RESEARCH PROGRAM ON Fish
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Rice-fish pathways to sustainable development impact in Cambodia and the Lower Mekong

Report on ACIAR and the WorldFish-IRRI-IWMI symposium and theory of change

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Rice-fish pathways to sustainable development impact in Cambodia and the Lower Mekong

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About ACIAR

The Australian Centre for International Agricultural Research (ACIAR) brokers, facilitates and invests in and manages strategic partnerships with public and private research institutions to improve the productivity and sustainability of agricultural systems and the resilience of food systems in partner countries.

About FiA, Fisheries Administration of the Royal Government of Cambodia

The Fisheries Administration (FiA) envisions management, conservation and development of sustainable fisheries resources that contribute to food security and socioeconomic development to enhance people´s livelihoods and the nation's prosperity.

About IRRI

The International Rice Research Institute (IRRI) aims to improve livelihoods and nutrition by abolishing poverty, hunger and malnutrition among those who depend on rice-based agri-food systems. In doing so, the IRRI's work protects the health of rice farmers and consumers, and the environmental sustainability of rice farming in a world challenged by climate change. The IRRI's work promotes the empowerment of women and supports opportunities for youths in an equitable agri-food system.

About IWMI

The mission of the International Water Management Institute (IWMI) is to provide evidence-based solutions to sustainably manage water and land resources for food security, livelihoods and the environment. The IWMI works in partnership with governments, civil society and the private sector to develop scalable agricultural water management solutions that have a tangible impact on poverty reduction, food security and ecosystem health.

About WorldFish

WorldFish is a nonprofit research and innovation institution that creates, advances and translates scientific research on aquatic food systems into scalable solutions with transformational impact on human well-being and the environment. Our research data, evidence and insights shape better practices, policies and investment decisions for sustainable development in low- and middle-income countries.

We have a global presence across 20 countries in Asia, Africa and the Pacific with 460 staff of 30 nationalities deployed where the greatest sustainable development challenges can be addressed through holistic aquatic food systems solutions.

Our research and innovation work spans climate change, food security and nutrition, sustainable fisheries and aquaculture, the blue economy and ocean governance, One Health, genetics and AgriTech, and it integrates evidence and perspectives on gender, youth and social inclusion. Our approach empowers people for change over the long term: research excellence and engagement with national and international partners are at the heart of our efforts to set new agendas, build capacities and support better decision-making on the critical issues of our times.

WorldFish is part of One CGIAR, the world's largest agricultural innovation network.

Acknowledgments

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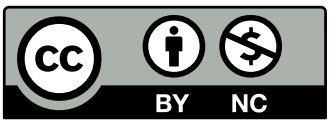

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Table of contents

List of abbreviations

ACIAR	Australian Centre for International Agricultural Research
FiA	Fisheries Administration of the Royal Government of Cambodia
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
One CGIAR	Consortium of International Agricultural Research Centers
UNSW	University of New South Wales

Executive summary

Rice and fish are central to the livelihoods and nourishment of the people of Cambodia and of other nations in the Lower Mekong Region. They are vital to progressing many of the targets of the Sustainable Development Goals (SDGs) related to livelihoods and nutrition and health. The ways that rice and fish are produced, distributed and consumed will also influence the degree to which biodiversity is conserved, ecosystem functions and services are protected, and the maintenance of water quality and flows that define the Mekong. Integrated production of rice and fish offers important lessons and opportunities for meeting multiple well-being targets and environmental objectives, as well as developing cross-sectoral partnerships. In recognition of this, a collaboration was developed to envision the contribution of integrated rice and fish production to impact pathways for meeting well-being targets and environmental objectives. This collaboration drew upon place-based and long-term experiences of WorldFish, the International Rice Research Institute (IRRI), the International Water Management Institute (IWMI), the Fisheries Administration of the Royal Government of Cambodia (FiA) and the Australian Centre for International Agricultural Research (ACIAR). These were shared through a symposium that reflected on context-specific lessons for integrated rice and fish production. This was followed by a participatory theory of change exercise that helped integrate lessons, diverse expertise and common objectives into on-farm, landscape and value chain impact pathways. There are several expected outcomes from the impact pathways, including (a) sustainably managed, resilient fish and rice agroecosystems, (b) equitable rural livelihood improvements, (c) improved availability of Cambodian produced fish/prawn in local and urban markets, and (d) enhanced nutrition security for women, men, youths and children in Cambodia. The aim of this report is to share the symposium lessons and the envisioned impact pathways and their associated theory of change to inform long-term planning and enable strategic investment in rice-fish agroecosystems in Cambodia and the Lower Mekong Region. Various One CGIAR initiatives that are currently under development may be able to build on this report in one of two ways: (1) implement or adapt and implement the proposed theory of change for Cambodia, or (2) use the information to plan investments into fish and rice systems in other nations within large river basins and deltas in Southeast Asia or elsewhere.

Community members fishing in rice fields with bamboo basket traps. They consume much of their catch and sell the rest to their neighbors, thereby improving diets and generating income.

Introduction

The Lower Mekong is a region with diverse societies, aquatic species and food production systems. Wetlands cover approximately 30% (roughly 191,000 km^2) of the Lower Mekong Basin, about 86% of which is classified as rice fields (Hortle et al. 2008). The majority of the 237 million people of the Lower Mekong live in rural areas, and agricultural employment remains especially important in Cambodia, Laos and Myanmar (Ingalls et al. 2018). Lower Mekong nations are also faced with complex challenges due to climate change, and setbacks to health and economies during the COVID-19 pandemic, as well as persistent poverty, food insecurity and malnutrition. At national and subnational levels, these challenges are shaped by dynamic environmental, sociopolitical and economic conditions. Rural populations are particularly affected, lagging behind their urban counterparts in benefitting from economic growth in the region (Ingalls et al. 2018). Additionally, they are in need of initiatives that position them centrally in accelerating progress toward the SDGs such as Zero Hunger, No Poverty and Climate Action. Rice and fish, which are central to the livelihoods and nourishment of these rural populations, offer key opportunities to address the challenges and meet the SDGs.

Transformation of agricultural landscapes and food systems is entering a new phase in Cambodia and the Lower Mekong. Previous transformations followed the Green Revolution model of intensified monoculture. Yet Cambodia and other nations in the region did not fully undergo this transformation (Freed et al. 2020a). Currently, while intensifying, commercializing and increasing production is still a focus, many countries are recognizing a sustainable approach requires additional strategies. Broadly these strategies emphasize a range of objectives, including diversification for more resilient production and livelihoods, high-value production, and nutrition-sensitive production for food security (MAFF 2019; MARD 2021). These shifts in agricultural transformation entail trade-offs, changes in resource allocation and use, and transitions in production practices and farm enterprises. A prerequisite for successful transformation is multipronged and strategically informed actions, based on sound scientific evidence.

In this report, "rice-fish" refers refer to the cultivation of rice while allowing simultaneous or rotational presence of naturally occurring fish and other aquatic species (that are harvested through fisheries) and/or introduced fish populations (that are cultured) (FAO 2014). There are a number of production systems fitting this description. The aim of this report is to lay out rice-fish research and development impact pathways that are situated in context and that draw from broad ranges of experience, knowledge and expertise in the geographic and technical areas. This can support strategic investment and inform long-term planning on rice-fish interventions in agri-food systems. This report summarizes a collaborative process among WorldFish, IRRI, IWMI, FiA and ACIAR that intended to produce a co-developed concept. As such, all of these organizations are ready to participate in the next steps with clear roles and modes of interaction, building on their respective strengths to deliver the necessary research, innovation and training alongside farmers and stakeholders within territorial food systems. The collaborative process comprised two key steps: a symposium and an exercise of theory of change development.

The symposium initiated the collaborative dialogue to determine the need and opportunity for a research-for-development investment in rice-fish systems. Six collaborative presentations were delivered, covering issues and opportunities known to influence fish and rice agri-food systems of the Lower Mekong. The scope was broad, from farm to landscape level, and the intention was to consider the achievement of development goals, including reducing hunger and malnutrition and increasing resilience to climate change impacts. The symposium presentations provided an overview of the status of rice-fish in Cambodia, lessons from rice-fish implementation in other countries in the region, and relevant work on cross-cutting themes of gender and food and nutrition security.

The information in the symposium informed a theory of change exercise. The objective of the exercise was to identify technical, social, cultural and political drivers and/or barriers to the rice-fish sector in Cambodia, key knowledge gaps, and particular areas for collaboration. Once again a collaborative process, a core group of symposium participants went on to develop the theory of change. Consultants from the Australian firm Clear Horizon Consulting facilitated the theory of change exercise, with the ACIAR Fisheries Programme providing support. The theory of change then underwent several iterations of feedback and revisions to refine logic and coherence, account for key drivers and assumptions and increase feasibility before its finalization.

Home gardening in rice-fish systems generates income and increases nutrition for women and children. Boeng Kampeng CFR, Pursat.

1. Presentations

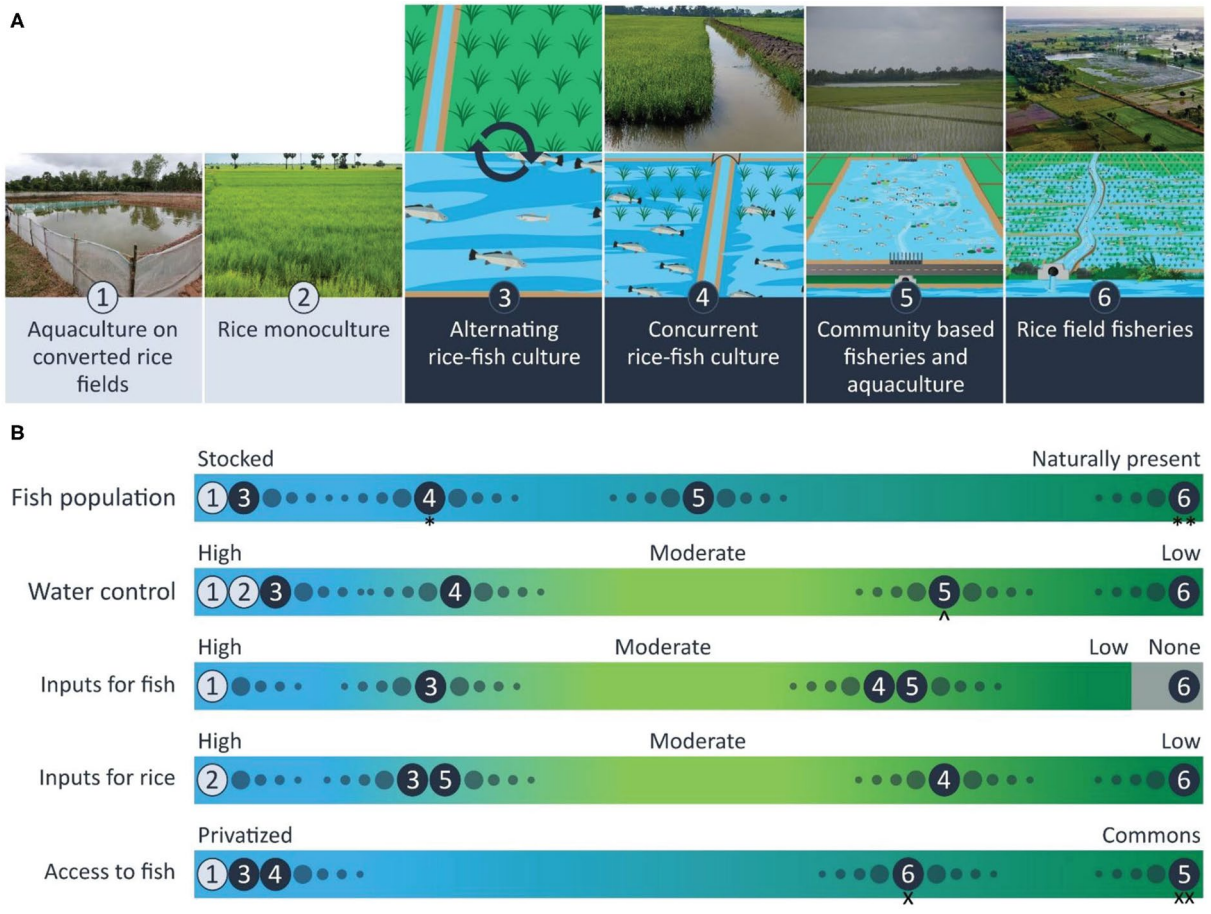
1.1. Rice-fish landscapes, knowledge and practice: An overview focusing on Cambodia, Myanmar and Bangladesh

Presenters: Sarah Freed, WorldFish; Sudhir Yadav, IRRI; Alexander Stuart, IRRI

Summary: This presentation introduced a typology of rice-fish systems across technical and governance parameters (Figure 1), followed by country specific information on predominant rice-fish systems, key areas of knowledge and innovation, and current considerations for implementation and scaling.

Cambodia, Myanmar and Bangladesh differ in predominant rice-fish systems and therefore also in key innovations and challenges.

In Cambodia, rice field fisheries are the predominant rice-fish system. They are governed as a commons, providing benefits across wealth and land ownership status. Best management practices of fish refuge areas have been innovated to enhance these fisheries. Increasing drought, flooded forest habitat loss, and road and irrigation infrastructure development all pose challenges to maintaining the integrity of Cambodia's fish agri-food systems, especially rice field fisheries.



* *May include some naturally present.*
** *May include some stocking.*
Λ *Water control is low during monsoon season and fish production, but irrigation is used during dry season for rice cultivation.*
× *May include privatization of fish remaining in ponds within rice fields after flood recession.*
×× *Commons for small wild fish harvest, contractual shared access for cultured and wild fish.*

Source: Adapted from Freed et al. 2020a.

Figure 1. Typology of rice-fish production practices. Note: (A) Illustrations and photos depict each of four exemplars (3–6) and their monoculture reference points (1, 2); (B) types distinguished by use of agroecological attributes along a continuum of (high to low) control and substitution of natural processes.

In Myanmar, rice field fisheries and coastal rice-fish alternating culture are both present in the country. Concurrent rice-fish culture has been tested by the ACIAR and CGIAR, and policy innovation to allow adaptation of rice fields to accommodate fish is a key need for implementation and scaling. Further innovations to the production techniques in light of resource trade-offs could be researched as well.

In Bangladesh, alternating rice-fish culture is prevalent. Commons style governance has been trialed for fish culture in large inundated areas. The coordination and benefits sharing required for this common-pool approach are challenging to implement successfully. Further research is needed on the most suitable fish species and managing water for both fish and rodent control.

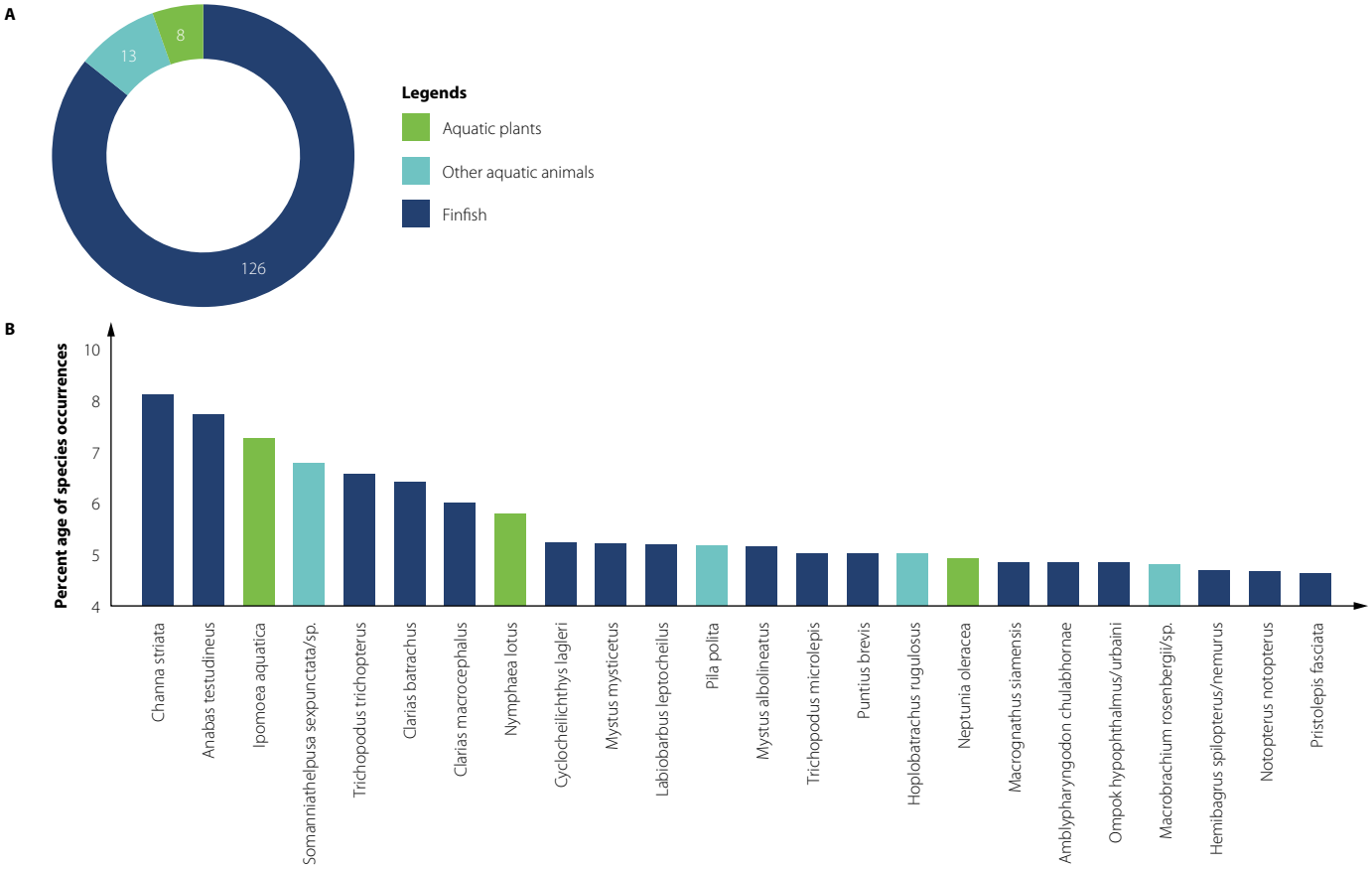
1.2. Policy environment and potential research for rice-fish in Cambodia

Presenters: Sarah Freed, WorldFish; Rica Flor, IRRI; Somony Thay, Department of Aquaculture, Fisheries Administration; Sudhir Yadav, IRRI

Summary: The state of rice-fish knowledge and practice in Cambodia was presented, including an overview of research, innovations, policies and other considerations relevant to rice-fish system development and scaling. Rice field fisheries are the most longstanding and widespread rice-fish system in Cambodia. Other systems that have been trialed are primarily the use of ponds to rear fish within the rice field landscape.

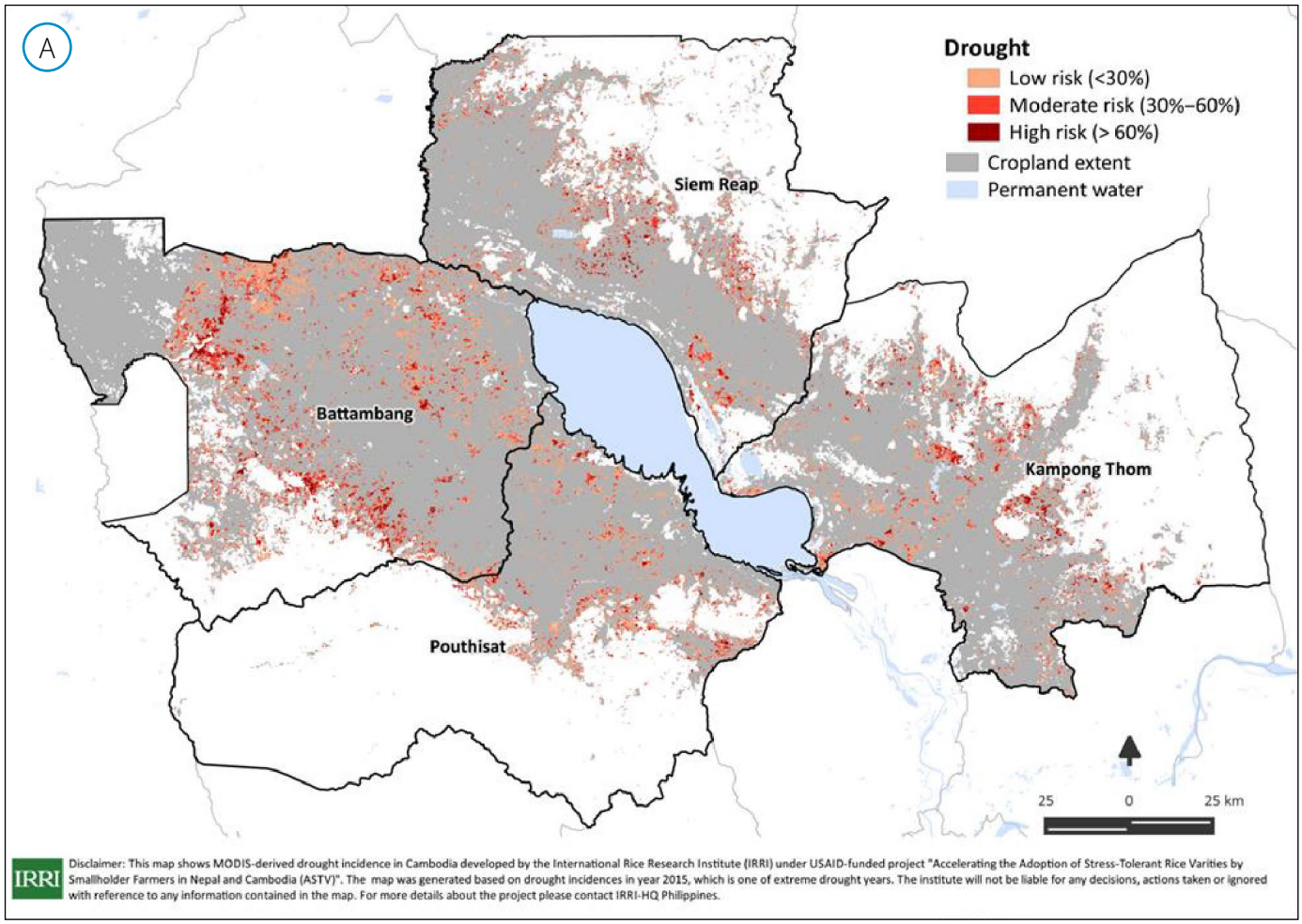
Fisheries, agriculture and nutrition policies recognize the contribution of rice field fisheries. However, more consistency is needed across policies as there is potential for intensified rice production and development of irrigation infrastructure to negatively affect rice field fisheries. WorldFish and Cambodia's Fisheries Administration have collaborated to develop management best practices for community fish refuges, an innovation to enhance rice field fisheries.

The high aquatic species diversity (Figure 2) and heterogeneous topography (Figure 3) within Cambodia's rice field landscapes mean there are several species- and water-related considerations to



Source: Reproduced with permission from Freed et al. 2020b.

Figure 2. Species reported in household catch recall surveys. Note: (A) number of species of finfish, other aquatic animals, and aquatic plants; (B) percentage of all occurrences in which a species was reported (figure is truncated at 75%, see Freed et al. 2020b supplementary Table 1 for full species list).



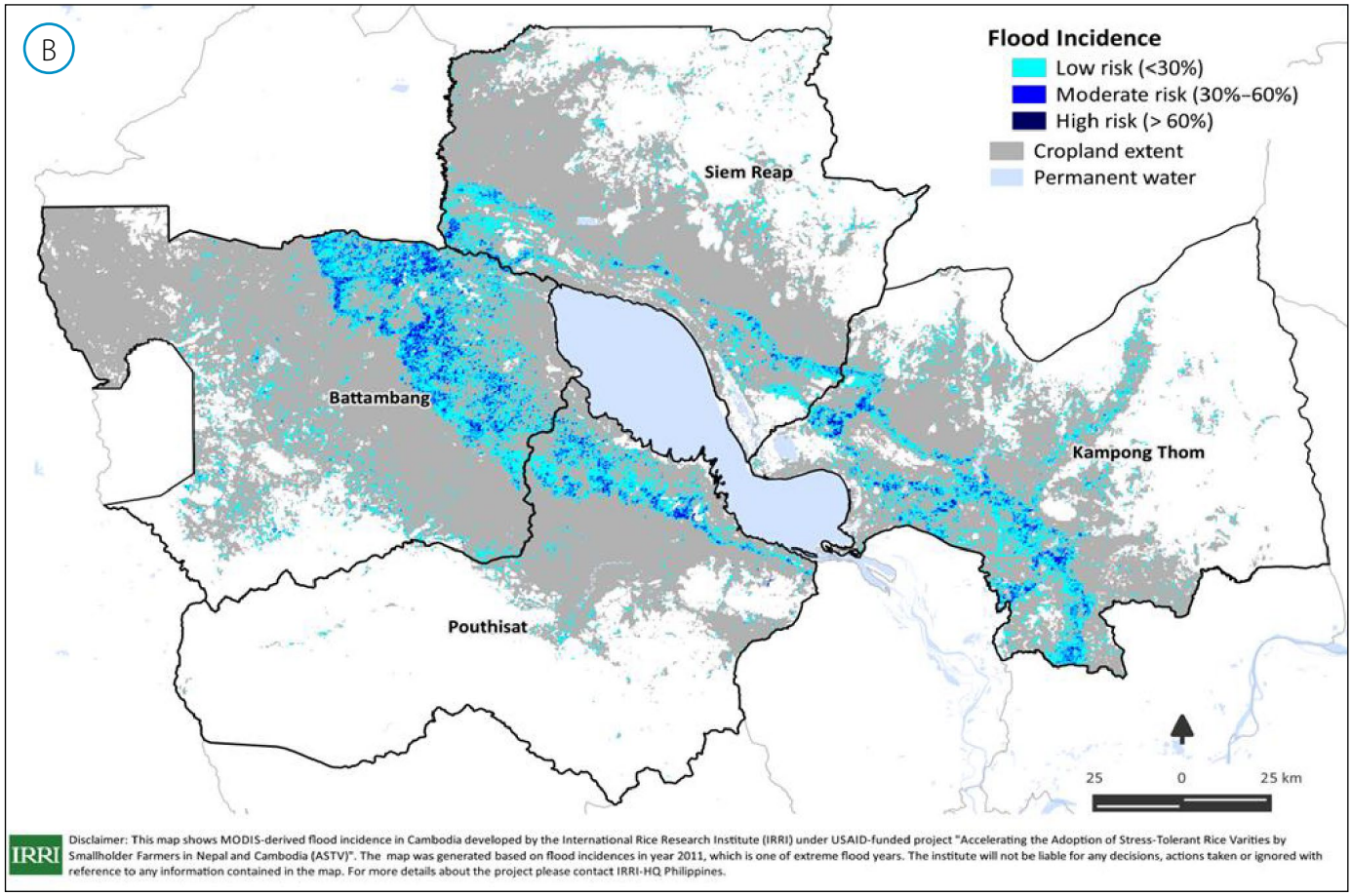


Figure 3. Example of studies on heterogeneous topography with varying risks for (A) drought and (B) flood within rice production areas in the Tonle Sap region of Cambodia.

make when designing a rice-fish system. Pesticide use and timing or synchronicity of rice planting, among other rice production practices, can constrain options for rice-fish production. Capacity of many actors along the rice-fish value chain may need to be assessed and improved. Among additional challenges are the low price of aquaculture imports from neighboring countries and techniques to sustain and diversify the pool of fish species cultured. Small indigenous species may provide feasible opportunities for the latter challenge.

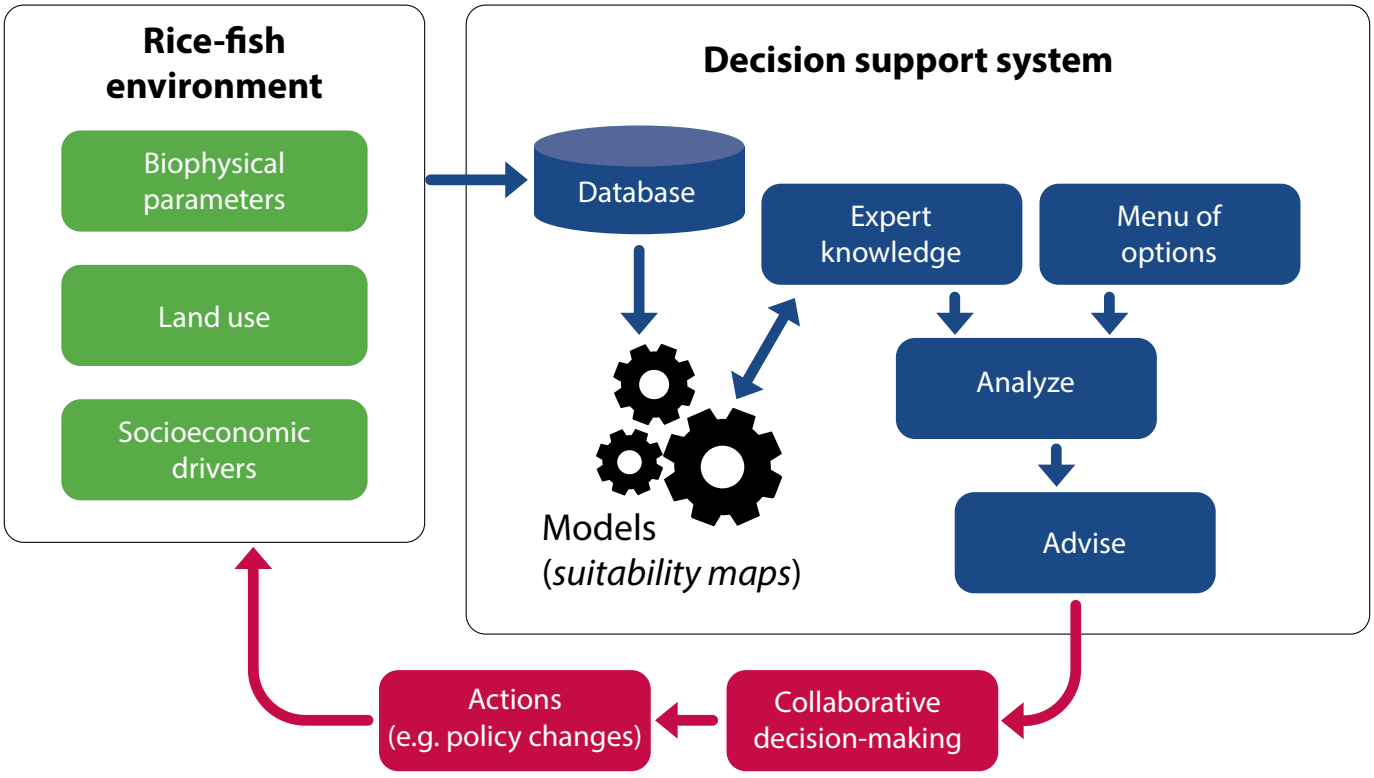
1.3. Novel fish agri-food system innovations: ACIAR & CGIAR collaborations in Myanmar

Presenters: Mark Dubois, WorldFish; Matthew McCartney, IWMI; Alexander Stuart, IRRI

Summary: This presentation shared lessons from collaboration (WorldFish, IWMI and IRRI) on a food systems approach to rice-fish research and innovation in Myanmar. Land use planning, policy and decision-making have been identified as primary challenges to scaling rice-fish culture in Myanmar. At the same time, there is growing recognition and support for diversified and nutrition-focused food production.

Results from a rice-fish concurrent culture field trial were presented along with preliminary results from suitability mapping for scaling rice-fish concurrent culture. Further refinement of the suitability map is planned to incorporate additional biophysical, land use and socioeconomic data. The goal of this mapping process is to contribute information for a decision support system that integrates the data with expert knowledge to provide a "menu of options" for decision-making on land use planning and policy (Figure 4). Capacity building is also needed in both the decision-making and agricultural extension services.

WorldFish and the IWMI have also collaborated on other resources for integrating fisheries into management of water infrastructure. Upcoming collaboration will look at regional diets and food production.



Source: Adapted from Rosso et al. 2012.

Figure 4. Designing a decision support system for integrated intersectoral planning.

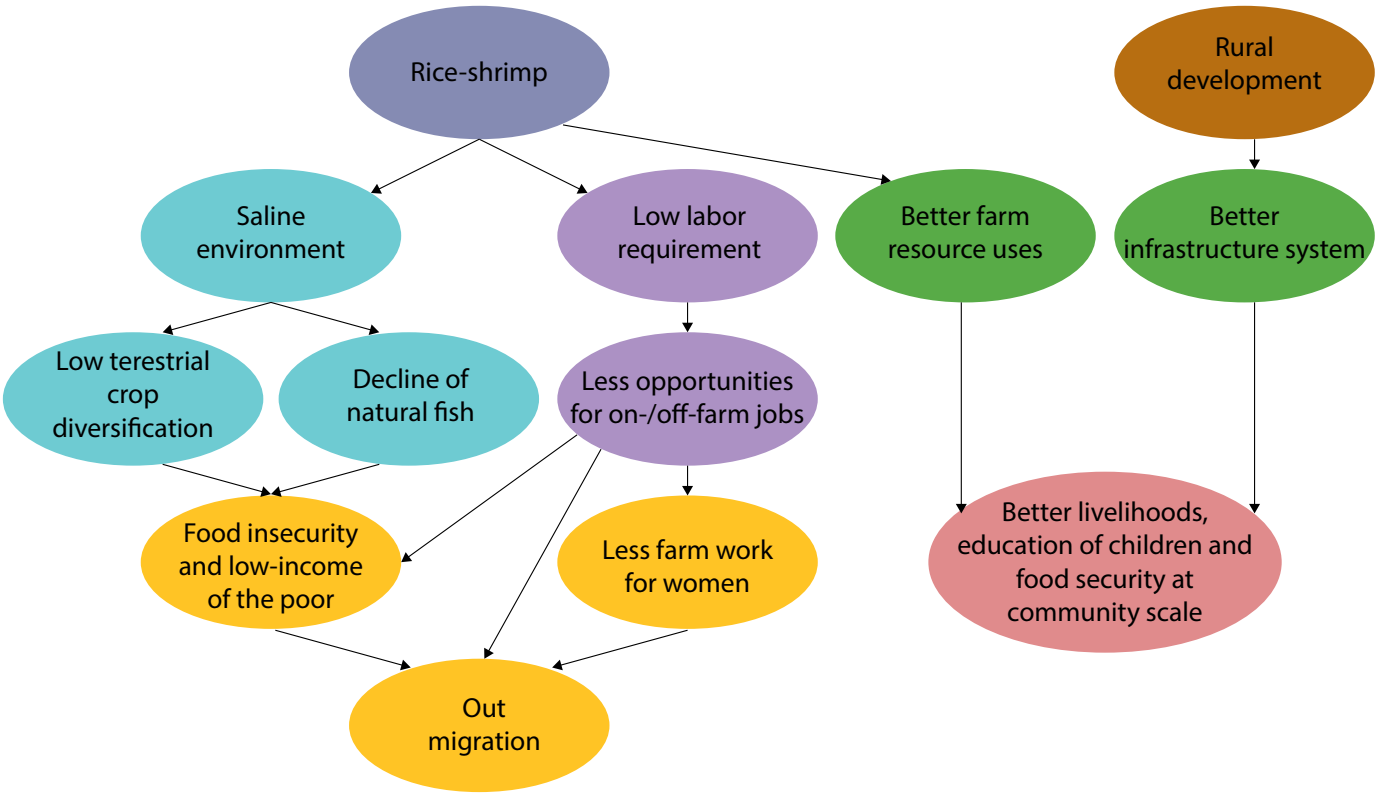
1.4. Improving the sustainability of rice-shrimp farming systems in the Mekong Delta, Vietnam

Presenters: Jes Sammut, UNSW; Dr. Nguyen van Sang, Director, Research Institute for Aquaculture, Vietnam

Summary: This presentation provided an overview of research on rice-shrimp farming systems in the Mekong Delta, Vietnam. The project investigated the sustainability of rice-shrimp farming systems by identifying key risk factors, describing and quantifying the productivity benefits, and developing, testing and promoting improved management strategies.

Bayesian Belief Networks were used to evaluate the production system and identify risk factors, using expert knowledge from farmers, extension officers and scientists, and incorporating environmental, production and economic data. Dry and wet season environmental processes were also investigated. High wet season salinity affected rice production. The key risk factor for shrimp production was poor water quality, particularly high water salinity, elevated water temperature and low dissolved oxygen concentration. Environmental stress and a lack of natural food production impacted shrimp growth. The project tested modified rice platform preparation, changes to the timing of rice planting, use of salt-tolerant rice varieties and fertilizer replacement using shrimp crop sludge; these methods improved rice production. Methods to improve water quality and shrimp nutrition have yet to be rigorously tested and require follow-up research. The shrimp nutrition issue needs to be resolved before the production system can be promoted, and it is a high priority for the Vietnamese government.

Research was conducted in a participatory manner with farmers and extension staff. Challenges and opportunities were identified for rice-shrimp production livelihoods (Figure 5), and farmer capacity building was conducted. Research capacity building was also achieved for Australian and Vietnam research universities.



Source: Adapted from Sammut et al. 2020.

Figure 5. Challenges and opportunities for rice-shrimp production livelihoods.

1.5. Women's empowerment in rice-fish value chains

Presenter: Jessica Scott, WorldFish

Panelists: Sarah Freed, Wae Win Khaing, Cynthia McDougall and Surendran Rajaratnam, WorldFish

Summary: This presentation shared lessons on research methods and inclusive processes using a gender lens. A brief presentation was followed by questions to a panel of researchers to illustrate specific examples of the gender lens approach.

The presentation provided the rationale for a gender lens approach, including the importance of recognizing and incorporating intersectionality. In developing a theory of change, the assumptions that the change mechanisms depend upon may or may not be correct and would be "tested" during the intervention (Figure 6). A typology of gender outcomes was also presented, including reach, access to resources and benefits, empowerment and transformation (Figure 7). Assumptions for meeting each outcome must be tested as well.

Panelists shared project-based experiences from Myanmar, India and Cambodia. Examples of the gender lens approach in these projects included (a) training project staff to recognize the project assumptions and evaluate their accuracy against the field results, (b) approaches to interventions to target specific gender outcomes, and (c) tools and methods for the approach, such as a tool to assess women's empowerment outcomes in aquaculture value chains.

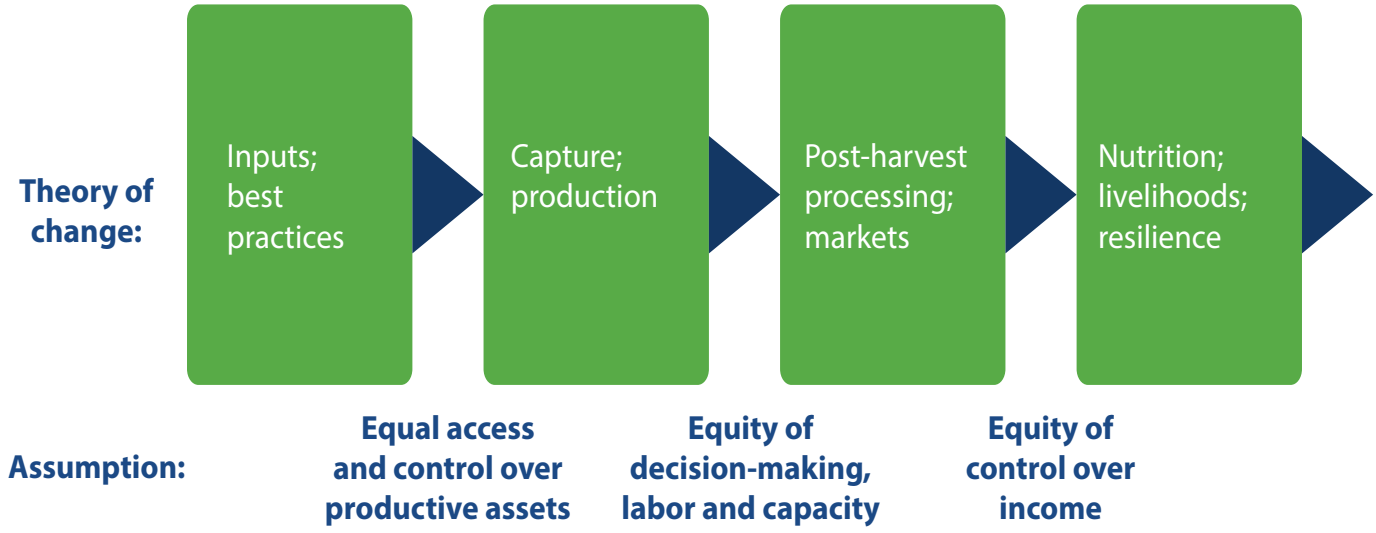
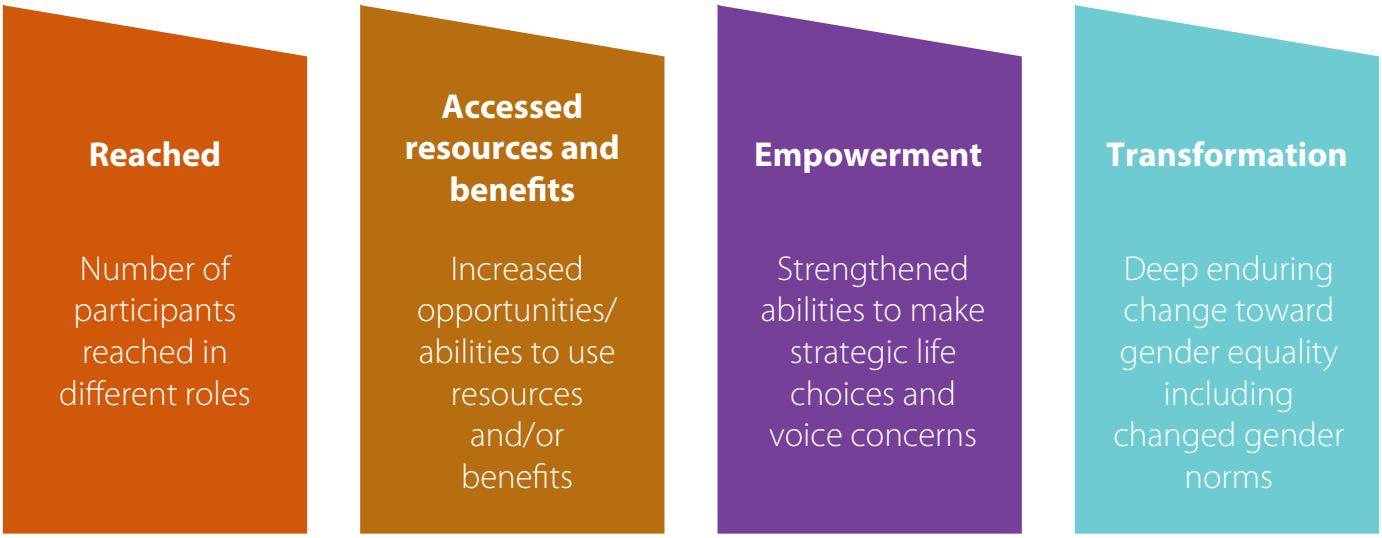


Figure 6. Sample of a simplified theory of change and assumptions made for gender-equitable outcomes.



Source: FISH Gender integration guidelines (forthcoming). Adapted from Johnson et al. 2018; Danielsen et al. 2018 and 2019.

Figure 7. Gender outcomes typology (work toward the right).

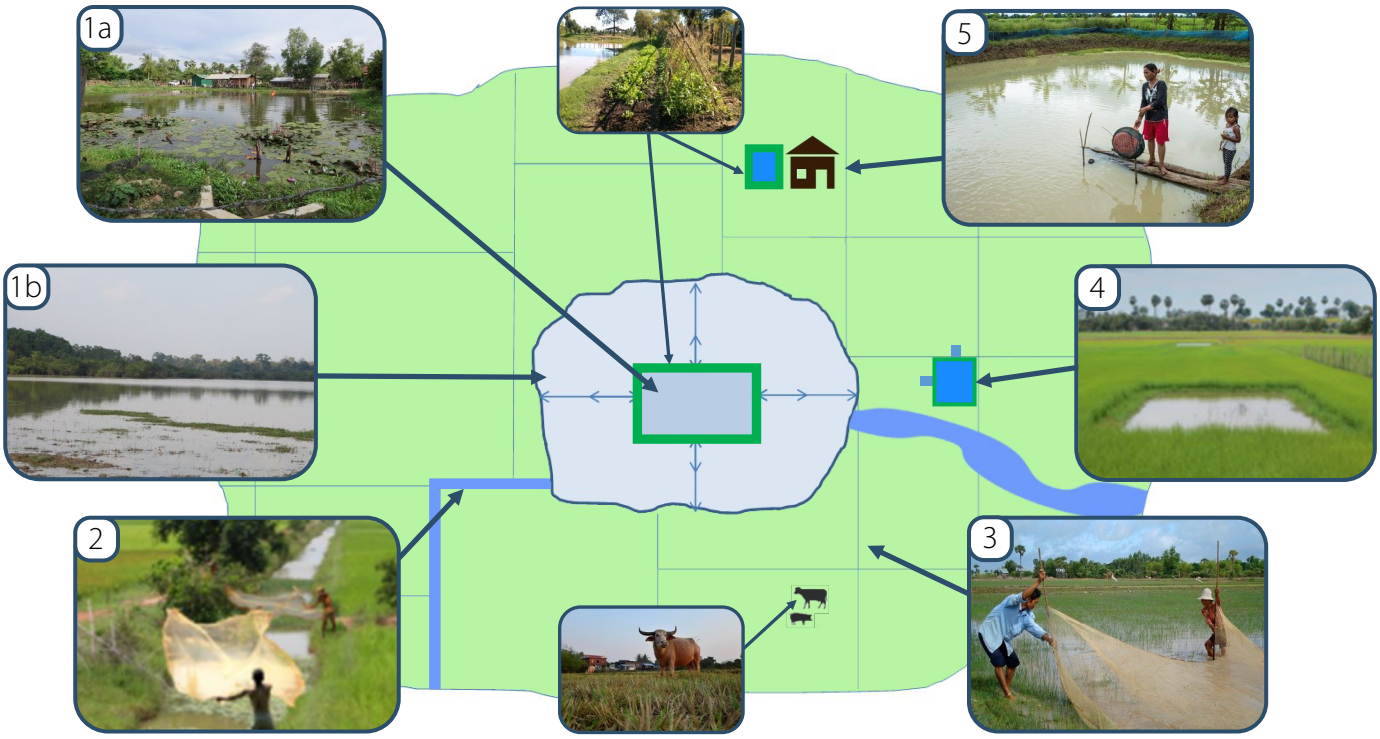
1.6. Fish and other aquatic foods in food systems for nourishing Cambodia

Presenter: Shakuntala Haraksingh Thilsted, WorldFish

Summary: This presentation summarized knowledge and experience on connecting rice-fish production with broader goals for food system sustainability, value chains and nutrition security aspects. A conceptual model developed by the Food and Agriculture Organization's High Level Panel of Experts provides a useful framework to identify the value chain links from rice-fish production to nutrition and health outcomes, as well as other impacts and drivers of change.

In Cambodia's Tonle Sap floodplain, a continuum of fish, rice and vegetable production occurs across habitats within the rice field landscape (Figure 8). Aquatic foods are particularly abundant, diverse and culturally valued in Cambodia (Figure 9) and can also provide essential micronutrients in a highly bioavailable form. This latter feature can contribute to improved childhood growth and development, school and work performance, and reduced mortality and morbidity.

Small fish are a particularly useful source of micronutrients due to their versatility for processing and consumption. They have similar benefits for children's growth as corn-soy-milk



Source: Reproduced with permission from "The Continuum of Fish Agri-food Systems in Cambodia" factsheet.

Figure 8. Key components of Cambodia's rice and fish agroecosystems, where a variety of food production is supported, including wild fish and other aquatic animals, rice, vegetables, livestock and cultured fish. Note: (1a&b) Community fish refuges provide protected habitat for fish and other aquatic animals year-round, water can be used for livestock and vegetables can be grown on the banks; (2) connecting waterways (streams, rivers and channels) facilitate movement of fish between community fish refuges and spawning and feeding grounds, including rice fields; (3) flooded rice fields are accessible for fishing; (4) rice field ponds harbor fish for grow-out after floodwaters have receded, and water is used for supplemental irrigation (vegetables and/or rice); (5) homestead ponds are used for aquaculture and watering home gardens.

products and are more locally suitable. Promotion of small fish preparation for enhancing childhood feeding has proved successful in nutrition initiatives within WorldFish's Rice Field Fisheries projects in Cambodia. A local company has also developed a small fish-based therapeutic feeding product for treating malnourishment in children. Challenges for using small fish include securing a steady supply of this seasonal resource, ensuring food safety from harvest through processing and storage, and also reducing waste and loss. Nutrition education and access to clean water and hygiene are also necessary to promote behavior change and improve diets and health.

There are several relevant nutrition-sensitive agricultural development initiatives of note. The International Fund of Agricultural Development has supported small indigenous fish in aquaculture in Bangladesh. Governments (including Cambodia) and UN agencies have piloted fish and fish-based products in public programs, such as school feeding programs. Research, including the recent FishNutrients addition to Fishbase, has been done on the systematic nutrient content and food safety of certain fish species. In addition, donors such as the United States Agency for International Development and the Bill & Melinda Gates Foundation and have supported nutrition-sensitive interventions.

Figure 9. Diverse and culturally valued aquatic foods in Cambodia. Note: (A) preparing a meal with fish caught from rice and fish agroecosystems; (B) harvest of water lily stems for market and meal preparation; (C) preparing prahoc using small fish caught from rice and fish agroecosystems; (D) Nutrix, a ready-to-use therapeutic feeding product made with small fish from the Tonle Sap lake; (E) consuming small fish in a vegetable-rice-fish porridge.

2. Theory of change

Facilitators: Caitlin Barry, Clear Horizon; Victoria Pilbeam, Clear Horizon

Participants: Ann Fleming, ACIAR; Somony Thay, Department of Aquaculture, Fisheries Administration; Rica Joy Flor, Sudhir Yadav, IRRI; Matthew McCartney, IWMI; Michael Akester, Philippa J Cohen, Mark Dubois, Sarah Freed, WorldFish

A goal statement was developed by the group:

Sustainably managed, resilient fish and rice agroecosystems contribute equitably to livelihood improvement and enhanced nutrition security for women, men, youths and children in the Cambodian Mekong Delta and Tonle Sap regions in the context of a changing climate.

The group identified actors who would be influential in realizing this goal. These included local, provincial and national governing bodies, policy and decision-makers, agricultural producers (ideally as groups rather than individuals) and public-private partners. Impact pathways and outcomes were identified as described in the theory of change narrative in sections 2.1 through 2.5 and the figure linked in Annex 2.

2.1. Context and scope

Rice and fish are longstanding staples in Southeast Asia. Both traditional and Green Revolution production methods for these staples are facing challenges from climate change and multiple water use demands. Rice and fish production are frequently integrated within the same agroecosystem, with substantial variation among the types of production practice and their extent. Innovations in rice-fish systems are needed to cope with climate change, to meet water use demands, and to contribute to livelihood and food security needs. Cambodia's fish and rice agroecosystems hold rich biodiversity and potential for increasing aquatic food productivity without increasing land use or intensifying agrochemical use. These agroecosystems also hold potential for ensuring people's access to nutritious foods and improved rural livelihoods across wealth and landholding status. Wild fisheries persist in up to 80 percent of Cambodia's rice farmland, and the culture of aquatic species is increasing. Sustainable management of rice production has been a focus of the government in previous years. This project will focus on fish and rice agroecosystems in two locations. One is the Cambodian Mekong Delta, where water control through irrigation is moderate to high. The other is the Tonle Sap floodplain and rice field ecosystems, where natural inundation is dominant and the presence of water control infrastructure is currently low, though changing rainfall patterns and large upstream dams affect flooding.

2.2. Outcomes

To meet the stated goal, the group identified necessary aims as follows:

- Water, agriculture and land management are integrated and enhance fish and rice agroecosystem functions.
- Rights and access to fishery and culture systems and their benefits (use) include smallholders, as well as landless in the low irrigation areas through collective aquaculture.
- There is improved resilience of production systems to critical drivers of change, including climate change and upstream water resource development.
- Food security and nutrition are improved for local households through increased micronutrient-rich fish consumption, especially for women and young children.
- Incomes are increased for culture stakeholders through production of cultured fish/prawn.
- Value chains for Cambodian cultured fish/prawn and micronutrient-rich fish products allow for integration and demand in local and urban markets.

These aims were mapped to targets of the SDGs and impact areas of One CGIAR (Table 1).

These aims will contribute to several outcomes: (a) sustainably managed, resilient fish and rice agroecosystems, (b) equitable rural livelihood

improvements, (c) improved availability of Cambodian produced fish/prawn in local and urban markets and (d) enhanced nutrition security for women, men, youths and children in Cambodia.

This project will coordinate three interlinked pathways to achieving the outcomes:

- Pathway 1: Production design innovation and trials, assessment of outcomes and potential trade-offs, and development of best practices for technical and environmental suitability, access and equity, and effective local management
- Pathway 2: Landscape planning, national policy, and institutional/ministerial integration
- Pathway 3: Value chains and nutrition

2.3. Influencing activities

2.3.1. Pathway 1: Design and conduct trials of various innovative integrated rice and fish production systems

Trials of rice-fish/prawn culture will take place in one province with medium to high irrigation infrastructure and Mekong-influenced hydrology (Takeo or Prey Veng). In addition, trials of collective fish/prawn culture in collective or individual water bodies in the rice field agroecosystem will take place in another province with less irrigation infrastructure and Tonle Sap influenced hydrology, including natural inundation (Battambang, Pursat or Kampong Thom). During trials, management practices and governance interventions will be tested and

Aim	SDG Target	One CGIAR Impact Area
Water, agriculture and land management are integrated and enhance fish and rice agroecosystem functions	2.4 Resilient agricultural practices that … help maintain ecosystems 2.5 Maintain genetic diversity of … farmed and domesticated animals and their related wild species	5.1 Stay within planetary and regional environmental boundaries 5.2 Maintain the genetic diversity of … farmed and domesticated animals and their related wild species
Rights and access to fishery and culture systems and their benefits (use) include smallholders, as well as landless in the low irrigation areas through collective aquaculture	1.2 Reduce poverty 2.3 Secure and equal access to land and other productive resources and inputs	2.2 Reduce poverty in all its dimensions
There is improved resilience of production systems to emerging disruptions, such as climate change and upstream water resource development	2.4 Resilient agricultural practices that … strengthen capacity for adaptation to climate change 13.1 Strengthen resilience and adaptive capacity to climate-related hazards	4.2 Equip small-scale producers to be more resilient to climate shocks
Food security and nutrition are improved for local households through increased micronutrient-rich fish consumption, especially for women and young children	2.2 End malnutrition	1.1 End hunger
Incomes are increased for culture stakeholders through production of cultured fish/prawn	1.2 Reduce poverty 2.3 Improve agricultural productivity and incomes	2.2 Reduce poverty in all its dimensions
Value chains for Cambodian cultured fish/prawn and micronutrient-rich fish products enable integration and demand in local and urban markets	1.2 Reduce poverty 2.1 End hunger and ensure access by all people … to safe, nutritious and sufficient food	1.1 End hunger 2.1 Lift at least 500 million people living in rural areas above the extreme poverty line

Table 1. Mapping of the theory of change aims to SDG targets and One CGIAR impact areas.

monitored using appropriate metrics, from farm to landscape scales. Outcomes will be assessed and compared with rice-only production (or rice and wild fish production in areas with rice field fisheries) as control. The factors assessed include the following:

- production and profitability, in accordance with emerging food safety standards in Cambodia
- soil health, water quantity and quality, agrochemical residue and greenhouse gas emissions
- income, food and nutrition security, and food provision
- benefit sharing across gender, age, wealth and land ownership status
- whether investments are adding risk and/or debt for smallholders
- climate change resilience in terms of water efficiency and water availability requirements (quantity, frequency and seasonality).

The findings will be used to develop recommendations on best management and governance practices, which will be communicated to different stakeholders. Partners from research organizations, nongovernmental organizations (NGOs) and government will strengthen producer capacity to implement and sustain adoption of best management practices (BMPs). These BMPs will focus on integrated agriculture, enhanced water productivity/efficiency, maintenance of ecological integrity (soil health and water quality in particular) and nutrition-focused practices. Research, NGO and government partners will ensure local authorities and producers have the skills and the decision-making and management rights to organize and maintain governance practices for timing of production, water management, and input and benefit sharing.

These activities will be planned, conducted, evaluated and adapted as necessary to ensure the following:

- Producers will be empowered to conduct integrated rice and fish production through organized planning and implementation for on-farm and collective landscape-level management.
- Benefits are shared across gender, age, wealth and land ownership status.
- Financial investment is empowering rather than adding risk and/or debt for smallholders. This includes tracking investment outcomes and implementing investment/risk spreading through community-based management.
- Production, environmental, income, food security and food provision objectives are reached.

2.3.2. Pathway 2: Landscape planning, foresight studies, national policy, and institutional/ministerial coordination

Mapping and quantifying biophysical features (including human-made infrastructure), vegetation, and hydrological patterns will inform the planning of the trials and control sites. Building on the trials, we will define a set of principles to guide effective scaling of the approaches and then conduct further modeling, based on hydrological and rice toposequence data. Foresight studies will be implemented to understand where and how such practices can be scaled out. Research and government partners will communicate the information, along with best practice recommendations, for officials and decision-makers at commune, district, province, cantonment and national levels, including for national policy and interministerial coordination. Implementing or joining a multistakeholder platform will aid the discussions and interactions to engage different actors at different policy levels and to impart understanding of the institutional support necessary for the potential rice-fish systems. We will use the recommendations and platform to promote a co-designed integrated agriculture strategy for rice-fish systems that supports scaling the practices and to facilitate discussions on wider impact, such as the potential to designate Globally Important Agricultural Heritage Systems in Cambodia. We hypothesize that the information and engagement will improve integration of planning and governance across national agencies.

2.3.3. Pathway 3: Sustainable value chains and nutrition incorporating gender and youths

Processing and value-adding technologies will be tested, such as the IRRI's solar dryer technology for collective processing. At the same time, partnerships will be formed with the actors in the value chains for the products from sustainable rice and micronutrient-rich fish production. These partnerships will support integration in the value chains and help producer

collectives to market their products and obtain higher incomes. Capacity building through these activities will also increase the knowledge and skills among producers and other market actors on processing, nutritional value of the products, and child-appropriate preparations. Lastly, involving the private sector will help to make nutrient-rich food available and accessible for more women and children.

2.4. Outcomes that cut across different pathways and connect to end of program outcomes

Together, the pathways build in tailored communication for varied stakeholders, especially on policies for integrated agriculture. Sharing knowledge across stakeholders and learning from other regions will also be facilitated. Donors and development actors will be made aware of rice-fish systems and benefits so that investments and development programs will support better water management and improved rice-fish systems. In complement, private sector involvement in the value chain activities will also encourage innovations and investment to improve fish availability, value-adding and consumption of nutrient-rich fish. Through all these activities, different stakeholders across all levels will act to maintain or restore ecosystem functions. National extension systems will support producers as they shift to rice-fish practices that are well adapted to the context and more resilient and sustainable than intensive monocultures. Empowered collectives of producers will improve practices and make their rice-fish production profitable. Co-designed integrated agriculture governance will also ensure that access as well as benefits from production will include smallholders and the landless.

2.5. Key assumptions

- The Mekong River flows can continue to support wetlands and diverse fish species in Cambodia. Mekong flows and droughts will not reduce critical water and sediment flows further than already experienced in the past 3 years.
- Initial results from this study will motivate buy-in among producers and irrigation development stakeholders, leading to a willingness among irrigation development stakeholders to collaborate and change practices to implement "fish friendly" infrastructure in existing and future irrigation development.
- Private sector incentives for production will be generated in a timely manner to encourage the adoption of the practices and sustain producer interest and activity.
- Government ministries and levels of authority will implement consistent/coherent policy to support long-term and sustainable rice-fish production, including revising or developing policies as needed.

2.6. Demand, innovation and scaling partners

During and after developing the theory of change, participants identified likely partners, including existing and incoming actors that contribute to the demand, innovation and/or scaling of rice-fish system innovation (Table 2).

Demand partners	Innovation partners	Scaling partners
Ministry of Agriculture, Forestry, and Fisheries	Cambodian Agricultural Research and Development Institute	Cambodian Agricultural Research and Development Institute
FiA	FiA	FiA
Ministry of Industry, Science, Technology and Innovation	IRRI-IWMI-WorldFish	International Fund for Agricultural Development
Ministry of Water Resources and Meteorology	Institute of Technology of Cambodia (Food Engineering & Nutrition Unit)	APDRA Pisciculture Paysanne
Asian Development Bank	Royal University of Agriculture	Asian Development Bank
	French Institute for Resarch and Development (AquaCam project)	Association of Southeast Asian Nations
	French Agricultural Research Centre for International Development	

Table 2. Demand, innovation and scaling partners at the food systems level.

3. Conclusion and next steps

Rice-fish systems are critical for meeting environmental and nutrition and food security objectives. In Cambodia, pathways that use local-level trials, landscape-level planning, and integration of small-scale production with value chains and markets aim to improve the following: agroecosystem function, resilience of production systems to changing conditions, inclusive rights and access to fisheries and culture production, incomes, nutrition, and food security for local households, and integration of products in local and urban markets.

This type of approach is aligned with several One CGIAR initiatives in development. There is alignment in both focal geographies of Cambodia and/or other nations in the Lower Mekong region and concepts such as the following:

- production systems design, foresight, value chains and nutrition (Asian Mega Deltas initiative)
- water management and multifunctional landscapes (Resilient Aquatic Food Systems initiative)
- inclusive agronomic solutions, engagement with public and private partners and National Agricultural Research Systems for inclusive impact pathways (Excellence in Agronomy initiative)
- living labs that bring actors together in participatory research, and development and testing of a framework to evaluate production systems across a range of sustainability criteria (Transformational Agroecology initiative).

If financial support is made available for the proposed pathways and theory of change, the next steps are to develop the research and implementation plan and convene local stakeholders and potential beneficiaries in the proposed sites for feedback on the objectives and theory of change. This feedback will be used to develop site-specific theories of change and will feed into the research and implementation plan. A resource plan will also be developed, including a budget, list of participants and roles (including the names of individuals who will provide specific inputs and expertise), and a timeline of activities and major milestones. WorldFish will lead the development of the research and implementation plan and the resource plan with input from partners, while WorldFish and the IRRI will co-convene the local stakeholder feedback sessions.

A fisherman checking his net, Cambodia.

Annex 1

Introduction

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Link to Presentation 1 slides

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Annex 2

Link to theory of change figure

Theory of change

Rice/Fish systems

Broader goals

- Improved availability of Cambodian produced fish/prawn in local and urban markets
- Sustainably managed, resilient fish and rice agroecosystems contribute equitably to livelihood improvement and enhanced nutrition security for women, men, youths and children in the Cambodian Mekong Delta and Tonle Sap regions in the context of a changing climate

End of project outcomes

- Water, agriculture and land management are integrated and enhance fish and rice agroecosystem functions
- Rights and access to fishery and culture systems and their benefits (use) are inclusive of landless and smallholders
- Improved resilience of production systems to emerging disruptions such as climate change and upstream water resource development
- Improved incomes for culture stakeholders through production of cultured fish/prawn
- Improved nutrition for local households, through increased household micronutrient-rich fish consumption, especially for women and young children
- Value chains for Cambodian cultured fish/ prawn and micronutrient-rich fish products allow for integration and demand in local and urban markets

Intermediate outcomes

- All levels of planning and management maintain/restore ecosystem functioning when implementing agricultural, natural resource and water management activities
- Effective integrated practices are continued post-project and adopted at other sites
- **Development programs are** more supportive of fish-friendly projects/systems and fund rice-fish projects
- **PNGO and GOV** train extension agents to provide ongoing guidance to producers on rice-fish systems
- Investors such as ADB and World Bank's awareness is raised on the benefits of rice-fish projects and how irrigation can support or conflict
- **GOV** conducts effective integrated planning across agencies
- **WF, IRRI, IWMI, AUS and GOV** participate in stakeholder platform and communicate best practices for integrated agriculture and considerations for irrigation developed to key stakeholders including **development actors** (World Bank, ADB); conduct regional knowledge exchange – lessons learned from other Southeast Asian countries; exchange of knowledge across stakeholder groups
- **Producers**' operations are more profitable (further income from fisheries and/or culture)
- **Producers** as a collective/at landscape scale are using and effectively managing appropriate sustainable integrated rice and fish production practices
- **PNGO and GOV** train and strengthen capacity for producers on farm-level techniques for enhanced water productivity, best management practices for integrated agriculture, and nutritional practices
- **WF, IRRI, IWMI, AUS and GOV** co-design communications with stakeholders to conduct tailored communication to commune, district, provincial, cantonment and national agencies on governance needs for integrated agriculture that also supports a decentralized approach
- **WF, PNGO and GOV** ensure producers are empowered to conduct management planning and implementation for integrated production, including coordination and collective (i.e. beyond farm plot) management as appropriate; producers and LA have the capacity and empowerment to organize and maintain collective approaches to production
- **GOV** receives information on water availability and seasonal change that enables planning for adoption or expansion of interventions
- Improved fish availability, value adding options, movement through the value chain and consumption of micronutrient-rich fish by women and children
- **Private sector**: bridging the gap between innovation and uptake through both direct investment and awareness raising/marketing
- Demand for products encourages **private sector** investment in production such as seed companies, feed companies, tech companies, traders (e.g. Sustainable Rice Platform)
- **Producers** partner with value chain actors to market micronutrient-rich fish and other fish/ prawn culture products
- Awareness raised through marketing and local trainings/demonstrations on nutritional value of micronutrient-rich fish and child-appropriate preparations

Actors

WF	WorldFish
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
AUS	Australian University partner (Deakin)
GOV	Cambodia government partners (FIA, GDA/PDAFF)
PNGO	Implementing partner NGOs
Producers	farmers and fishers
LA	village, commune, and/or district level authorities

Influencing activities

1 Practices and outcomes: technical and environmental suitability, access and equity, and effective local management

- 1A. **WF, IRRI, AUS and GOV** develop integrated practice protocol for trials (1B and 1C); provide capacity strengthening and protocol training to PNGO and producers.
- 1B. In areas of mid- to high irrigation, **PNGO, GOV** and **producers** trial integrated practices for rice and fish (poly) culture.
- 1C. In areas of low irrigation, where fishing in rice fields is common, **PNGO, GOV** and **producers** trial integrated practices for rice, (collective) fish culture, and wild fish, including organization of collective (i.e. beyond farm plot) management.
- 1D. **WF, IRRI, AUS** and **PNGO** compare trials to control sites to evaluate improvements in the following: production and profitability; water quality and efficiency, soil health, greenhouse gas emissions; income, food security, and food provision; benefit sharing across wealth and land ownership status; and financial investment that is empowering rather than adding debt and risk for smallholders, including equitable benefits and risk spreading through community management of production and/or value chain.
- 1E. **WF, IRRI, AUS** and **GOV** develop best practice guidelines for the preferred approaches to integrated rice and fish production.

2 Landscape planning, national policy, and institutional/ministerial integration

- 2A. **IRRI** and **IWMI** map vegetation and hydrological situation (and changes across seasons) to inform planning and governance needs, especially water regimes affecting potential and timing for fish/prawn culture, and investigating dry season water availability and dry season rice cultivation
- 2B. **WF** and **IWMI** conduct modeling/foresight studies to inform where/how such integrated practices can be scaled out

3 Value chains and nutrition

- 3A. **WF, IRRI, PNGO** and **producers** trial and develop best practices for value added/ postharvest processing, such as IRRI's solar dryer technology for collective processing
- 3B. **WF** and **PNGO** support collectives to organize for processing and value chain integration to market products
- 3C. **WF** identifies traders and market integration options, facilitates connections for collectives

Foundational activities

- Consider creation of a multistakeholder platform, or tie in with aquaculture association formed by Commercialization of Aquaculture for Sustainable Trade (CAST) (USDA)
- Networking with policy actors, project to develop coherent policies and objectives that can then be communicated to government agencies
- The various private sector investment options are investigated: agricultural certification, insurance, micro-credit, small business networks, heritage grants, government grants
- Investigation of diverse sources of funding, including Commune Fund

Annex 3

List of participants

Name	Affiliation	Position
Ann Fleming	ACIAR	Fisheries Research Program Manager
Bethany Davies	ACIAR	Planning and Impact Evaluation Program Manager
Dulce Simmanivong	ACIAR	Regional Manager, East and Southeast Asia Regional Office
Ebony Ackland	ACIAR	ACIAR Graduate Officer (Water and Climate)
James Quilty	ACIAR	Soil and Land Management Research Program Manager
Lee Nelson	ACIAR	Associate RPM Climate Change
Robyn Johnston	ACIAR	Water and Climate Research Program Manager
Somony Thay	Department of Aquaculture, Fisheries Administration, Cambodia	Director
Viseth Hav	Fisheries Administration, Cambodia	Deputy Director General
Kong Kea	General Directorate of Agriculture, Cambodia	Director, Rice Department
Mike Rimmer	Independent Consultant and University of the Sunshine Coast	
Alex Stuart	IRRI	Scientist - Ecology
Jon Hellin	IRRI	Platform Leader, Sustainable Impact
Rica Flor	IRRI	Scientist - Innovation Systems, Cambodia
Robert Caudwell	IRRI	Representative for Myanmar
Sudhir Yadav	IRRI	Senior Scientist, Lead of Soil, Climate and Water Cluster
Yurdi Yasmi	IRRI	Regional Representative for Southeast Asia
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Sanjiv De Silva	IWMI	Researcher - Natural Resources Governance
Sonali Senaratna Sellamuttu	IWMI	Representative Southeast Asia and Myanmar
Nicki Duncan	IWMI and Charles Sturt University	Intern
Nguyen Van Sang	Research Institute for Aquaculture, Vietnam	Director
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Cynthia McDougall	WorldFish	Gender Research Leader
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Philippa Cohen	WorldFish	Resilient Small Scale Fisheries Leader
Sarah Freed	WorldFish	Postdoctoral Fellow, Cambodia
Shakuntala Haraksingh Thilsted	WorldFish	Value Chains and Nutrition Leader
Surendran Rajaratnam	WorldFish	Postdoctoral Fellow
Wae Win Khaing	WorldFish	Social Awareness Officer, Myanmar

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RESEARCH PROGRAM ON Fish

Led by WorldFish

About FISH

The CGIAR Research Program on Fish Agri-Food Systems (FISH) is a multidisciplinary research program. Designed in collaboration with research partners, beneficiaries and stakeholders, FISH develops and implements research innovations that optimize the individual and joint contributions of aquaculture and small-scale fisheries to reducing poverty, improving food and nutrition security and sustaining the underlying natural resources and ecosystems services upon which both depend. The program is led by WorldFish, a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

For more information, please visit fish.cgiar.org