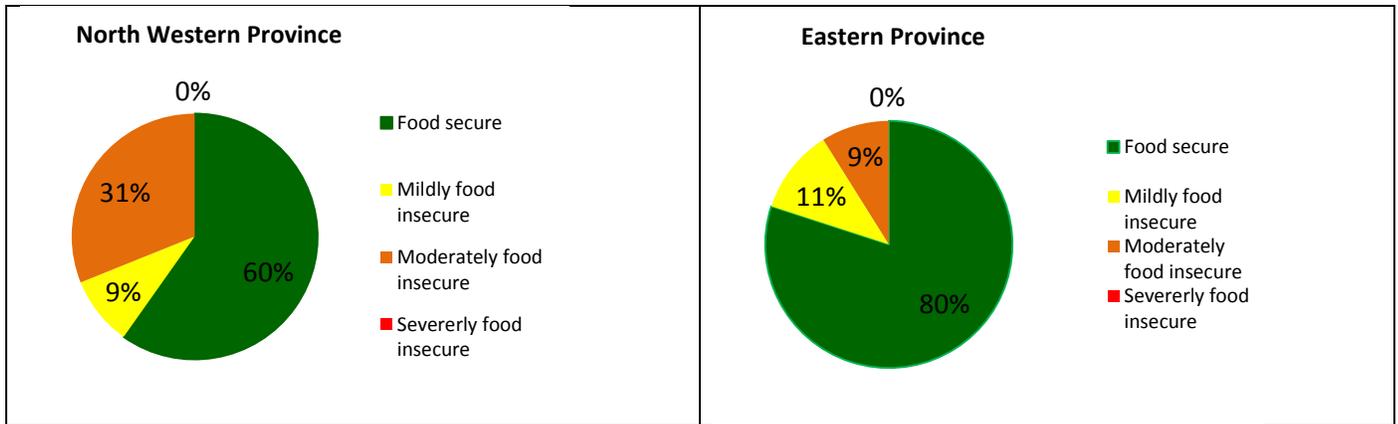


Figure 3: Food Insecurity in shrimp farming households in NWP and EP

Men generally ranked their household more food secure than did their wife. Women were considered to be the gatekeepers of the household and had increased awareness of food preparation, food supplies, and food intake in the household. Therefore, women may be better positioned to determine the food security status of households. There was higher prevalence of food insecurity in the Puttalam district and therefore efforts should be focused on these farmers. Shrimp farming contributed to household food security by increased income, not by increasing household food supplies. Approximately 1% of shrimp harvested was consumed in the household due to the high economic value from the sales of shrimp. Shrimp farming appears to be an aquaculture sector associated with high levels of food security and thus should be considered as a prime candidate for aquaculture development planning to enhance rural food security.

Women in the Sri Lankan shrimp farming industry (preliminary results)

Data were collected from the surveys of shrimp farming households and from interviews with female shrimp farm owners that focused on their experience as shrimp farm owners. Only five women were identified as shrimp farm owners in Sri Lanka, all in the Puttalam district, accounting for less than 1% of shrimp farms in Sri Lanka. In the Batticaloa district, no shrimp farm owners were women, primarily due to the ethnicity and religion of the villages where shrimp farms were located. The majority of women shrimp farm owners received outside funding and support from overseas, either from their own previous work overseas, or investments from spouses and relatives working overseas. Women who owned shrimp farms faced typical problems in the shrimp farming industry (e.g. credit and disease problems). Women also discussed specific difficulties with jealousy and not receiving fair treatment, as well as the amount of labour required in running a shrimp farm. Female spouses of shrimp farm owners were primarily involved in feeding, guarding, and cleaning the ponds (Puttalam district: 35.89%, 25.2%, and 23.7% respectively). In the Batticaloa district, most female spouses of shrimp farm owners reported they were not involved in the farm (71.4%). A small proportion of hired workers on farms were women. More conducive and supportive conditions are needed to increase participation of women in the shrimp farming. Strategies will need to be developed before female-headed households have access to the full benefits of farm ownership.

Lessons from measuring sustainable farming practices of smallholder shrimp farms in the North Western and Eastern Provinces of Sri Lanka

The survey of 225 smallholder shrimp farms conducted in both the NWP and EP of Sri Lanka in June – September 2011 informed this project. ‘Smallholder’ was defined as a farm with five or fewer ponds, with the farmer actively working on the farm and no delegation of decision-making to another person. A baseline farm-level sustainability index was created, to identify similarities and differences in farm-level sustainability between the more established NWP and the newly developing EP, and to explore the implications of those similarities and differences. Similar themes were gleaned from both the content-based and system-based sustainability frameworks. Farms in the NWP were acting in a manner more consistent with our expectation of higher sustainability than farms in the EP. Disease was a driving factor for farms that could not be sustained. The EP had yet to experience the disease impacts seen in the NWP. It was surprising that farms in the NWP had significantly higher overall sustainability scores than farms in the EP, as the NWP has been plagued disease since the 1990s. Disease may have been a stimulus for the NWP farmers remaining in the industry to take steps to ensure more sustainable livelihoods, which was subsequently reflected in their sustainability scores.

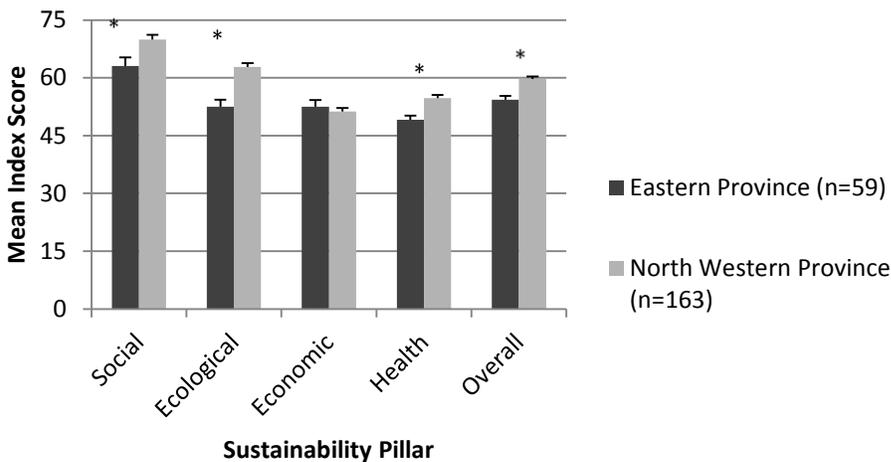


Figure 4: Mean index scores for the EP and NWP for each of the sustainability pillar sub-indices, and the overall sustainability index, for a framework based on the Sustainability Assessment of Farming and the Environment (SAFE) model. * denotes significance at $p < 0.05$.

Farms in the two provinces had similar scores in the economic sub-index of the Sustainability Assessment of Farming and the Environment (SAFE) model. Farms in the NWP scored significantly higher in the social, ecological, and health sub-indices. The majority of farmers in both provinces had at least one additional income source and felt they had enough money to pay off debts and live comfortably. Farmers in the EP had higher yields and were more likely to make a profit than farmers in the NWP, likely due to less mortality from disease. Farmers in the NWP reported less debt, more options for selling shrimp, and greater access to training. The higher social scores in the NWP were surprising, given that farms in the EP reported a greater sense of community, as measured by knowledge and sharing with neighbours. Farmers in the EP were less sustainable in almost all aspects of the ecological sub-index: less than half of the farmers in the EP reported following more than 50% of ecological best management practices compared with 72% in the NWP. To effectively tailor policy and education programs to specific areas, it is important to identify geographic and demographic factors that influence overall sustainability scores. Farm-level sustainability scores did not cluster by geographical region, implying that regional

environmental conditions may not influence farm-level sustainability scores. Farmers with more land (≥ 1.78 hectares) tended to have higher sustainability scores than farmers with smaller amounts of land (< 1.78 hectares). Farmers who had completed high school exams or higher education were more likely to have higher sustainability scores as compared with less educated farmers. Farm density was positively associated with sustainability scores in the EP (perhaps reflecting social learning) and negatively associated with sustainability scores in the NWP (likely reflecting environmental cross-contamination).

Identifying best management practices associated with reduced disease prevalence on smallholder shrimp farms in the North Western Province of Sri Lanka

This project extracted data from the survey of 225 smallholder shrimp farms conducted in both the NWP and EP in June – September 2011. Farmers who implemented a greater number of BMPs (> 27) were significantly less likely to report white spot-like disease than farmers who implemented fewer BMPs (< 24). In the NWP, 53% of farmers reported disease that likely led to reduced income from lower yields, but, only 43% followed more than 50% of measured biosecurity practices. In the EP, 51% of smallholder farmers in this area follow more than 50% of best management practices. Access to training was a limiting factor in both the NWP and EP. Only 35-47% of farmers reported having good-excellent knowledge. Four variables were found to be significantly associated with decreased disease prevalence in a multivariable model: presence of a water reservoir, non-membership in a shrimp society, the perception that an ideal amount of post-larvae was stocked, and geographic location. Additional significant variables from univariate analysis included: checking feed trays to determine the quantity of feed to use; appropriate pond aeration; record keeping; treatment of waste water and no release of diseased shrimp into the lagoon. Education and training courses should be implemented and encouraged to enable farmers to gain technical knowledge on culturing shrimp as well as improve access to experts in the shrimp farming industry. Biosecurity and disease best management practices should be a priority. Areas new to shrimp farming should be equally prepared to deal with disease due to its significant impact on farm sustainability.

Using network analysis on how shrimp farmers access knowledge about shrimp farming

Network analysis was used to examine how 225 smallholder shrimp farmers, 34 leaders of farmer organizations and 34 shrimp farming experts in the NWP and EP accessed and shared knowledge. The most common method farmers used to seek information about shrimp farming was in person (73%), followed by mobile phone calling (16%), land phone calling (8%) and mobile phone text messaging (3%). Farmers named a median of two people as experts with whom they might discuss problems on their shrimp farm. When facing a problem associated with poor shrimp growth or increased shrimp mortality, this decreased to one person. Within the NWP, 124/165 farmers had ties to the expert network that included experts in government, input supply companies and hatcheries, while others ($n=41$) had ties only to farmer peers who they perceived as experts. Leaders spent the majority of their time in administration, followed by providing information to farmers directly and indirectly. Leaders ranked disease, followed by post larvae quality as the most common issue they discussed with farmers and experts. Most leaders communicated with farmers and experts in person (100%) and by mobile phone using voice (100%), with fewer using letters (24%), text messages (21%) or land phone (12%). Leaders did not use email to communicate. Shrimp farmers and shrimp society leaders primarily sought knowledge through in person communications with people they know. Peer-to-peer farmer networks were the strongest existing knowledge sharing networks. Both farmers and shrimp society leaders had limited access to formally trained experts in shrimp farming. Based on these results, two techniques could be used to improve knowledge available to shrimp farmers. The first is to provide accurate knowledge through existing peer-to-peer farmer networks, including through shrimp society leaders. The second is to strengthen farmer-expert networks to allow knowledge from formally trained experts to reach a greater number of farmers. In particular, efforts to build farmer awareness and trust of National Aquatic Development Authority

officers, as well as efforts to increase officers' capacity to provide extension services, would allow farmers to obtain accurate information through a national governmental organization with an existing mandate to provide education services. Farmers must be educated how, when and where to seek knowledge when facing serious problems such as poor shrimp growth or increased shrimp mortality. For this to succeed, negative impacts of seeking knowledge must be eliminated.

Experts NWP shrimp farmer's reported they knew in private companies

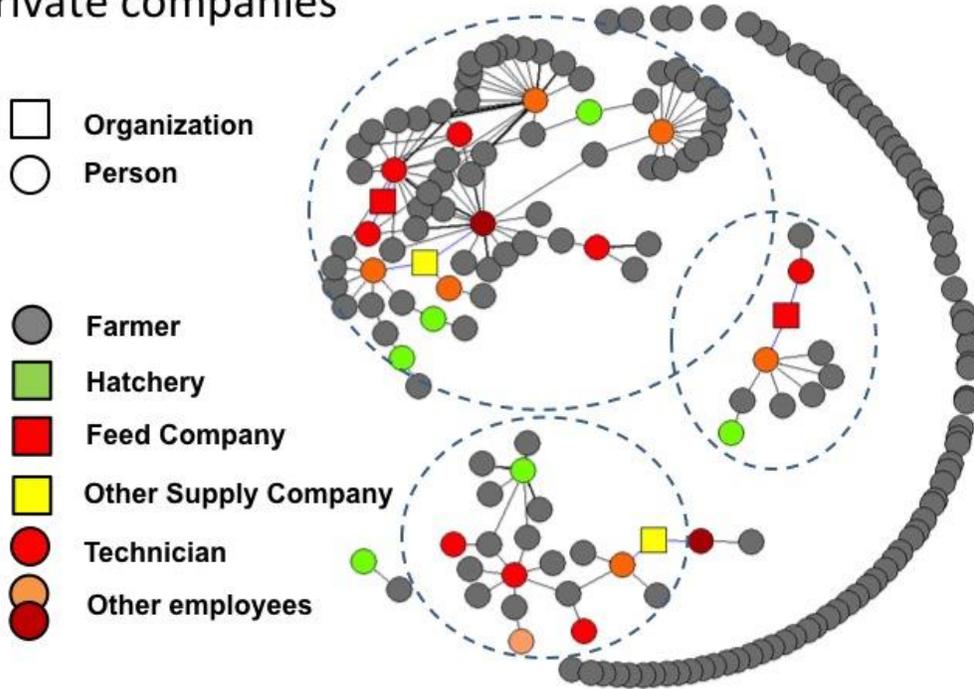


Figure 5: Network created from egocentric ties reported by 165 shrimp farmers in the NWP of Sri Lanka to experts in supply companies. Note isolated groups and a large number of farmers who are disconnected from the industry expert network

Changing the role of shrimp farmer society leaders to improve knowledge sharing in Sri Lanka

Data from shrimp society leaders was collected by in-person interviews using a questionnaire. It evaluated what topics leaders communicated about, with whom they communicated and what communication method they used. Data from farmers was collected from the primary survey of 165 farmers in the NWP and 60 in the EP. In addition, 34 leaders of farmer organizations and 34 shrimp farming experts were interviewed. Approximately half of the farm society leaders lacked formal education about shrimp production. Leaders sought knowledge about novel problems most often from talking to others they viewed as knowledgeable, followed by newsletters. Many farmers did not communicate regularly with shrimp society leaders in their zone. In part, this is because farmers did not view leaders as relevant sources of knowledge. Leaders communicated with experts to seek information primarily in person and by mobile phone. This limited the pool of experts available to leaders to those they have met and obtained contact information from. Leaders had limited access to online and printed sources of knowledge about shrimp farming. Efforts to improve communication between leaders and farmers in some zones are necessary. The role of societies and their leaders in enforcing regulatory compliance versus providing knowledge might need to be fully understood before this is possible.

Development of locally adapted Best Management Practices for shrimp farming in Sri Lanka

Workshops and farm society meetings were held with 13 farmer societies in the different sub-zones to gather farmer, industry leader and local expert input on constraints and issues affecting implementation of BMPs. Local perceptions were integrated with data collected from the surveys of 225 farms (see above) and used to review existing BMPs. Gaps or additions were addressed in existing BMPs to help tailor BMPs to local needs and conditions. A new BMP manual, produced in local language was created and distributed. This will be used as the content for further web development and can provide a baseline for adaptive BMP creation as further local insights emerge as the industry evolves and expands.

Can Short Messaging System (SMS) delivered over mobile phones to farmers improve responsiveness to and implementation of BMPs to improve disease management and sustainability?

A purposive sample of 60 farmers, including the 5 zonal leaders participated in a trial over 1 production cycle of 4 months from March to July 2012. They received timely information pertaining to water quality, disease and health condition, pond management and related topics, all of which would enable them to act quickly with farm interventions. Farmers were provided with contact information for technical experts to respond to farmer questions. An exit survey was conducted to determine perception of value and response to information. Farmers communicate about information received by SMS most readily with other farmers, with the technical support person, and with government extension officers, and less so with hatcheries, feed company representatives, and shrimp buyers. Farmers rarely or never contacted university experts. Farmers readily acted on information and implemented specific BMPs such as water exchanges, and increasing biosecurity measures. For BMPs such as treating water, and obtaining additional disease testing (e.g. PCR), response was lower due to the cost or lack of infrastructure. The SMS information system encouraged farmers to act in greater cooperation with other farmers, attend meetings, seek technical support, and share information with government agencies. An information delivery and response system using SMS over mobile farms was found to be an effective means to support BMP implementation and improve responsiveness and compliance. Specific BMPs important for achieving sustainability goals and improving disease management outcomes can be reinforced and targeted with SMS delivery. SMS information delivery could be scaled up to include all farmers. An effective SMS information delivery system in tandem with BMPs will require greater availability of technical resource persons and more effective means of incorporating the best available knowledge.

Using Multi-Criteria Decision Analysis (MCDA) to identify fish fingerling production options for culture based fisheries in Sri Lanka

MCDA was used as a participatory decision making process to identify preferred carp and tilapia fingerling production systems to support culture based fisheries in Batticaloa. Seven alternative production systems were compared and ranked according to their perceived performance and efficiency to reach sustainable development and food security objectives. Stakeholders preferred production systems where all of the carp and tilapia breeding would be conducted by either a National (NAQDA/ AQDC) or Provincial (EP Council) government hatchery. An EP Council and NAQDA/ AQDC hatchery joint venture was the top ranked fish fingerling production system. When examining the fish fingerling production options, the stakeholders most highly valued: 1) maximizing financial sustainability; 2) minimizing risk to the genetic integrity of fish; and 3) increasing the availability of acceptable fish protein for household consumption. Our approach and outcomes were well received by policy makers and culture based fisheries stakeholders. The participatory nature of the MCDA provided an important opportunity for culture based fisheries community members and farmers to engage with each other and with provincial and national government agents involved in policy making and planning – a situation that had not occurred prior to this project.

Does the national policy environment support development of sustainable freshwater fish aquaculture in Sri Lanka?

Lacking a validated aquaculture policy evaluation tool, a framework for policy evaluation was developed based on three core concepts: 1) critical policy elements, 2) sustainable aquaculture goals, and 3) sustainable development principles. The results showed that there was no policy specific to freshwater fish aquaculture, few policies for shrimp farming and no strategic or action plans to guide sustainable aquaculture development. There were no mechanisms described to monitor and evaluate policy to determine whether policy goals remain relevant or if strategies to implement policy goals were successful. In the absence of specific aquaculture policy goals, government and aquaculture stakeholders will be unable to develop strategic plans to properly address issues and impacts, which may risk unsustainable practice. In the absence of specific criteria, indicators and standards, managers will be unable to measure success in achieving goals and thus be unable to reliably report to stakeholders, consumers and trading partners the progress this sector has made in terms of integrating its social, ecological and economic imperatives.

Knowledge transfer, management, and sustainability of culture-based fisheries in non-perennial reservoirs

Although CBF in non-perennial reservoirs has a forty-year history, many paddy farming communities have not adopted it due to lack of awareness, environmental influences, management difficulties, socio-cultural values, and a shortage of fingerlings. A survey was conducted to gather information regarding knowledge transfer mechanisms, communication among different institutions, different management strategies used in CBF, and factors affecting sustainability. The lack of effective knowledge mobilization in CBF is an obstacle for its sustainability. Among the interviewed farmers 80% of them identified poor knowledge transfer as an obstacle for development. Only 30% of farmers were aware of fisheries extension services provided by government agencies and peer communication is the principal mechanism of knowledge sharing between community members regarding CBF. Farmers believed that effective knowledge connectivity would improve CBF practices, yields and income and would help to minimize conflict between multiple resource uses.

The relative performance of stocked species for culture-based fisheries in non-perennial reservoirs in North-Western Province of Sri Lanka

In CBF four fish species are combined and stocked occupying four different food niches in the reservoirs. Since CBF are practiced in natural or quasi-natural water bodies, competition of wild species, food availability, duration of culture period and predation (e.g. from snake head fish) can influence the fish production of stocked species. The study was conducted in 11 non-perennial reservoirs in the NWP. Reservoirs were stocked with hatchery-reared fingerlings of catla, rohu, genetically improved farm tilapia (GIFT), and common carp during the 2011-2012 culture cycle. Total length and weight of randomly selected fingerlings and sub-samples of fish catches of each species were measured. Total fish yield was curvilinear related to reservoir area ($P < 0.05$) and negative curvilinear relationships were evident with stocking density and SGR of rohu, GIFT and common carp ($P < 0.05$). GIFT strain of Nile tilapia had the highest growth rate among stocked species. Occurrence of snake head in reservoirs had negative impacts on the stocked fish species.

Pilot projects in new community opportunities – applied research in aquaculture

While shrimp culture is the greatest revenue generator and income is the principle impediment to food security in this project, there are additional opportunities for people to supplement their income from the culture of aquatic organisms. Previous team work examined the value and benefits of the ornamental fish farming industry. In this project two new areas were investigated for developing income opportunities for communities dependent on declining capture fisheries. A pilot oyster culture project was initiated with an isolated fisher community in the Kala-oya estuary of the Puttalam Lagoon area. Oysters are not traditionally consumed foods, but there is a growing market for export as well as for the local tourist trade. The project has developed preparation and cooking booklets for the promotion of oysters as a high value food for nutrition to encourage local consumption. A pilot culture system was evaluated in the community to collect oyster seed and grow the oysters to market size using locally available materials. Extension materials were developed to educate and train the participants. During the course of the project 150,000 oysters were purchased for export and a local market developed that is now 200 oysters per day and growing. The community earns 10 Sri Lanka Rupees per oyster generating an income of approximately 2.2 million rupees per year. The market demand for both export and domestic is growing significantly, providing a good opportunity for further growth.



Figure 6: Kala-Oya estuary, site of the pilot project in oyster culture with a community of 35 fisher families.

For lobster culture, new policies were created to regulate harvest size and thus support a lobster fattening industry (see ASF outcomes for further details). These projects are examples of animal science research that have helped WUSL build relationships with communities and provide production relevant research and expertise.

VI. Synthesis of Results towards AFS Outcomes

1. New technologies and/or farming systems and practices.

Two main farming system and practice themes were explored: (1) Those affecting practices influencing short-term farm sustainability and (2) those demonstrating new farming opportunities for income generation through aquaculture. Theme 1 (influencing practices) had four main areas of activity or

outcomes. First, risks factors associated with disease outcomes and on-farm sustainability scores were identified. These outcomes can inform farm and industry management practices. Second, participatory approaches to management plan development were applied. This included cross-sectoral activities to develop locally relevant BMPs and MCDA for selecting strategies to overcome impediments to CBF. Third, strategies to mobilize knowledge on management practices were identified. A trial with mobile SMS was conducted to help farmers to access information to carry production through to full cycle rather than be forced into early “emergency” harvests due to disease outbreaks that occur often as a result of poor management practices. This was followed by development of an integrated web platform through which collected information can be collected and analysed and through which farmers can access knowledge resources and production information. By mapping knowledge flows the industry and government has been enabled to address gaps in knowledge mobilization that are impeding BMP implementation Fourth, the research has nominated variables to measure and monitor on-farm sustainability and has linked these variables to farm and farmer attributes to help connect the theory of sustainable aquaculture to strategies to encourage specific on-farm behaviours.

Theme 2 (demonstrating opportunity) consisted of five component areas. First, the overview of global experience with aquaculture emphasized the need to support research that measures human development outcomes impacts before conclusions can be drawn on the validity of the strategy of using aquaculture for rural development. Second, survey evidence showed that shrimp farm households are generally food secure, making this a candidate sector for expansion in the East and North. Third, participatory community based decision support tools were developed and used to address key impediments to expansion of CBF including lack of awareness of optimal stocking practices and a chronic shortage of tilapia and carp fingerlings to supply communities who are involved in culture based fisheries. Trials of optimized stocking in seasonal reservoirs in the NWP and EP provided the necessary evidence of sustainable capacities of reservoirs and provide knowledge to communities to put this into practice. Seasonal and perennial reservoirs are woefully underutilized for fish production in Sri Lanka. Outcomes of this process will also enable Provincial and Central government agencies to plan for sustainable growth and management of this sector. Fourth, the potential was shown for oyster culture to be an entirely new and sustainable means of income for an isolated community dependent on a diminishing capture fishery. Knowledge for mollusc culture had almost disappeared in Sri Lanka due to the years of conflict that affected all of the most suitable growing areas in the country. Our project spearheaded the development and updated of production knowledge. Oysters have been exported from Sri Lanka for the first time as a result of the project activities. Fifth, working with fishing communities in EP, this project showed the potential for lobster fattening (culturing undersize lobsters to grow them to market size) to provide new livelihood opportunities.

2. Dietary diversity & nutrition

In shrimp farm households, little of the farmed shrimp was consumed; farm profits affected food security (See section on Income Generation below). There was little opportunity for women to be farm owners (in the shrimp industry), instead being relegated usually to farm labourers or household chores. Other forms of aquaculture provided a more direct access to fish protein in addition to income generation. The CBF initiatives and shellfish culture increased locally supplied fish, thus contributing to affordable sources of protein and fatty acids. In the case of mollusc culture the local community as well as the fisheries officers of NWP and Northern provinces have been introduced to consumption of oysters and different cooking methods of oysters. For the CBF, the project has (i) disseminated a model to help communities identify better culture locations and optimize stocking of fingerlings, and (ii) developed a strategy to address the principle bottleneck to CBF expansion in the EP with respect to availability and access to fingerling supply.

3. Engagement of Canadian researchers with Southern researcher organizations (for CIFSRF-funded projects only)

This project allowed a core set of researchers at the Department of Ecosystem and Public Health (University of Calgary) and Centre for Coastal Health to translate trans-disciplinary thinking into practical, on-farm tools to promote aquatic food production. It enhanced the teams' skills, knowledge and understanding in the use of theory of behavior change for knowledge mobilization in aquaculture. Canadian knowledge of a holistic approach to sustainability and health is being shared and taken up by research partners. The team is supported through provision of literature and statistical insight into experimental design as well as data analysis by the Canadian team. The Sri Lankan partners led in helping the Canadians understand the context for research in southern institutions and in translating the results to local needs and situations. The research collaboration with WUSL and EU is bringing a greater appreciation and utilization of ecosystem based approaches to aquaculture-related investigations. The team took a unique approach to linking network theory, theories of social learning, and principles of health promotion to understand why people did (or did not) use certain management practices. To date, aquaculture research has been almost exclusively focused on technology development. This project focused on the implementation barrier and provided the team with new tools and insights that are already being applied to other situations (e.g. pig farmers and protection against Japanese Encephalitis in Nepal). Sri Lankan partners helped in the design and delivery of research tools to access people's perceptions in a culturally and linguistically appropriate manner. Canadians provided methodological and analytical capacities.

4. Research groups

New clusters of interaction emerged from project activities that have resulted in stronger collaboration and progress toward co-management. The project facilitated development of a network of organizations and people in Sri Lanka that can collaboratively contribute to development of evidence-based policies and decision-making. Project activities created structures, practices, and systems that serve to improve knowledge flow and connectivity. Project workshops and activities created new avenues for dialogue between farmers and senior policy makers. The project improved connectivity between government, academia, and industry that will address a critical gap identified in the project. Examples include: (1) WUSL and the Eastern University (EU) partnered with farmers and industry leaders. This increased the profile and relevance of the universities, which will be critical for future research. (2) The project gave WUSL and the EU important new experience in international team-based collaborative research in food security and sustainability. (3) Involvement of the Provincial Councils in the research has strengthened relationships with central government agencies (NARA, NAQDA) and formed new links with academia and industry including groups like the Aquaculture Technologists Society and SLADA. (4) Working with NWP Council and EU as participating institutions is helping build ground level capacity in the target regions of the country to contribute to research in food security and sustainability of aquaculture. (5) The project provided new opportunities for WUSL to develop a graduate training program.

5. Food distribution

Our project is contributing to increasing rural economic development and improving incomes and may help to increase availability and consumption of fish in rural areas, particularly from developing under-utilized reservoirs for sustainably culturing fish. It has facilitated access to new markets for the oyster cultivation sector and developed tools to expand the culture-based fisheries to improve community access to this food and income-generating source.

6. Risk-mitigation

Disease is perhaps the biggest risk to sustainable aquaculture in Sri Lanka. Disease has a strong two-way association with the environment. Environmental conditions are essential determinants of disease and disease control BMPs can have adverse environmental impacts including drug and chemical use, water extraction, and abandonment of farms and creation of new farms. The reliance of some sectors on capture of wild stock for broodstock or replacements (e.g. shrimp broodstock, lobster fattening) and the cultural practice of release rather than euthanasia of sick fish (which was seen in the ornamental sector) creates disease risks to biodiversity as well as increased pressures on wild stock to replace deaths in culture due to disease. The project helped to identify and better manage risk factors for disease in aquaculture production. The project conducted the first observational studies to associated BMP use with reported disease status. It discovered fractures in trusting relations and market forces that create disincentives to use BMPs. It worked in a participatory fashion to modify BMPs to local conditions and discovered and tested ways to improve farmer's knowledge to better empower them to make management decisions to control disease.

7. Access to resources

Our project focused on social capital as a resource, and our activities and research are working towards more effectively connecting farmers, information and decision makers (industry, government, production).

8. Income generation

The premise of the project is that sustainable aquaculture diversifies rural incomes, improving access to more and better quality food. Sustainable aquaculture will also enhance local protein availability in local markets, especially through improvements in culture based fisheries. Shrimp farms households were generally found to be food secure, but fish farm productivity was volatile due to disease outbreaks. An improvement in shrimp production through better disease management reduces risk and has potential to improve and stabilize smallholder incomes. Our work on improved BMPs and enhanced means to disseminate information affecting disease prevention and control will be a critical step in industry disease reduction and prevention, especially in the EP and North where the industry is just beginning. Oyster culture systems successfully implemented during this project will enable communities to achieve additional income of 200,000 Rs per rack system (based on 25,000 oysters per unit). Labor costs must yet be validated to ensure net profitability to community members. The project also assisted in identifying market opportunities and connecting marketers with farmers in the Northern Province. The project showed the viability of a lobster fatty sector as a new means for income supplementation.

9. Policy options

The project identified the need for a coherent national policy for aquaculture development in order to enable a co-learning approach that prevents ad hoc selection of opportunities for income generation through aquaculture and to avoid past mistakes and disasters such as disease outbreaks. The project has provided research outcomes that can be used to inform a strategic approach to government policy change and influences on-farm policy, for example in implementing a regulatory system to enhance BMPs. In general, the project identified (1) the need for policy on sustainable aquaculture; (2) the need for measurable implementation plans and goals for the national strategy; (3) the need for an improved evidence base for selection of BMPs for on-farm policy; and (4) the need for improved knowledge mobilization policies and programs to implement on-farm practices. The participatory approach to developing disease best management practices have improved connection between farmers, academia and

government while at the same time inspiring new practices to improve disease screening in the shrimp industry. The inter-sectoral nature of this project has cultivated a climate receptive to the concept of co-management. The research outputs have been shared with national and provincial government and with industry organizations.

The project took a multi-level approach to policy – at the farm management level, community level, and provincial/national policy. Examples of policy relevant research impacts include:

Government level

- Policy development: A policy framework for sustainable aquaculture in Sri Lanka has been completed and given to the Director General of the National Aquaculture Development Agency (NAQDA) of Sri Lanka. A policy and legislation gap assessment for the sustainable development of freshwater fish aquaculture in Sri Lanka has been submitted for publication. New policies on lobster harvest were created.
- Policy implementation: Strategies for improvements to extension programs for sustainable aquaculture have been shared in facts sheets with details in theses and peer-reviewed papers. NWP developed new capacity for enhanced Polymerase Chain Reaction (PCR) testing for pathogens in shrimp. NWP is adopting MCDA to support local decision-making.
- Policy evaluation: Candidate system to score on-farm sustainability that can be used to set and measure progress in meeting sustainable development policy goals

Industry-level

- The outcome of the MCDA process provided quantitatively ranked fish fingerling production systems in the context of food security and sustainable development that has set the stage for EP culture-based fisheries development planning. A critical performance review of existing policies and recommendations for policy directions for expansion of aquaculture in the Eastern Province for income security and diversification are being provided to Sri Lankan regulatory agencies.

Farm-level

- First critical evaluations of BMPs and strategies to improve their implementation will effect on-farm management policies

10. ICTs

Improving mobile phone connectivity strengthened farmer social learning networks, and provided enhanced knowledge sharing by using SMS. A pilot scale trial with 60 farmers demonstrated that farmers are more likely to implement better practices if encouraged by timely and specific directions and information on management practice interventions, especially related to disease management. (e.g. water exchanges, increasing biosecurity measures, checking water quality more often, checking shrimp health condition more often, adjusting aeration, and adjusting harvesting timing). Additional work showed the importance of farmer-to-farmer networking and the use of mobile phones as sources of expert information as opposed to consultation with universities, government or via the Internet. Our work therefore, showed not only that SMS can be an effective ICT platform but that it is perhaps a preferred method for knowledge mobilization affecting short term sustainability. However, the team recognized the value of the Internet for other members of the industry. The development of the web platform has been done to provide information and connect farmers to knowledge sources. Key information from farm production and farm environment was gathered along with hatchery production information and PCR results to

enable more effective knowledge sharing for management practices. The web platform will contribute to forming a collaborative linkage in the knowledge network between industry, government and university.

11. Gender

The research found that aquaculture ownership is a largely male dominated opportunity, particularly in the shrimp industry and especially in the EP due to religious and cultural reasons. This resulted in few women leading or owning farms and thus women were underrepresented in the demographics of farmer included in this study. However, while ownership opportunities for women were rare, labourer opportunities, either as part of the farm family or as hired help, were available to women. Results of the surveys showed also that women have a different perception of food security than men. In some sectors, such as ornamental fish farming, contract fish rearing was an important source of households' income for female-headed households and this may have important implications for emerging sectors such as oyster culture. Final results of an examination of gender issues in shrimp farming are pending upon the completion of J. Wu's PhD in 2013.

12. Environment

In addition to our work on disease control for environmental protection, potential environmental predictors of risks to sustainability were included in the farm level studies. The project team observed that locally adapted practices can be an important means of achieving sustainability rather than introducing new practices that could create environmental harms. Household surveys, disease investigations, and MCDA all have environmental variables as key factors for analysis. The investigation of optimum siting and environmental variables associated with oyster culture sites can be developed into a system of industry management that incorporates and builds upon this environmental baseline data.

VII. Problems and Challenges

The project was faced from the outset with a change in the original partnerships because of political change. In the proposal preparation and partnership development phase, key junior ministers and program directors endorsed the project and agreed to join as participating institutions. After a federal election, none of these key players remained in government and their replacements selected other priorities and opted out of the project. This required WUSL to take on a more direct role as project co-lead on relatively short notice. Processes for moving funds from government to WUSL took considerable time due to this change and WUSL needed to develop improved governance and project management systems. This resulted in financial and administrative challenges throughout the project. However, the team was able to meet the project milestones and address all of the research questions. This required relationships with other institutions such as NW Provincial Council, Eastern University, and the Eastern Provincial Council, who all came on board as participating institutions. These new partners played a key role in working with the farming communities and enabled the project to achieve the desired outcomes. These institutions also benefitted from mentoring by senior project leads.

One of our primary research findings – the lack of a centralized, coordinate strategy for aquaculture development – not only led to interesting comparative situations that could be exploited in the research, but also made it difficult to get information and resources flowing to different actors in different areas. For example, the low level of farmers' recognition of university and government partners as sources of expert knowledge required ongoing relationship building. The extent of this disconnect was greater than originally anticipated based on initial understanding in the project planning stage. Project managers and PIs were required to spend significant time in relationship building. This has left an important legacy of

the project but did cause significant challenges in implementing the research activities. While these did create some communication and logistic challenges, they emerged as key findings in the assessment of the knowledge network – issues that need to urgently be addressed to enhance trusted knowledge flow to farmers.

The way in which the budget was allocated to the two collaborating institutions in this project resulted in some challenges in team building. While this strategy allowed for both institutions to progress towards milestones, management over funding allocations within project activities proved challenging at times and resulted in some power imbalances and subsequent impacts on within-project trust. However, having our Co-PI in Sri Lanka (S. Daniel) unaffiliated with any specific institution receiving funds allowed him to broker costs and effort sharing agreements. But the amount of time dedicated to these activities emphasizes the need for full time project managers as Dr. Daniel was significantly distracted from more strategic management issues because of the constant need for him to be a project negotiator.

VIII. Recommendations

The Canadian International Food Security Research Fund is geared towards “applied research for development” and it would be helpful to demonstrate to the funded projects the proportion of effort and outcomes expected to be dedicated to achieving research objectives versus required for achieving development impacts. The role of International Development Research Centre role, as the team understood it, is to support “research for development” while the Canadian International Development Agency is focused more on the development outcomes and impacts. Projects can achieve both aims, but the experience of this project was that the latter take time and in some cases structural or policy changes in the institutions and organizations involved as partners and stakeholders. Within a two-year project, it did not seem realistic to affect some of the systemic changes needed to improve incomes and food security. Expectations of stakeholder and partners in the project tended to be focused on much-needed equipment and capacity-building rather than on the necessity of pursuing research objectives and obtaining evidence that can then be more effectively applied to policies, institutional changes, and development impacts with capacity-building and equipment needs strategically applied to these needs. Consequently, the project team leaders had to direct significant effort towards mentoring and strategic planning to address this issue.

A two-year time line for an international project is indeed challenging, particularly for a project involving extensive fieldwork and obtaining baseline data. The team set out an ambitious agenda for this project because it presented a unique opportunity to play a key role in the vision and plan for aquaculture expansion in Sri Lanka due to its prominence within its rural development agenda. The project was successful in meeting the research goals and milestones and it was important to the team and stakeholders that an additional short time period to mobilize the results with stakeholders was negotiated. However, a subsequent phase available for projects that successfully meet key milestones, with additional reserve funds made available to implement research outcomes and mobilize knowledge with partners and stakeholders would enable projects such as this one to have more penetrating and extensive impact. Project results have been shared with key partners and stakeholders. More will be created as trainees publish their work. A late-stage systematic implementation to reinforce and further disseminate the results would increase the likelihood of broader impact.

Annexes

ANNEX 1: TEAM COMPOSITION

Organization 1: Wayamba University of Sri Lanka , Sri Lanka						
Family name	Given name	Male (M) / Female (F)	Job title	Address (mailing address, phone number, fax, email)	Project role/responsibility (please indicate if lead PI and identify if consultant)	% of time committed on this project
Prof. Jayakody	D.S.	M	Professor	Department of Aquaculture and Fisheries, Wayamba University of Sri Lanka, Makandura Campus, Gonawila 60170. jayakodysunil@yahoo.com ,0094 (0)312299874	Sustainability of the lobster fishery in Eastern Sri Lanka	20
Prof. Jayasinghe	J.M.P.K.	M	Professor	Department of Aquaculture and Fisheries, Wayamba University of Sri Lanka, Makandura Campus, Gonawila 60170. jayasp@wow.lk , 0094(0) 312299874	Best Management Practices applicable to shrimp farms Eastern and Northwestern Provinces	40
Prof. Wanninayake	W.M.T.B.	M	Professor	Department of Aquaculture and Fisheries, Wayamba University of Sri Lanka, Makandura Campus, Gonawila 60170. wanninayake@hotmail.com ,0094(0) 312299874	Diversification of coastal aquaculture practices- Mollusc culture Eastern and Northwestern Provinces	30
Dr. Jayakody	Sevvandi	F	Senior lecturer	Department of Aquaculture and Fisheries, Wayamba University of Sri Lanka, Makandura Campus, Gonawila 60170. Sevvandi_jayakody@yahoo.com ,0094(0) 312299874	Disease outbreak analysis in shrimp farms Northwestern Province	70
Dr. Wijenayake	W.M.H.K.	M	Senior lecturer	Department of Aquaculture and Fisheries, Wayamba University of Sri Lanka, Makandura Campus, Gonawila 60170. Hiranya_kelum@yahoo.com ,0094(0) 312299874	Culture Based Fisheries- Food Security and Nutrition Eastern and Northwestern provinces	70
Prof. Silva	Renuka	M	Dean	Faculty of Livestock fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura Campus, Gonawila 60170. renukasilva2008@yahoo.com	Food security in communities of emerging aquaculture	5
Wijethunga	M.U.I.	F	Junior Researcher	Department of Aquaculture and Fisheries, Wayamba University of Sri Lanka, Makandura Campus, Gonawila 60170. uditha.wijethunga@yahoo.com ,0094(0)312299874	Researcher supporting all main research activities of the project	100

Organization 2: University of Calgary, Canada						
Family name	Given name	Male (M) / Female (F)	Job title	Address (mailing address, phone number, fax, email)	Project role/responsibility (please indicate if lead PI and identify if consultant)	% of time committed on this project
Stephen	Craig	M	Professor	Faculty of Veterinary Medicine, University of Calgary TRW 2D26 3280 Hospital Dr. N.W. Calgary, AB T2N 4Z6 cstephen@ucalgary.ca	Project Co-Principal Investigator	25
Dejager	Timothy	M	Research Associate	Faculty of Veterinary Medicine, University of Calgary TRW 2D26 3280 Hospital Dr. N.W. Calgary, AB T2N 4Z6 tdejager@ucalgary.ca +1.250.753.3245 x2755	Researcher for knowledge intervention, project manager Canada	100
Burns	Theresa	F	Postdoctoral Fellow	Faculty of Veterinary Medicine, University of Calgary TRW 2D26 3280 Hospital Dr. N.W. Calgary, AB T2N 4Z6 theresa_burns@hotmail.com	Researcher knowledge networks	100
Ribble	Carl	M	Professor	Faculty of Veterinary Medicine, University of Calgary TRW 2D26 3280 Hospital Dr. N.W. Calgary, AB T2N 4Z6 cribble@ucalgary.ca	Supervisor for T Westers	10
Checkley	Sylvia	F	Professor	Faculty of Veterinary Medicine, University of Calgary TRW 2D26 3280 Hospital Dr. N.W. Calgary, AB T2N 4Z6 sylvia.checkley@ucalgary.ca	Supervisor for J Wu	10
Daniel	Sam	M	Project Manager	Colombo, Sri Lanka	Co-Principal Investigator and Project Manager, Sri Lanka	50

Organization 3: Centre for Coastal Health (NGO National, Canada)						
Family name	Given name	Male (M) / Female (F)	Job title	Address (mailing address, phone number, fax, email)	Project role/responsibility (please indicate if lead PI and identify if consultant)	% of time committed on this project
Dawson-Coates	Jennifer	F	Policy Analyst	900 Fifth Street, Nanaimo, BC V9R 5A6 Jennifer.Dawson-Coates@viu.ca +1.250.753.3245 x2370	Policy process consultant	60
Anderson	Kristopher	M	Intern	900 Fifth Street, Nanaimo, BC V9R 5A6 ksa2@ualberta.ca	Internship student summer 2011 – Masters of Public Health, University of Alberta	Summer 2011 F/T

Organization 4: Eastern University, Sri Lanka (Participating Institution role in process and MOU to be completed September 2011)						
Family name	Given name	Male (M) / Female (F)	Job title	Address (mailing address, phone number, fax, email)	Project role/responsibility (please indicate if lead PI and identify if consultant)	% of time committed on this project
Devadasan	G.C.	F	Professor	Department of Zoology, Eastern University, Vantharumoolai, Chenkalady, Sri Lanka. Stanley@esn.ac.lk	Project liaison and research associate for activities in Eastern Province, Sri Lanka. Managed field team for shrimp farm survey in Eastern Province.	25

Organization 5: Small Fishers Federation (NGO National, Sri Lanka)						
Family name	Given name	Male (M) / Female (F)	Job title	Address (mailing address, phone number, fax, email)	Project role/responsibility (please indicate if lead PI and identify if consultant)	% of time committed on this project
Thissera	Duglas	M	Manager	Pamballa, Kakkapalliya, Sri Lanka Tel: 032 22 48707, www.smallfishers.lk	Managing field teams and logistics for conducting surveys of shrimp farms in Puttalam District	10

Organization 6: Ministry of Fisheries, Northwestern Provincial Council						
Family name	Given name	Male (M) / Female (F)	Job title	Address (mailing address, phone number, fax, email)	Project role/responsibility (please indicate if lead PI and identify if consultant)	% of time committed on this project
Weersekera	Kumari	F	Secretary	Pamballa, Kakkapalliya, Sri Lanka	Chair of project steering committee with representatives from Shrimp farm stakeholders	5
Kumara		M	Manager	Pamballa, Kakkapalliya, Sri Lanka	Coordinator for joint project activities with NWPC	10
Sirisena	Suraj	M	Fisheries Officer	Pamballa, Kakkapalliya, Sri Lanka	Supervisor of joint project activities with NWPC	25

Organization 7: Ministry of Fisheries, Eastern Provincial Council						
Family name	Given name	Male (M) / Female (F)	Job title	Address (mailing address, phone number, fax, email)	Project role/responsibility (please indicate if lead PI and identify if consultant)	% of time committed on this project
Suthaharan	Sivapathasundram	M	Deputy Provincial Director of Fisheries	Eastern Provincial Council. Trincomalee, Sri Lanka	Coordinator for joint project activities with EPC	10

ANNEX 2: OUTPUTS

Table 1: Peer Reviewed Articles & Thesis dissertations

Title	Date	Primary authors	Institution	Journal/Citation
Assessing sustainability of smallholder shrimp farms in Sri Lanka	2012	Westers, T.	University of Calgary	Thesis dissertation (MSc)
Aquaculture, food security, and gender roles in Sri Lanka	2014	Wu., J.	University of Calgary	Thesis dissertation (PhD) (in preparation)
Use of the household food insecurity access scale and household hunger scale in the shrimp farming industry of Sri Lanka: validation and socio-economic factors associated with household food insecurity	2013	Wu, J., Checkley, S. Stephen, C. and Silva, R.	University of Calgary and Wayamba University of Sri Lanka	In preparation for submission
Women's roles and experiences in the shrimp farming industry of Sri Lanka: a mixed method approach	2013	Wu, J., Checkley, S. and Stephen, C.	University of Calgary	In preparation for submission
Assessing and comparing relative farm-level sustainability of smallholder shrimp farms in two Sri Lankan provinces using indices developed from two methodological frameworks	2013	Westers, T., Ribble, C., Stephen, C.	University of Calgary	In preparation for submission
Identifying demographic and geographic variables affecting farm-level sustainability of smallholder Sri Lankan shrimp farms using a multi-level modeling approach	2013	Westers, T., Ribble, C. Stephen, C.	University of Calgary	In preparation for submission
Identifying best management practices associated with reduced white spot disease prevalence on smallholder shrimp farms in the North Western Province of Sri Lanka	2013	Westers, T., Ribble, C. Stephen, C.	University of Calgary	In preparation for submission
Initial oyster culture trials in Sri Lanka	2013	Wanninayake, WMTB	Wayamba University of Sri Lanka	In preparation for submission
Existing knowledge transfer mechanisms in Culture Based	2013	Wiejenayake, K., Amarasinghe, U.S.	Wayamba University of Sri Lanka and University of Kelaniya	In preparation for submission

Title	Date	Primary authors	Institution	Journal/Citation
Fisheries in Sri Lanka and potential improvements				
Mapping the spread of disease in shrimp aquaculture in NWP of Sri Lanka in relation to current culture practices	2013	S. Jayakody, C. Stephen	Wayamba University of Sri Lanka and University of Calgary	In preparation for submission
Knowledge networks in the Sri Lanka shrimp industry	2012	Burns, T. Stephen, C.	University of Calgary	Aquaculture (submitted)
Policy and legislation gap assessment for the sustainable development of freshwater ornamental fish aquaculture in Sri Lanka	2012	Dawson, JA, Stephen, C., Wade, J.	Vancouver Island University, University of Calgary, Fundy Aqua Services, Centre for Coastal Health	Aquaculture (submitted)
Review of evidence of aquaculture as a contributor to human development: policy implications	2012	Burns, T., Stephen, C., Dawson, J., Wade, J.	University of Calgary, Centre for Coastal Health, Vancouver Island University and Fundy Aqua Services	Ecohealth (submitted)
Using theories of behaviour change as a framework to examine the implementation of disease better management practices on Sri Lankan shrimp farms	2012	DeJager, T., Anderson, K., Jayasinghe, JMPK., Stephen, C.	University of Calgary, University of Alberta, and Wayamba University of Sri Lanka	Aquaculture (submitted)
Application of Mobile SMS to enhance knowledge connectivity and improve shrimp health and sustainability outcomes for Sri Lanka aquaculture	2012	DeJager, T. , Burns, T., Sandaruwan, KRP, Stephen, C., Jayasinghe, JMPK., Daniel, S.	University of Calgary,	Aquaculture (submitted)
Using Multi-Criteria Decision Analysis to identify fish fingerling production options for culture based fisheries in Sri Lanka	2012	J. Dawson, C. Stephen, K. Wijeyanayake	University of Calgary, Vancouver Island University, Wayamba University of Sri Lanka and Centre for Coastal Health	Aquaculture (submitted)

Table 2: Conference presentations, proceedings and posters

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
Project dissemination workshop: Promoting rural income from sustainable aquaculture through social learning in Sri Lanka	Sri Lankan research partners, government agents (Governor of North-western province, Minister of Fisheries and Aquatic Resources, Secretary of Fisheries, NWP, Directors Fisheries, NWP and Eastern province), shrimp and culture based fishery industry leaders and farmers, aquaculture researchers and academics, students, IDRC project leader	Community based mangrove oyster (<i>Crassostrea madrasensis</i>) culture at Kala Oya estuary of Puttalam lagoon, Sri Lanka: new challenges in aquaculture	December 2012	Wanninayake, WMTC, Subasinghe, M.	Poster
		Sustainable oyster culture through new technology and knowledge transfer in Puttalam Lagoon, Sri Lanka	December 2012	Wanninayake, WMTC, Subasinghe, M.	Poster
1 st international conference on Animal Nutrition and Environment, September 14-15, Khon Kaen, Thailand	International environmental and agriculture researchers and academics	Community based mangrove oyster (<i>Crassostrea madrasensis</i>) culture at Kala Oya estuary of Puttalam lagoon, Sri Lanka: new challenges in aquaculture	September 2012	Wanninayake, WMTC, Subasinghe, M.	Presentation and proceedings
World Aquaculture Society, Prague	International aquaculture policy makers, researchers, academics, industry	Clusters and connections: Improving adoption of better management practices in Sri Lanka's aquaculture industry.	Sept. 2012	DeJager T, Stephen C, Sandaruwan P, Anderson K, Burns T, Jayasinghe JMPK	Presentation
World Water Week, Stockholm	International policy makers, researchers, academics	The Last Mile: Mobilizing Farmers at the Front Line	Aug 2012	Dejager, T.	Presentation
		Moving from generic to actionable policy for sustainable aquaculture	Aug 2012	Dawson, J.	Presentation
		Networks and social learning in aquaculture: Bridging the information to implementation gap	Aug 2012	Burns, T.	Presentation
		Safeguarding water to sustain food security contributions of aquaculture: The shrimp culture case study	Aug 2012	Jayacodi, S.	Presentation
		Future prospects of culture-based	Aug 2012	Wijenayake, K.	Presentation

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
		fisheries as an enhancement strategy in developing countries: A Sri Lankan case study			
Proceedings of the Eighteenth Session of the Sri Lanka Association for Fisheries and Aquatic Resources, Sri Lanka	Sri Lankan aquaculture researchers and students	Risk of aquaculture on coastal environment: mitigation through better management practices	May 2012	Gunarathna, TVNM, Jayasinge,	Abstract and presentation
		Change in attitudes and perception of shrimp farming communities towards implementing Best Management Practices (BMPs) to improve the sustainability of shrimp farming	May 2012	Gunarathna, TVNM, Jayasinge, Jayakody, S.	Abstract and presentation
		The slipper lobster (<i>Thenus orientalis</i>) fishery off Negombo: status and recommendations.	May 2012	Hewapathirana, K. Jayakody, D.S.	Abstract and presentation
		Studies on some aspects of breeding biology of the slipper lobster (<i>Thenus orientalis</i>) in Sri Lankan waters	May 2012	Hewapathirana, K. Jayakody, D.S.	Abstract and presentation
		Disease spread in shrimp farms in Northwestern Province: are farmers geared for successful prevention	May 2012	Mahagamage, MGYL, Jayakody, S.	Abstract and presentation
		Community based mangrove oyster (<i>Crassostrea masrasensis</i>) culture at Kala Oya estuary of Puttalam lagoon, Sri Lanka: new challenges in aquaculture	May 2012	Wanninayake, WMTB, Subasinghe, M.M	Abstract and presentation
		Research and outcome dissemination: are we reaching the right audience	May 2012	Jayacodi, S.	Abstract and presentation
		Sustainable aquaculture: knowledge management, communication and the environment	May 2012	Wijenayake, K, Jayakody, S.	Abstract and presentation
Aquaculture Canada, PEI, Canada	Canadian aquaculture policy	Policy needs for sustainable	May 2012	Dawson J., Stephen, C., Wade, J.	Presentation

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
	makers, researchers, academics, industry	aquaculture – the need for implementation			
		Systematic review of aquaculture's contributions to human development	May 2012	Burns T., Stephen, C.	Presentation
International society for veterinary Epidemiology and economics (ISVEE 2012) Conference, Maastricht, Netherlands	International veterinary epidemiologists, academics, researchers and graduate students	Aquaculture, food security, and gender roles in Sri Lanka	Aug 2012	Wu J, Checkley S, Westers TJ, Dejager T, Daniel S, Stephen, C.	Poster
		Identifying best management practices associated with reduced white spot disease prevalence on smallholder shrimp farms in the North Western Province of Sri Lanka	Aug 2012	Westers TJ, Ribble C, Jayasinghe, JMPK, Wu J-Sears W, Stephen C	Poster
		Adoption of best management practices on smallholder shrimp farms in the Eastern Province of Sri Lanka	Aug 2012	Westers TJ, Ribble C, Jayasinghe JMPK, Wu J-Sears W, Stephen C	Poster
Global Development Conference, University of Guelph, Ontario, Canada	Canadian veterinary epidemiologists, academics, researchers and graduate students	Developing indices for identifying obstacles to achieving sustainability on smallholder Sri Lankan shrimp farms	May 2012	Westers T, Ribble C, Stephen C	Poster
One Health Conference, Melbourne	Veterinary and human health researchers and clinicians	Personal insights from the 1 st International One Health Congress in Melbourne (Plenary).	2011	Stephen, C.	Presentation

Table 3: Workshop presentations

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
Promoting rural income from sustainable aquaculture through social learning in Sri Lanka: project findings	Sri Lankan aquaculture researchers, academics, government researchers, government policy makers, governments extension officers; shrimp, freshwater ornamental and culture based fisheries farmers; Canadian Researchers, IDRC representatives; Minister of Fisheries, Director (s) Fisheries of NWP and EP; IDRC representative; Wayamba University aquaculture undergraduate and graduate students	Culture based fisheries in non-perennial reservoirs in North-western Province of Sri Lanka: knowledge transferring, management and sustainability.	December 2012	Wijenayake, WMHK	Presentation and poster (Sinhalese)
		Sustainable oyster culture through new technology and knowledge transfer in Puttalam lagoon, Sri Lanka	December 2012	Wanninayake, WMTB	Presentation and poster (Sinhalese)
		Better management interventions for sustainable shrimp farming industry in Sri Lanka through a participatory process	December 2012	Gunarathna, TVNM, Jayasinghe, JMPK	Presentation and poster (Sinhalese)
		Towards sustainable aquaculture in Sri Lanka: project findings	December 2012	DeJager, T.	Presentation (English and Sinhalese)
Final team workshop: project findings	Wayamba University of Sri Lanka project team; University of Calgary team; Shrimp exporter; oyster processor and exporter; IDRC representative and Wayamba University aquaculture and undergraduate students	Using SMS to enhance the knowledge network of shrimp culture in Sri Lanka	December 2012	DeJager, T.	Presentation and abstract
		Assessing the sustainability small holder shrimp farms in Sri Lanka	December 2010	DeJager, T.	Presentation and abstract
		Sustainable culture-based fisheries in non-perennial reservoirs through effective management approaches	December 2012	Wijenayake, WMHK	Presentation, poster and abstract
		Better management practices and sustainability of the shrimp farming industry in Sri Lanka	December 2012	Gunarathna, TVNM, Jayasinghe, JMPK	Presentation, poster and abstract
		Sustainable oyster culture through new technology and knowledge transfer in Puttalam lagoon, Sri Lanka	December 2012	Wanninayake, WMTB	Presentation, poster and abstract
		Moving from generic to actionable policy for sustainable aquaculture: participatory decision making to improve culture based fisheries planning	December 2012	Dawson, J.	Presentation and abstract

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
		Promoting sustainable rural aquaculture through social learning in Sri Lanka	December 2012	Wu, J.	Presentation and abstract
		Information networks for Sri Lankan prawn farmers	December 2012	Dejager, T., Burns, T	Presentation and abstract
		Improving livelihood of small scale lobster fishery of the Eastern and North-western provinces of Sri Lanka	December 2012	Jayacodi, DS	Presentation and abstract
		Farming at stake: an analysis of disease spread in shrimp aquaculture in North-western province of Sri Lanka	December 2012	Jayacodi, S.	Presentation and abstract
Small Fisheries Federation, Pambala	Puttalam district school teachers and shrimp farmers	Oyster culture in Puttalam Lagoon, Sri Lanka	October 2012	Wanninayake, WMTB	Presentation
Wildlife Disease Association pre-conference workshop, Lyon, France	International Veterinary academics, researchers, practitioners, wildlife health biologists and researchers, policy makers	My five lessons in capacity development	July 2012	Stephen, C.	Presentation
National Science Foundation	Sri Lankan National and Provincial scientific officers	Bivalve culture in Sri Lanka: New Challenges	March 2012	Wanninayake, WMTB	Presentation
Shrimp Farmer Society meeting, Keeriyankaliya District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 1	February 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of information of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Thoduwawa District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 2	February 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of information of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Kothantive District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 3	February 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of information of local shrimp culture knowledge and practice
SMS orientation for Shrimp farmers (NWP)	Shrimp farmers, fisheries officers (NWP), Shrimp Aqua Technology Society, Minister of Fisheries	Shrimp Mobile SMS Workshop	March 2012	DeJager, T.	Mobile phones and orientation brochure

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
Shrimp Farmer Society meeting, Muthupanthiya District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 4	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Uddapuwa District	Shrimp farmers , Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 5	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Pulichchikulama District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 6	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Pinkattiya District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 7	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Ambakandawilla District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 8	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Kalpitiya District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 9	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Puttalam District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 10	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Kusala District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 11	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice
Shrimp Farmer Society meeting, Karukkaoane District	Shrimp farmers, Secretary of Fisheries (NWP), fisheries officers, and Shrimp Aqua Tech Society members	Implementation of Shrimp Best Management Practice (BMP): Zone 12	March 2012	Gunarathna, TVNM and/or Jayasinghe, JMPK and/DeJager, T.	Presentation and exchange of local shrimp culture knowledge and practice

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
Oyster culture community awareness program: Kandakkuliya District	Fishermen and fisher women	Oyster culture in small fisheries communities	October 2012	Wanninayake, WMTB, Karunathilake, HCB, MM.	Presentation and Expert support to communities to support new and on-going oyster culture and research activities
Oyster culture community awareness program: Gangewadiya District	Fishermen and fisher women	Oyster culture in small fisheries communities	October 2012	Wanninayake, WMTB, Karunathilake, HCB, MM.	Presentation and Expert support to communities to support new and on-going oyster culture and research activities
Oyster culture community awareness program: Gangewadiya District	Fishermen and fisher women	Oyster culture in small fisheries communities	July 2011	Wanninayake, WMTB, Karunathilake, HCB, MM. Subasinghe	Presentation and Expert support to communities to support new and on-going oyster culture and research activities
Culture based fishery farmer meeting	Eastern Provincial culture based fishermen and fisherwomen; pond farmers; fisheries officers, academics (Eastern University), Director of fisheries and aquaculture students	Decision making methods to improve fingerling production, Eastern Province	March 2012	Dawson, J.	Presentation, glossary of terms, questionnaire, briefing statement (Tamil and English)
		Current status of culture based fisheries in Sri Lanka: future prospective, issues and constraints	March 2012	Wijenayake, K.	Presentation, glossary of terms, questionnaire, briefing statement (Tamil and English)
Culture based fishery expert meeting	Culture based fisheries government and academic researchers, policy makers, private fish breeder, government fish breeder, Director Fisheries(Eastern Province)	Current status of culture based fisheries in Sri Lanka: future prospective, issues and constraints	June 2012	Wijenayake, K.	Presentation, glossary of terms, questionnaire, briefing statement
		Using MCDA to make informed decisions to improve fingerling production in the Eastern Province, Sri Lanka	June 2012	Dawson, J.	Presentation, glossary of terms, questionnaire, briefing statement
		Current status of culture based fisheries in the Eastern Province: issues and constraints	June 2012	Sudaharan, S.	Presentation, glossary of terms, questionnaire, briefing statement
Culture based fishery stakeholder meeting	Culture based fishermen and fisherwomen; pond farmers; aquaculture academics and	Evaluation of MCDA stakeholder meeting	June 2012	Wu, J.	Presentation, glossary of terms, briefing statement and

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
	government researchers, policy makers, NGOs, fisheries officers, fish breeders, Directors Fisheries/aquatic resources (NWP and Eastern Province)				questionnaire (all outputs disseminated in Tamil, Sinhalese and English)
		The fingerling production strategies in Sri Lanka	June 2012	Wijenayake, K.	Presentation, glossary of terms, briefing statement and questionnaire (all outputs disseminated in Tamil, Sinhalese and English)
		Current status of culture based fisheries in the Eastern Province: issues and constraints	June 2012	Sudaharan, S.	Presentation, glossary of terms, briefing statement and questionnaire (all outputs disseminated in Tamil, Sinhalese and English)
		Using MCDA to make informed decisions to improve fingerling production in the Eastern Province, Sri Lanka	June 2012	Dawson, J.	Presentation, glossary of terms, briefing statement and questionnaire (all outputs disseminated in Tamil, Sinhalese and English)
Mid-term workshop: Promoting rural income from sustainable aquaculture through social learning in Sri Lanka	Wayamba University of Sri Lanka project team; University of Calgary team; Eastern University researchers, Director (s) Fisheries NWP and EP; IDRC representative	Project research update presentations (7 presentations) from Canadian and Sri Lankan team members	March 2011	Wijenayake, K., Dawson, J., DeJager, T. Wanninayake, WMTB, Jayacodi, DS, Jayacodi, S., Jayasinghe, JMPK	Presentations (7)
Scientific forum of Grant Commission Committee	Sri Lankan University Grant Commission committee members: academics, government agents and policy members	Bivalve culture in Sri Lanka: Future prospects	November 2011	Wanninayake, WMTB	presentation

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
Oyster culture community awareness program: Gangewadiya District	Fishermen and fisher women	Oyster culture in small fisheries communities	September 2011	Wanninayake, WMTB, Karunathilake, HCB, MM. Subasinghe	Presentation and Expert support to communities to support new and on-going oyster culture and research activities
Oyster culture community awareness program: Gangewadiya District	Fishermen and fisher women	Oyster culture in small fisheries communities	August 2011	Wanninayake, WMTB, Karunathilake, HCB, MM. Subasinghe	Presentation and Expert support to communities to support new and on-going oyster culture and research activities
Oyster culture community awareness program: Gangewadiya District	Fishermen and fisher women	Oyster culture in small fisheries communities	July 2011	Wanninayake, WMTB, Karunathilake, HCB, MM. Subasinghe	Presentation and Expert support to communities to support new and on-going oyster culture and research activities
Culture based fishery awareness program: Mataluwawa Reservoir, Polpitigama	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Kumbalporea Reservoir, Polpitigama	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Wawulewa Reservoir, Polpitigama	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Nelumwewa Reservoir, Polpitigama	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Amunakole Reservoir, Polpitigama	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery	Culture based fishery and	Culture based fisheries activities in	September	Wijenayake, K.	Presentation, training

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
awareness program: Bogahamula Reservoir, Polpitigama	reservoir community members including fishermen and fisher women	Sri Lanka	2011		material (Sinhalese and English)
Culture based fishery awareness program: Heeralugama Reservoir, Polpitigama	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Talambuwa Reservoir, Polpitigama	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Katupiladambuwa Reservoir, Bingriya	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Wannappuwa Reservoir-north, Wennappuwa	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Wannappuwa Reservoir-south, Wennappuwa	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Soya Reservoir, Anamaduwa	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Wettamurukkuwa Reservoir, Anamaduwa	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)
Culture based fishery awareness program: Daluwegama Reservoir, Anamaduwa	Culture based fishery and reservoir community members including fishermen and fisher women	Culture based fisheries activities in Sri Lanka	September 2011	Wijenayake, K.	Presentation, training material (Sinhalese and English)

Event at which presentation was given	Audience reached	Title	Date	Primary author/presenter/researcher	Product disseminated
Shrimp Farming Sustainability Workshop Batticaloa, Eastern Province	Sri Lankan shrimp farmers, university students, government agencies and Sri Lankan Air Force	Improving Knowledge and Information Access and Sharing	September 2011	DeJager, T.	presentation
		Sustainability issues in shrimp aquaculture: lessons from the North Western Province	September 2011	Jayasinghe, JMPK.	presentation
Sri Lanka Aquaculture Development Alliance	Sri Lankan policy makers, farmers, service providers	The status of present BMP implementation in Sri Lanka	July 2011	Jayasinghe, JMPK.	presentation
Research in progress series, University of Calgary	Canadian graduate students	A Survey of Shrimp Aquaculture in Sri Lanka: Identifying Farm-level Challenges to Achieving Sustainability	April 2011	Westers, T.	presentation
Project inception workshop: Promoting rural income from sustainable aquaculture through social learning in Sri Lanka	Sri Lankan aquaculture researchers, academics, government researchers, government policy makers, shrimp, freshwater ornamental and culture based fisheries farmers; Canadian Researchers, IDRC representatives	Proposed Project research presentations (9 presentations) from Canadian and Sri Lankan team members	February 2011	Wijenayake, K., Dawson, J., DeJager, T. Wanninayake, WMTB, Jayacodi, DS, Jayacodi, S., Jayasinghe, JMPK, Stephen, C., Castledine, A.	Presentations (9)
Research in progress series, University of Calgary	Canadian graduate students	Sustainable aquaculture in Sri Lanka: social networks, knowledge and gender.	Dec, 2010	Wu, J.	presentation
International Development Community of Practice	International veterinary practitioners, academics, government agents, policymakers IDRC program manager	Project management challenges for international development research	Dec 2010	DeJager, T.	On-line presentation
International Association of Project management professionals	International project management specialists	Building and maintaining health research across cultures'	Oct, 2010	Stephen, C.	On-line presentation

Table 4: Technical Research reports

Title	Date	Primary authors/ organizations responsible	Audience reached	Product disseminated
A Proposed Policy Framework for the Sustainable Development of Freshwater Ornamental Aquaculture & Review of Sri Lanka Policy & Legislation to support the Sector.	November 2011	Dawson, J., Stephen, C., Wade, J.	Director General of Fisheries and Aquatic Resources, National Aquaculture Development Authority; Director(s) Fisheries, North-western Province and Eastern Province; Research team Wayamba University of Sri Lanka	Hard copy and digital format

Table 5: Books

Title / Reference & Summary Description	Date	Primary authors	Product disseminated	Location of output
Oyster Culture in Sri Lanka	September 2012	Wanninayake, WMTB, Subasinghe, MM	Book (Sinhalese, Tamil and English)	Wayamba University of Sri Lanka and CD
Brackish Water Shrimp Culture Industry in Sri Lanka: Better management interventions	December 2012	Jayasinghe, JMPK, Guhnarathna, TVMN, PKR, Sandaruwan	Book (Sinhalese, Tamil and English)	Wayamba University of Sri Lanka; distributed to government and academic researchers; shrimp farmers and shrimp industry leaders; aquaculture graduate students of Wayamba University

Table 6: Bulletin, newsletter, pamphlets

Title	Date	Primary authors/ organizations responsible	Audience reached	Product disseminated
Utilization of acid soil for coastal aquaculture	December 2012	Jayasinghe, JMPK, Arshad Ali, A.	Small holder shrimp farmers (North-western and Eastern Province)	Brochure (language: Sinhalese and Tamil)
Biosecurity: shrimp farms	December 2012	Jayasinge, JMPK, Gunarathna, TVNM	Small holder shrimp farmers (North-western and Eastern Province)	Brochure (language: Sinhalese and Tamil)
Pond preparation: shrimp farms	December 2012	Jayasinghe, JMPK, Gunarathna, TVNM	Small holder shrimp farmers (North-western and Eastern Province)	Brochure (language: Sinhalese and Tamil)
Pond bottom management: shrimp farms	December 2012	Jayasinghe, JMPK, Gunarathna, TVNM	Small holder shrimp farmers (North-western and Eastern Province)	Brochure (language: Sinhalese and Tamil)
Water quality management: shrimp farms	December 2012	Jayasinghe, JMPK, Gunarathna, TVNM	Small holder shrimp farmers (North-western and Eastern Province)	Brochure (language: Sinhalese and Tamil)
What does the global scientific literature reveal about aquaculture impacts on human well-being and food security?	December 2012	Burns, T.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Using research about how shrimp farmers access knowledge about shrimp farming to increase farmer success in Sri Lanka	December 2012	DeJager, T.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Changing the role of shrimp farmer society leaders to improve knowledge sharing in Sri Lanka	December 2012	DeJager, T.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Food Security in the Sri Lankan Shrimp Farming Industry	December 2012	Wu, J.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website

Title	Date	Primary authors/ organizations responsible	Audience reached	Product disseminated
Women in the Sri Lankan shrimp farming industry (preliminary results)	December 2012	Wu, J.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Lessons from measuring sustainable farming practices of smallholder shrimp farms in the North Western and Eastern Provinces of Sri Lanka	December 2012	Westers, T.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Best management practices associated with reported white spot disease prevalence in the North Western Province	December 2012	Jayacodi, S.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Using Multi-Criteria Decision Analysis to identify fish fingerling production options for culture based fisheries in Sri Lanka	December 2012	Dawson, J.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Does the national policy environment support development of sustainable freshwater fish aquaculture in Sri Lanka?	December 2012	Dawson, J.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Can Short Messaging System (SMS) to farmers improve implementation of Better Management Practices to manage disease and increase sustainability?	December 2012	DeJager, T.	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
The relative performance of stocked species for culture-based fisheries in non-perennial reservoirs in North-Western Province of Sri Lanka	December 2012	Wijenayake, K	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Knowledge transfer, management, and sustainability of culture-based	December 2012	Wijenayake, K	Sri Lankan and international aquaculture researchers,	AquaLanka Website

Title	Date	Primary authors/ organizations responsible	Audience reached	Product disseminated
fisheries in non-perennial reservoirs in North-Western Province of Sri Lanka			academics, industry, students, government policy, research, and extension officers	
Community based mangrove oyster (<i>Crassostrea madrasensis</i>) culture at Kala-oya estuary of Puttalam lagoon, Sri Lanka: New challenge in aquaculture through knowledge transfer	December 2012	Wanninayake, WMTB	Sri Lankan and international aquaculture researchers, academics, industry, students, government policy, research, and extension officers	AquaLanka Website
Slipper Lobster Fishery in Sri Lanka	April 2012	Jayacodi, DS	Southeast Asia Lobster academics and researchers	The Lobster Newsletter: 25 (1)
Empowering people to maintain sustainable aquaculture	June 2011	Empowering People to Maintain Sustainable Aquaculture	Shrimp farming industry association members (SLADA)	Brochure

Table 7: Policy briefs

Title / Reference & Summary Description	Date	Primary authors	Audience reached	Location of the output
North-western Province Fisheries and Aquaculture Policy and Five Year Plan	June 2011	Jayacodi, S.,	Secretary and Director of Fisheries, North-western Province	North-western Provincial Council, and Faculty, Aquaculture Department, Wayamba University of Sri Lanka
Using MCDA to assist in making informed decisions to improve Culture-based fisheries planning in Sri Lanka	November 2011	Dawson, J.	Director (s) Fisheries North-western Province and Eastern Province; Secretary of Fisheries Eastern Province; Director of National Aquaculture Development Authority (NAQDA)	North-western Provincial Council, Eastern Provincial Council and Faculty, Aquaculture Department, Wayamba University of Sri Lanka
Review and gap analysis of Sri Lankan freshwater fish aquaculture	June 2011	Dawson, J.	Director (s) Fisheries North-western Province and Eastern Province; Secretary of Fisheries Eastern Province; Director of National Aquaculture Development Authority (NAQDA)	Director (s) Fisheries North-western Province and Eastern Province; Secretary of Fisheries Eastern Province; Director of National Aquaculture Development Authority (NAQDA) and faculty of Wayamba University of Sri Lanka

Table 8: Essays

Title	Product disseminated	Date	Primary authors/ organizations responsible	Audience reached	Location of the output
Mapping the spread of disease in shrimp aquaculture in NWP of Sri Lanka in relation to current culture practices	Faculty Essay	2011	Jayacodi, S,	Researchers and students	Wayamba University of Sri Lanka -Library
Can Sri Lanka produce more lobsters?	Faculty Essay	June 2012	Jayacodi, DS	Researchers and students	Wayamba University of Sri Lanka -Library
Perception of Muslim shrimp farming community in Puttalam toward implementing BMPs	Undergraduate dissertation and abstract	August 2012	Arshad, A.	Researchers and students	Wayamba University of Sri Lanka -Library
Assessment of farm performances and economic viability of shrimp farms during disease outbreaks in North-western province and Eastern province	Undergraduate dissertation and abstract	August 2012	Hassan, ALI	Researchers and students	Wayamba University of Sri Lanka -Library
Rack culture of oysters (<i>Crassostrea madrasensis</i>) at Kal Oya estuary of Puttalam lagoon with special reference to spat falling, substrate competition and water quality parameters	Undergraduate dissertation and abstract	August 2012	Wickramapathirana , WPNV	Researchers and students	Wayamba University of Sri Lanka -Library

Table 9: Databases

Title / Reference & Summary Description	Date	Primary authors	Product disseminated	Location of the output
GIS data base on shrimp disease spreading in NWP	2011	Jayacodi, S.	No	Jayacodi, S.
Database of Shrimp Farm Survey (MS Access)	August 2011	Westers, T.	No	Westers, T.

Table 10: Photographs

Title / Reference & Summary Description	Date	Primary authors/ organizations responsible	Product disseminated	Location of the output
Project Photograph libraries	2011-2012	All team members	Photographs	Project Facebook Site, Photographs on file

Table 11: Manuals and training material

Title	Date	Primary authors/ organizations responsible	Product disseminated	Audience reached	Location of the output
Shrimp Survey Enumerators Training Manual	May 2011	Dr. J. Wu, Dr. T Westers	Trainees for shrimp farming survey	Field staff: shrimp survey	Wayamba University of Sri Lanka Library; Westers, T., Wu, J.
Introduction and overview of multi-criteria decision analysis	2011	Anderson, K.	Manual	Director, National Aquaculture Development Authority; Director, Fisheries Eastern Province, Sri Lanka; Aquaculture policy reviewers	Director, National Aquaculture Development Authority; Director, Fisheries Eastern Province, Sri Lanka; Centre for Coastal Health
Animal Health and Society Teaching Case (VETM 323)	May 2011	Stephen, C.	Manual	University of Calgary veterinary students	University of Calgary

Table 12: Evaluation reports

Title / Reference & Summary Description	Date	Primary authors/ organizations responsible	Product disseminated	Location of the output
Review of the IDRC-Funded Project: Promoting Rural Income from Sustainable Aquaculture through Social Learning in Sri Lanka	December 2012	Castledine, A.	Report	Centre for Coastal Health, Nanaimo, BC., Canada; Wayamba University of Sri Lanka

Table 13: Websites

Website Title	Date	Primary authors/ organizations responsible	Product disseminated	Audience	Location of the output
AquaLanka	On-going	DeJager, T., Daniel, S.,	Website	Sri Lankan shrimp farmers, researchers and government officers	http://lankashrimp.com
Sri Lanka Aquaculture Food Security Group – Google Group	On-going	University of Calgary and Wayamba University of Sri Lanka team members	Google group	Team members	http://groups.google.com/group/SLAFS
Facebook	On-going	Jayacodi, S.	Facebook page	Team and stakeholders	http://www.facebook.com/profile.php?id=1052255959

Table 14: Websites and other training tools

Website/Tool Title	Date	Primary authors/ organizations responsible	Product disseminated	Audience	Location of the output
AquaLanka	On-going	DeJager, T., Daniel, S.,	Website	Sri Lankan shrimp farmers, researchers and government officers	http://lankashrimp.com
Sri Lanka Aquaculture Food Security Group – Google Group	On-going	University of Calgary and Wayamba University of Sri Lanka team members	Google group	Team members	http://groups.google.com/group/SLAFS
Facebook	On-going	Jayacodi, S.	Facebook page	Team and stakeholders	http://www.facebook.com/profile.php?id=1052255959
Mobile SMS: mobile phone network and SMS gateway to disseminate real time best practices information	2012	Dejager, T., Sandaruwan, KRP	Mobile phone communication tool (Sinhalese and English)	Shrimp farmers	

Table 14: Newspapers and on-line news articles

Title / Reference & Summary Description	Date	Primary authors/ organizations responsible	Product disseminated	Location of the output Please provide weblink if applicable
Canada Helps Sri Lanka Improve Shrimp Farming	20 Feb 2012	No author	On-line article	http://www.thefishsite.com/fishnews/16496/canada-helps-sri-lanka-improve-shrimp-farming
Lankan Canadian Researchers to Improve Shrimp Farming	20 Feb 2012	Fernando, C.	Article: Sri Lanka Daily News	http://www.dailynews.lk/2012/02/20/news22.asp
Project Targets Sustainable Development of Sri Lanka's Shrimp Farming Industry in Wayamba	Feb 2012	DeJager, T.	Project Brief for Journalist	
Several newspapers in Sri Lanka in English, Sinhala and Tamil. Television report in Tamil. 2 plus 2 web announcements.	2011	No author	On-line article (s) and television	http://www.thefishsite.com/fishnews/14165/programme-set-up-to-boost-sri-lankas-aquaculture http://www.sundayobserver.lk/2011/02/06/oostory.asp?sid=20110204_08&imid=orna.jpg&dt=[February%2004%202011]
Development of Sustainable Shrimp Farming in the Northwestern Province	February 2012	DeJager, T.	Article	

ANNEX 3: GRADUATE STUDENT INFORMATION

Surname	Given name	Gender	Institution	Department	Country of research	Degree pursued	Title of Thesis	Date expected
Wu	Jessica	F	University of Calgary	Faculty of Veterinary Medicine	Sri Lanka	PhD	Aquaculture, food security, and gender roles in Sri Lanka	2014
Westers	Trisha	F	University of Calgary	Faculty of Veterinary Medicine,	Sri Lanka	MSc	Assessing sustainability of smallholder shrimp farms in Sri Lanka	Completed
De Silva	Janitha	M	Wayamba University of Sri Lanka	Department of Aquaculture and Fisheries	Sri Lanka	MPhil	To be determined	On-going
Gunarathne	Madavi	F	Wayamba University of Sri Lanka	Department of Aquaculture and Fisheries	Sri Lanka	MPhil	Cluster level adoption of better management practices in the shrimp farming industry in Sri Lanka	Completed
Karunathilake	Chandana	M	Wayamba University of Sri Lanka	Department of Aquaculture and Fisheries	Sri Lanka	MPhil	To be determined	On-going
Mohomed	Riyaz	M	Wayamba University of Sri Lanka	Department of Aquaculture and Fisheries	Sri Lanka	MPhil	To be determined	On-going
Hewapathirana	Kalani	F	Wayamba University of Sri Lanka	Department of Aquaculture and Fisheries	Sri Lanka	PhD	To be determined	On-going

ANNEX 4: POST-DOC INFORMATION

Surname	Given name	Gender	Institution	Department	Country of research	Research
Wijenayake	WMHK	M	Wayamba University of Sri Lanka	Department of Aquaculture and Fisheries	Sri Lanka	Identify good management approaches in culture-based fisheries for its sustainability in the North-western Province. This research also looked at the performance of food fish stocked into the study area's reservoirs.
Jayacodi	S	F	Wayamba University of Sri Lanka	Department of Aquaculture and Fisheries	Sri Lanka	Investigated environmental aspects of shrimp farming in the North-western Province. This research was based on water quality fluctuations during both farming and non-farming seasons of shrimp culture cycles and the influence of water quality fluctuation on disease outbreaks.
Burns	T	F	University of Calgary	Faculty of Veterinary Medicine, University of Calgary	Canada	Investigated knowledge network flows and the application of Mobile SMS to enhance knowledge connectivity and improve shrimp health and sustainability outcomes for Sri Lanka aquaculture. Performed a systematic literature review on aquaculture and links to food security and poverty reduction