Socio-economic Analysis of Rice-Fish Culture based Systems in Myanmar

Understanding the factors contributing to the adoption of and the benefits arising from rice-fish systems in the Ayeyarwady Delta

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1. Introduction

Rice-fish systems can be broadly defined as "*the cultivation of rice with the 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*" (Freed et al. 2020a). Traditionally, farmers and neighbouring households in South and Southeast Asian countries caught wild fish from water bodies in and around rice fields for household consumption and as an alternate source of income (Halwart and Gupta 2004; Dey et al. 2013). However, with the intensification of rice production (high yielding varieties of rice and chemical fertilisers and pesticides), the prevalence of traditional rice-fish systems declined (Ahmed and Luong-van 2009; Dey et al. 2013; Nguyen et al. 2018). The emergence of intensive rice production resulted in several negative impacts on the environment and human health, such as the extensive use of chemical fertilisers and pesticides resulting in soil and water pollution (Berg et al. 2012), extraction of groundwater affecting the water table (Mainuddin et al. 2020) and decreases in household collection and consumption of wild fish and wild vegetables which are important sources of nutrition and income (Dey et al. 2013; Nguyen et al. 2018).

In the 1960s, the Government of Myanmar undertook different measures to develop the agricultural sector such as the construction of irrigation facilities, cultivation of fallow lands and the expansion of areas for multi-cropping (Zaw et al. n.d.). Agricultural inputs and support were also provided to farmers, such as high-yielding varieties of seeds, chemical fertilisers, insecticides, tractors and water pumps, in order to increase productivity and promote intensive cultivation (Zaw et al. n.d.). Agriculture was the backbone of the economy then (Zaw et al. n.d.), as it is now, where for example rice and fish production are the first and fourth largest contributors to GDP, respectively (Raitzer et al. 2015). Additionally, fish acts as the primary source of animal protein within the diet of the Myanmar population; with individual consumptions rates estimated at 30 kg per person per year (WorldFish 2017). However, considerable disparity between social classes results in many low-income households having limited access to protein sources, instead subsisting on a low quality, nutrient deficient diet, primarily comprised of rice (Wilson and Wai 2013). This lack of diversity has been linked to intermediate rates of malnutrition within Myanmar; where according to the Myanmar Multi-sectoral National Plan of Action on Nutrition (MS-NPAN) 2018 – 2022: Malnutrition among children under 5 years is 7%; Stunting among children under 5 years is 29%; Anaemia among children under 5 years is 48% and anaemia among women of reproductive age is 47% (Ministry of Health and Sports 2018). As such, a transition within Myanmar's food system is required to support the development of national food and nutritional security (Dubois et al. 2019). To do so, the agricultural system must shift towards the use of more integrated and sustainable practices which focus on the provision of a diverse and nutritious diet for all inhabitants (Willett *et al.,* 2019).

In general, the need for the transformation of intensive agricultural systems into more diverse and sustainable systems is being realised across the region, and governmental, non-governmental institutions and research organisations have begun exploring and promoting new and different versions of traditional Rice-fish systems (Dey et al. 2013; Garaway et al. 2013; Islam et al. 2015; Freed et al. 2020a; Ahmed and Turchini 2021). These systems would be able to sustain farmers in their nutrition intake and livelihoods, and lessen environmental impacts compared to their intensive counterparts, rice monoculture and aquaculture (Freed et al. 2020a; Ahmed and Turchini 2021).

Studies have demonstrated that rice-fish systems can enhance ecosystem services and provide benefits to farmers and communities, by increasing and maintaining biodiversity, efficient use of water and land resources, reducing the need for agrochemicals and improving water quality, and improving nutrition and food security (Garaway et al. 2013; Freed et al. 2020a; Ahmed and Turchini 2021). These systems have also proven to positively impact socio-economic aspects by increasing income and generating more revenue per hectare compared to rice monoculture systems under certain conditions (Halwart and Gupta 2004; Dwiyana and Mendoza 2006; Ahmed et al. 2011; Freed et al. 2020a).

Rice-fish (RF) systems and variations of the system have been well established in several countries in the Southeast Asian region, and studies have been conducted and are ongoing to understand the various impacts of these systems, the conditions in which they are suited, and the factors influencing adoptability. The profitability of rice-fish systems largely depends on the suitability of the area. Dey et al. (2013) found that in a favourable environment such as in Mymensingh in Bangladesh, even the least profitable RF system is more profitable than rice monoculture. This has been demonstrated experimentally within Myanmar by WorldFish, where RF trials produced rice yields that were equivalent to fish-free systems and led to an increased gross profit of 9-41% (CGIAR Research Programme on Fish Agri-Food Systems, 2019).

RF systems are dependent on geographical and physical factors (such as rainfall, flood patterns, proximity to floodplains, availability of infrastructure) (Dey et al. 2013; Freed et al. 2020a), socio-cultural and economic factors (input costs, labour costs and availability) (Ahmed et al. 2011; Islam et al. 2015) and institutional and political factors (e.g., land use policy) (Dubois et al. 2019). Furthermore, these factors may differ for different types of RF systems. For example, rice-fish systems in Cambodia depend on natural processes, whereas similar rice-shrimp systems in Vietnam are reliant on input and infrastructure (Freed et al. 2020a). In Myanmar, land use policy is a key factor in the adoption of RF systems and although current land use rules do not allow the cultivation of RF (Dubois et al. 2019), these systems still occur informally to a limited extent. While rice and fish production are significant contributors to GDP and rural incomes in Myanmar (FAO 2020b; Freed et al. 2020a), the proportion of contribution from rice-fish systems is yet to be determined.

Research has demonstrated the feasibility of RF systems in terms of the bio-physical aspects (Dey et al. 2013) and is continually updated with new information (e.g., climate risk) (Ahmed et al. 2014). However, a comprehensive understanding of the socio-economic aspects of RF systems – the required conditions and the impacts – is lacking in the region. In addition, more assessments are required on the institutional and policy aspects and investments of RF systems. This dearth of information may be contributing to the slow adoption and promotion of systems across various stakeholders, from farmer to government agency (Dey et al. 2013; Freed et al. 2020a). Identifying all the factors that contribute to the suitability of RF systems and the impacts generated from the implementation of these systems, will inform policy and further investment in RF in South and Southeast Asia (Freed et al. 2020a), and contribute to the achievement of national and global plans or targets such as the Myanmar MS-NPAN 2018-2022, the Myanmar Agriculture Development Strategy and SDG 2 – food security, nutrition and sustainable agriculture.

The current land use policy in Myanmar (Farmland Act, Pyidaungsu Hluttaw Law number 11/2012, see Dubois et al. 2019) needs to be challenged or altered to promote the wide scale adoption of Rice-fish systems. Progress has already been made through the development of the Naypyitaw Integrated Rice-Fish Agreement which emerged from the Rice-Fish Systems Symposium organised in August 2018 by WorldFish and ACIAR (WorldFish 2019). The key element of this Agreement was the encouragement by His Excellency Minister Dr. Aung Thu, Ministry of Agriculture, Livestock and Irrigation (MOALI), of the Departmental Directors to actively promote integrated agriculture, incorporating best management practices for both rice and fish (WorldFish 2019). To enable this, noting the current restrictions under the Farmland Act, the Minister recommended that farmers be allowed to convert up to 15% of their rice field to a fish-pond, based on the encouraging results of rice-fish field trial undertaken by WorldFish (CGIAR Research Programme on Fish Agri-Food Systems, 2019; WorldFish 2019).

In addition, a rice-fish suitability model developed by WorldFish (Dubois et al*.* 2019) provides an estimation of the total land area suited to rice-fish implementation within the Ayeyarwady delta Region, enabling policy and decision makers to identify potential locations for rice-fish systems within the Delta. There have been regular updates to the model. Initially to add a number of socioeconomic variables that either 1) play an important role in the ability for RF to be successfully implemented at the local scale, or 2) variables that may help in prioritising investments, for example in areas with incidences of high malnutrition or poverty. The latest version of the model includes a predictive element to 2040 by incorporating data on key climate related hazards. However, the model is still limited by the availability of data and specifically with regards to a more detailed understanding of the potential benefits derived from adoption of rice-fish farming.

To contribute and further these efforts, this study aims to understand socio-economic aspects of RF systems in Myanmar. The objectives are therefore to:

(1) Assess the potential socio-economic benefits of RF cultivation in Myanmar, and
(2) Identify any socio-economic factors contributing to the adoption of RF.

The following section describes the value transfer approach undertaken to achieve the two main objectives, and as part of the process, the literature review section in this report identifies studies in the South and Southeast Asian region that include socio-economic analysis of RF. The review section consists of two parts, where the first outlines the different types of RF systems in the region, and the second describes the types of socio-economic studies conducted and the available information. Suitable values are identified and analysed, and the results are described thereafter organised according to the broader categories: equity, productivity, environment, and health. The report concludes with utilising the findings and moving forward with the development of an investment or business plan for RF in Myanmar.

2. Approach

The benefit or value transfer method was utilised to achieve the two main objectives mentioned above, to inform changes to Myanmar agricultural land use policy, to provide reasons to target RF development in particular areas and to assist in prioritisation given limited investment. Primary data collection from fields and farmer households, although ideal in fully understanding social and economic aspects, was not feasible at the time of the study due to the political situation in Myanmar and the COVID-19 pandemic.

The value transfer method is used to "*estimate benefits for one context by adapting an estimate of benefits from another context*" (Ecosystem valuation 2021). This method is predominantly used in the ecosystem services concept to understand values of services that have not been calculated for a particular ecosystem. Similarly, this approach can be used in the agricultural ecosystem context, where in this case, socio-economic benefits of RF systems from different countries and different studies were used to understand the potential value of RF in Myanmar. This type of study is beneficial in instances where there is a time constraint or lack of finances to conduct a primary valuation study, or as in the situation in Myanmar where it was not practically possible.

According to Brander (2013) there are three main types of value transfer – unit value transfer, value function transfer, and meta-analytic function transfer. The unit value transfer method uses values from another context combined with information on the quantity of units at the site of interest or policy site (in this case, the Ayeyarwady Delta Myanmar). It's a simple method that is used to effectively communicate the benefits of RF systems to decision makers. However, a limitation of the method is that differences between the studies may not be accounted for, resulting in generalisation of values. Finding and selecting studies that are most similar to the policy site is therefore important in lessening generalisation error.

Both the value function transfer and meta-analytic function transfer methods, require information from primary valuation studies that "*relates the value of the ecosystem service* (for e.g., rice and fish production) *to the characteristics of the ecosystem and its beneficiaries* (e.g., HH income, Gender, HH size of farmer)" (Brander 2013). As demonstrated in the literature review section, studies that analyse the relationships between different socio-economic factors and the outcomes of Rice-fish systems in Southeast or South Asia are limited. These methods also require detailed information on farmer characteristics in Myanmar, and the analysis may be time consuming. A summary of the strengths and weaknesses of each approach is found in Table 2.1.

Due to these reasons, and because of the short time frame in which to conduct the analysis, the unit value transfer approach was undertaken to understand the socioeconomic benefits of RF systems in Myanmar. Rather than considering the unit values of a single study, based on the literature review that has been conducted, several studies were assessed and the average values or range of values of studies with similar contexts to the Ayeyarwady Delta were utilised. The unit value transfer method guideline developed by Brander (2013) was followed and adapted accordingly to suit the context (see Box 2.1). It is important to note that all the points under the four main steps may not be applicable to every context in which the approach is used (Box 2.1).

Table 2.1: Strengths and weaknesses of value transfer methods; where study site refers to completed studies in a different context, and policy site refers to the area of interest (Source: Brander 2013).

	Approach	Strengths	Weaknesses
Unit value transfer	Select appropriate values from existing primary valuation studies for similar ecosystems and socio-economic contexts. Adjust unit values to reflect differences between study and policy sites (usually for income and price levels)	Simple	Unlikely to be able to account for all factors that determine differences in values between study and policy sites. Value information for highly similar sites is rarely available.
Value function transfer	Use a value function derived from a primary valuation study to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g., differences in population characteristics)	Requires detailed information on the characteristics of the policy site.
Meta-analytic function transfer	Use a value function estimated from the results of multiple primary studies to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g., differences in population characteristics, area of ecosystem etc.) practical for consistently valuing large numbers of policy sites.	Requires detailed information on the characteristics of the policy site. Analytically complex.

Box 2.1: Unit Value Transfer Guidelines (Source: Brander 2013)

Step 1: Describe the policy case/context – Ayeyarwady Delta, Myanmar

- Description of policy or development under consideration
- Identify the ecosystem services to be assessed (e.g., socio-economic benefits from RF systems)
- Describe the current situation with available information (e.g., rice and fish production in Myanmar)
- Identify the population of beneficiaries and time scale over which the changes occur or benefits are realised.

Step 2: Identify existing studies or values that can be used for the transfer

- Compare geographical area, climate, rainfall patterns, water availability, soil quality etc.
- Compare characteristics of farmers – age, gender, household size, average income, farm area etc.
- Evaluate the quality of the studies – ideally select studies that have primary data, larger numbers of respondents and less uncertainties.
- Select the studies that are most suitable to the policy site – Ayeyarwady Delta, Myanmar.

Step 3: Transfer values

- Select the appropriate units based on the variable/factor. The values can be presented in terms of the beneficiaries and/or the ecosystem service, for e.g., rice and fish yield will be kg per ha and income will be USD per household or farmer. The selection of units is also based on the available data from various studies and available data at the policy site.
- Estimate the values to be transferred to the policy site.
  - Values from other studies that were estimated in previous years need to be adjusted for inflation.
  - When transferring values between countries, purchasing power parity adjusted exchange rates need to be used.
  - Identify the time scale in which these values are estimated. For e.g., productivity of rice or fish can be presented per year or per season.
- Aggregate values across the population or the farm area at the policy site. The household or farm level values from other studies can be scaled up to reflect values at the township level in Myanmar. However, this is dependent on the availability of information in Myanmar. Data such as the total number of farmers or farming households and farming area at the township level will be required.

Step 4: Report results

- Identify and describe uncertainties in the unit value transfer method.
- Report results and tailor according to different audiences.

As mentioned in the introduction, the combined approach of the review and unit value transfer will allow for an improved understanding of the potential socio-economic benefits of RF systems in the Ayeyarwady Delta, and the socio-economic factors influencing adoption of RF systems. The study sought information on the following broader categories, to provide some direction in the literature search for socio-economic aspects. The categories were:

1. Productivity of integrated RF systems – yields of rice and fish, total costs and total benefits involved in RF systems.
2. Nutrition – contribution of integrated RF systems to household consumption patterns

3. Environment – impact of RF systems on pesticide use, biodiversity, water consumption etc.
4. Equity – wealth, land ownership, age, educational level and any other factors that may affect reasons to adopt RF systems.

2.1 Review: Rice-Fish Systems in South and Southeast Asia

2.1.1 Process

A literature review was conducted as part of the second step in the unit value transfer method (Box 2.1) and to understand the level of available socio-economic information and different types of rice-fish systems in South and Southeast Asian countries. The literature search was conducted systematically, using various combinations of the key words "rice-fish or rice-shrimp systems in south and southeast Asia" and "socio-economic analysis of rice-fish systems". The International Water Management Institute (IWMI) inter-library search facility and Google Scholar searches produced over 100 articles with the related key words, which through reviews of the abstracts were tailored down to 37 studies with some mention of socio-economic analysis in the abstract. From further assessments of these articles, and due to time constraints, 22 studies providing some form of socio-economic data of a RF system were identified.

During the review process, it was found that the same source of primary data was used in different studies or articles. For example, data representing household/farm surveys conducted in Mymensingh in Bangladesh were presented in two or more different studies (e.g., Ahmed & Garnett 2011, and Ahmed et al. 2011). Where possible, these overlaps were noted in the database. Most articles contained socio-economic analysis of RF systems in Bangladesh and Vietnam (See Table 2.2). Out of the 22 studies in the database, 11 provided information on Bangladesh, 7 studies on Vietnam, 2 studies on India, one each for Cambodia and Indonesia. Some of the studies also included reviews of data from other countries outside of the region (see Halwart and Gupta 2004). It should be kept in mind that one study may include data from more than one country.

Table 2.2: Availability of socio-economic information according to country

Country	**Studies/Articles**
Bangladesh	Gupta et al. 1998; Rabbani et al. 2004; Dey and Prein 2005; Haque 2007; Ahmed and Luong-van 2009; Ahmed et al. 2011; Ahmed and Garnett 2011; Rahman et al. 2012; Dey et al. 2013; Kabir et al. 2020;
Vietnam	Berg 2002; Dey et al. 2005; Dey and Prein 2005; Berg et al. 2012; Berg et al. 2017; Loc et al. 2017; Berg et al. 2018;
India	Goswami et al. 2004; Nair et al. 2014
Cambodia	Freed et al. 2020b
Indonesia	Dwiyana and Mendoza 2008

Data and information from each study was subsequently organised according to the broader categories mentioned above: productivity, nutrition, environment, and equity (see Annex 1). The review of Rice-fish systems in South and Southeast Asia provided an understanding of the different types of systems implemented and the socio-economic impacts of these systems on farmers or households. Due to the difficulties in obtaining field level data in Myanmar, the review provided insights into utilising findings from other countries to demonstrate the potential positive socio-economic outcomes of RF in the Ayeyarwady Delta.

2.1.2 Types of Rice-fish Systems

A rice-fish system, as defined in the introduction, is a rice field or rice field-waterbody complex where naturally occurring (wild) fish and other aquatic species are harvested, and/or deliberately stocked (fish/shrimp culture) (Freed et al. 2020a; IRRI 2021). A waterbody in this context refers to ponds, streams, canals, trenches, and a rice field may consist of one or a combination of waterbodies. As such there are many variations of a rice-fish system and due to the continuous innovation and adaptation of such systems, current literature consists of many different terms to define the various types. For example, Dey et al. (2013) use "rice field ecosystems" and Freed et al. (2020a) use "rice-fish production practices" as holistic terms to describe an area in which rice and fish cultivation occur. For this study, the term rice-fish system will be used as an overarching term for the different variations of rice-fish cultivation.

The main difference in RF systems that is often clearly outlined in literature, is distinguishing an integrated system from an alternate RF system. An integrated rice-fish system would consist of rice and fish in the same area (rice field or rice field waterbody complex) at the same time, and an alternate system would utilise the same area to cultivate rice in one season and fish in another season (Table 2.3). Integrated RF systems can be created to provide for naturally occurring fish or involve fish culture. Initially for this review, the studies on RF systems in the region with available socio-economic information, were categorised according to these two broader types, integrated and alternate RF (Annex 1), and section 2.2 the type of integrated RF is identified.

Table 2.3: Types of RF systems and the characteristics used to define them (source: Dey et al. 2013; Freed et al. 2020a)

Type of Rice-fish system	Also known as	Brief description
Integrated Rice-fish	Concurrent; rice-cum-fish	The rice field is modified to create habitats for fish when the water levels are low (trenches, small ponds etc.). This provides for movement of naturally occurring fish (wild fish) and/or involves culturing of fish within the same plot as the rice crop. Mainly practiced in the rainy season.
Alternate Rice-fish	Rotational; Rotating systems	Alternating cultivation or seasonal rotations between rice and fish. E.g. in Bangladesh, Boro, rice is cultivated in the dry season and fish in the wet season. This allows for the use of crop specific inputs during each cultivation, and can therefore be considered an intensive form of RF.

Freed et al. (2020a) go one step further in distinguishing the different types according to the level of human intervention. A continuum was created to provide clarity on how the different types of RF systems are formed and operated (Freed et al. 2020a). One end of the spectrum consists of systems that involve high levels of human control and substitution of natural processes, and the other end has less human involvement and greater reliance on natural processes (Freed et al. 2020a). For example, rice monoculture and aquaculture lie on the human control end of the spectrum and rice-field fisheries (traditional RF with harvesting of wild fish) lie on the natural processes side. Integrated and Alternate RF systems are placed somewhere in the middle, involving both human intervention and natural processes.

2.1.3 Availability of Socio-economic Information

The studies reviewed included various types of rice-fish systems, and often comparisons were made between rice monoculture and one or more types of RF, such as integrated or alternate systems. Some studies also included comparisons between RF farmers with and without Integrated Pest Management (IPM) (Berg 2002; Berg et al. 2012). IPM is an ecological approach to preventing or controlling pests, and uses various biological, chemical, and physical tools with the aim of keeping pesticide use to environmentally safe levels (EC 2021). Almost all the studies evaluated rice-fish systems and only four were assessments of rice-shrimp or rice-prawn systems (Ahmed and Garnett 2010; Nair et al. 2014; Loc et al. 2017; Kabir et al. 2020), and one included an assessment of community fish refuges (Freed et al. 2020b).

The available socio-economic factors differed from one study to the other and was based on the objective of the study and different research methods. For example, some studies provided productivity information such as rice and fish yields, and nutritional information such as household consumption of fish (Ahmed & Luong-van. 2009; Ahmed & Garnett 2011; Ahmed et al. 2011), whilst others provided data on total costs and net returns of rice-fish systems along with farmer demographics (Dwiyana and Mendoza, 2008; Rahman et al. 2012). The different combinations of data presented in the studies is depicted in Annex 1. Understanding the different socio-economic benefits of various RF systems will assist policy development and be useful in investment plans within Myanmar. However, to transfer values into the Myanmar context and present the information systematically, data cleaning, verification and adjusting of values may need to be conducted (Box 2.1).

2.2 Selecting Studies for the Unit Value Transfer

The identified rice-fish studies from the South and Southeast Asian region were thereafter compared with characteristics of the policy site (the Ayeyarwady Delta) in order to select studies that were most similar to the policy site for the unit value transfer method. By doing do this reduced the uncertainties in the value being transferred.

The following geographical factors were compared: average annual rainfall, elevation, soil type, climate, and population density of the district/province. This helped in identifying areas within South Asian and Southeast Asian countries that were similar to the Ayeyarwady Delta. In addition, the following farm level characteristics were compared: farm size (ha), average age of the farmer (years), and average farming household size (number of family members). Average household income was also considered initially, however only 1-2 studies had this information and so the factor was dropped. A simple table was created with these different factors and the characteristics of each study site, as well as the characteristics of the Ayeyarwady Delta, was added for comparison (see Annex 2). The geographical characteristics of the Delta include tropical monsoon climate with dry and rainy seasons, average annual rainfall of 1500-3500mm, low elevation, swampy and clay soils, and population density of 230 inhabitants/km^2 (BOBLME 2013; Chen et al. 2020). The farm level characteristics include average farm size of 4.2 ha, average farm household size of 4.4 and average farmer age range of 45 – 55 (World Bank 2019) (Annex 2).

All the study sites are generally similar in terms of climate, which was the basis of searching for studies in the South and Southeast Asian region. However, there are variations in terms of soil type, rainfall, and elevation. Studies that consisted of 3 or more of the above characteristics (geographical and/or farm level) in common with the Ayeyarwady Delta were considered for the unit value transfer approach. For example, the study in Assam, India was not considered as it is a higher elevation and contains different types of soils to the Ayeyarwady Delta. In addition, information on farmer age and household size were not provided. The Tonle Sap region, Cambodia was not considered as it was only similar in climate and elevation, and the study was regarding community fish refuges.

In addition to the characteristics above, two significant aspects that were considered and eliminated some of the studies were:
1) Whether the study included data on integrated RF systems and;
2) Whether the sample size was more than 20 integrated RF farms/respondents.

For example, although Kerala showed similar geographical characteristics to the Delta, the study was not considered as the sample size consisted of only 8 farms. The study by Rabbani et al. (2004) and Loc et al. (2017) were eliminated as only alternate/rotational RF systems were assessed, and Haque (2007) was not included as it assessed fish seed production. Ultimately, the following 11 integrated RF studies were included for the analysis where all involved culture-based systems (Table 2.4).

Table 2.4: Selected studies for unit value transfer

NO.	STUDY REF.	LOCATION
1	Ahmed & Garnett 2011	Mymensingh District, Bangladesh
2	Ahmed et al. 2011	Mymensingh District, Bangladesh
3	Ahmed & Luong-van 2009	Mymensingh District, Bangladesh
4	Berg 2002	Tien Giang Province, Vietnam
5	Berg et al. 2012	Can Tho and Tien Giang Province, Vietnam
6	Berg et al. 2017	Cai Be District, Tien Giang, Vietnam
7	Berg and Tam 2018	Can Tho and Tien Giang Province, Vietnam
8	Dwiyana & Mendoza 2008	Magelang District, Indonesia
9	Gupta et al. 1998	Mymensingh District, Bangladesh
10	Kabir et al. 2020	Khulna District, Bangladesh
11	Rahman et al. 2012	Mymensingh District, Bangladesh

2.3 Analysis of Unit Values

Under the *productivity category*, the values for rice yield, fish yield, total cost, and total benefit of integrated RF systems were identified from the selected studies and adjusted (where necessary) for the policy site. The average yield (and the range) of the selected studies were calculated and used as an indication for RF in the Ayeyarwady Delta.

For the total cost and total benefit calculations, the values from each study site were adjusted for purchasing power parity (PPP) and inflation to be used in the context of the policy site. The value adjustment process was informed by the value transfer guideline (Brander 2013) and adapted as follows:

1. The year of the study was identified and recorded, and the total cost and total benefit values were identified and adjusted to local currency per hectare per year. Where for example, a total cost per crop or per season is provided, the value is doubled to present an average total cost per hectare per year for integrated RF (indicated in Annex 3). Generally, 2-3 crops per year is practiced in countries such as Bangladesh and Vietnam (Berg and Tam 2018; FAO, n.d.).

2. The study site values were first adjusted for PPP to the context of the US, at the time of study (Annex 3). For example, VND/ha/year to USD/ha/year using the PPP conversion factor for Vietnam for the year 2007.

   TCUS = TCSS / PPP

   Where,

   TCUS = Total cost in the US at the time of study

   TCSS = Total cost in the study site in local currency at the time of the study

   PPP = PPP conversion factor, local currency to $ at the time of the study

   World Bank Indicators were used to obtain the PPP conversion factors (Box 2.2).

3. Since the PPP conversion factors is a spatial price deflator, the growth rate in the conversion factor for the year 2020 was calculated using the equation 1 below and then equation 2 was used to obtain the total cost or total benefit of integrated RF in the context of the US for the year 2020.

   (1) Growth rate = (A – B)/ B

   Where,

   A = PPP conversion factor for 2020

   B = PPP conversion factor at the time of the study

   (2) TC2020 = TCUS * (1+ Growth Rate)

   Where,

   TC2020 = Total cost in the US for 2020

   TCUS = Total cost in the US at the time of study

4. Finally, to present the values in the context of the policy site (in Myanmar) the values were adjusted using the PPP conversion factor for Myanmar in 2020 and presented in MMK/ha/year.

   Total cost at the policy site = TC2020 * PPP

   Where,

   TC2020 = Total cost in the US for the time of study

   PPP = PPP conversion factor for Myanmar in the year 2020

Box 2.2: PPP Conversion Factor (Source: World Bank Development Indicators)

PPP conversion factor, private consumption (LCU per international $) - Purchasing power parity (PPP) conversion factor is a spatial price deflator and currency converter that controls for price level differences between countries, thereby allowing volume comparisons of gross domestic product (GDP) and its expenditure components. This conversion factor is for household final consumption expenditure.

The total cost and total benefit values at the policy site (in MMK) are also shown in USD using standard market exchange rates. The average of the study site values was calculated to indicate the total cost and total benefit of integrated RF per hectare per year in the Ayeyarwady Delta. Thereafter these values were aggregated to depict total cost and total benefit of RF at the township level.

For the *nutrition, environment and equity* categories average values were calculated and are presented in the Findings section. Information for these categories were somewhat limited in the studies and especially for equity considerations where information on land ownership and household income was rarely included.

3. Findings

This section presents the results and the unit values transferred to the policy site context (Ayeyarwady Delta) under the broader categories of productivity of RF systems, nutritional benefits of RF systems, environmental and equity considerations.

3.1 Productivity of RF Systems

3.1.1 Yields of RF Systems

The fish and rice yields of integrated RF systems in the different study sites is depicted in Table 3.1. The average of these values can be used as an indication of the potential yield in the policy site. Due to the variations in reporting of the study site values, the fish yield is provided per year and the rice yield per season. In instances where data from two seasons is provided (in the study site), the average rice yield is calculated. For e.g., the study by Ahmed and Garnett (2011) provides rice yields for Boro and Aman seasons, and the average value is presented in Table 3.1 as 5089 kg per hectare per season.

The potential average fish yield from integrated RF in the Ayeyarwady region is 543 kg per hectare per year and a rice yield of 5039 kg per hectare per season. The analysis includes 10 of the 11 pre-selected studies, as one of the study sites (Rahman et al. 2012) did not include information on yields. According to MOALI, the average rice production in Myanmar is 3510 kg per ha (World Bank, 2019) which shows that integrated RF will not decrease current rice production and may instead improve productivity.

Table 3.1: Average rice and fish yields of integrated RF systems

Study Ref.	Integrated RF systems		Comments
	Fish Yield (kg/ha/year)	Rice yield (kg/ha/season)	
Berg 2002	367.2	4209	
Ahmed and Garnett 2011; Ahmed et al. 2011; Ahmed and Luong Van 2009	259	5089	Average of Boro and Aman rice yield.
Gupta et al. 1998	417	4395.5	This study had fish yield for Boro and Aman seasons, it was added to give total fish yield per year. For rice yield per season, average of Boro and Aman was calculated
Dwiyana and Mendoza 2008	413.8	4222.9	This study had fish yield for wet and dry seasons, it was added to give total fish yield per year. For rice yield per season, average of wet and dry seasons was calculated. Only rice cum fish values considered for consistency across studies.
Kabir et al. 2020	376	3175	The study included values on Large, Medium and Small farms. The values of small farms (0.10 to 2.20 ha) are presented here, for consistency in farm size across studies. Fishery value includes fish + shrimp yield.
Berg and Tam 2018	792.9	6668	Fish yield here includes farmed + wild fish. The study included separate values for RF high pesticide use and RF low pesticide use. The average of these is presented here.
Berg et al. 2012	687	5744	
Berg et al. 2017	966	6806	
Average	**542.59**	**5038.68**	
Range	**259 - 966**	**3175 - 6806**	

3.1.2 Total Costs and Total Benefits of RF Systems

Two of the studies (Gupta et al. 1998 and Dwiyana & Mendoza 2008) did not include total cost/benefit calculations in their analysis, and therefore the values of 9 integrated RF study sites are presented in Table 3.2. The average of these values can be used as an indication of the potential costs and benefits of implementing integrated rice-fish in the Ayeyarwady Delta. There were variations in the reporting of study site values which were adjusted prior to the analysis (see Section 2.3). Each of the study site values are also adjusted for purchasing power parity and inflation to obtain the current total cost and total benefit in MMK (Myanmar Kyat) per hectare per year in the context of the policy site (See Annex 3 for breakdown of calculations). The final values are presented in Table 3.2.

The average total cost of integrated RF systems is 2.4 million MMK per hectare per year (1746 USD/ha/year[1]) and the average total benefit is approx. 5.5 million MMK per hectare per year (3975 USD/ha/year) (Table 3.2). As expected, the cost of integrated RF is higher than the current cost of rice monocrop which is approx. 1107 USD/ha/year (World Bank 2019, See Box 3.1), due to the added costs from fish culture such as fingerlings and feed. The initial cost for integrated RF systems may be even higher with required adjustments to rice fields such as the construction of canals, bunds.
The net benefit of integrated RF per farmer household is approximately 3.1 million MMK per hectare per year (2228 USD/ha/year). This is three times more than the current net margin from rice monocrop of approx. 550 USD/ha/year (World Bank 2019, see Box 3.1).

Table 3.2: Average Total Cost and Total Benefit values of integrated rice-fish systems

Study Ref.	Total Cost in Myanmar Kyat/ha/year (adjusted for PPP)	Total Benefit in Myanmar Kyat/ha/year (adjusted for PPP)	Equivalent TC USD/ha/year (Market Exchange Rate)	Equivalent TB USD/ha/year (Market Exchange Rate)
Berg 2002	1,968,864.85	5,012,062.27	1,425.06	3,627.72
Ahmed and Garnett 2011; Ahmed et al. 2011; Ahmed and Luong Van 2009	2,203,765.90	7,024,006.13	1,595.08	5,083.97
Rahman et al. 2012	4,033,733.73	4,945,468.07	2,919.61	3,579.52
Kabir et al. 2020	2,322,457.56	3,374,609.03	1,680.99	2,442.54
Berg and Tam 2018	1,681,955.40	4,900,360.74	1,217.40	3,546.87
Berg et al. 2012	2,771,048.16	8,637,416.08	2,005.68	6,251.75
Berg et al. 2017	1,911,625.35	4,551,991.84	1,383.63	3,294.72
Average	**2,413,350.13**	**5,492,273.45**	**1,746.78**	**3,975.30**

[1] Market exchange rate 1 USD = 1381.6 MMK in the year 2020

Table 3.3 depicts the separate revenue/benefit from fish and rice components of integrated RF farming, from the available information in the selected studies. Only 4 studies included a breakdown of the benefits of RF according to each component (Berg 2002; Ahmed et al. 2011; Berg et al. 2017; Berg and Tam 2018). A breakdown of the costs is not included, as this information is often presented as aggregated values in the studies. For e.g., labour costs for integrated RF farming are provided as a total for both rice and fish, and not indicated separately.

The average revenue from cultured and wild fish of integrated RF systems is 823,675 MMK/ha/year (596 USD/ha/year) and the average revenue from the rice component of integrated RF is 4.5 million MMK/ha/year (3292 USD/ha/year) (Table 3.3). The benefit from the rice component of integrated RF is nearly double that of current benefits from rice monocrop of 1659 USD/ha/year (World Bank 2019, see Box 3.1).

Table 3.3: The cost and revenue of rice and fish components of integrated RF systems

Study Ref	Fish Revenue in Myanmar Kyat/ha/year (adjusted for PPP)	Rice Revenue in Myanmar Kyat/ha/year (adjusted for PPP)	Equivalent Fish Revenue USD/ha/year (Market Exchange Rate)	Equivalent Rice Revenue USD/ha/year (Market Exchange Rate)
Berg 2002	715,479.10	4,296,583.18	517.86	3,109.86
Ahmed et al. 2011	722,115.35	6,301,890.78	522.67	4,561.30
Berg and Tam 2018	558,047.14	4,342,313.59	403.91	3,142.96
Berg et al. 2017	1,299,060.32	3,252,931.53	940.26	2,354.47
Average	**823,675.48**	**4,548,429.77**	**596.18**	**3,292.15**

Box 3.1: Cost and revenue of rice monocrop cultivation in the Ayeyarwady Region (source: World Bank, 2019)

In the Ayeyarwady region, for the year 2017/18, the total cost and total revenue for monsoon paddy production is 475 USD/ha and 710 USD/ha respectively. The total cost and revenue for dry season paddy production is 600 USD/ha and 900 USD/ha respectively.
Therefore, assuming two seasons per year:
Total Cost = 475 + 600 = 1075 USD/ha/year
Total Benefit = 710 + 900 = 1610 USD/ha/year

Adjusted for inflation using World Bank Indicators:
TC of rice cultivation (2020) = TC of Paddy in 2018 * (GDP Deflator for 2020/GDP deflator for 2018)
= 1075 * (108.6/105.4)
= **1107.6 USD/ha/year**
and,
TB of rice cultivation (2020) = TB of Paddy in 2018 * (GDP Deflator for 2020/GDP deflator for 2018)
= 1610 * (108.6/105.4)
= **1658.8 USD/ha/year**
Therefore

Net benefit of rice cultivation (2020) = 1658.8 – 1107.6

= **551 USD/ha/year**

The types of costs and benefits accounted for in each of the primary studies may vary, which results in a wide range of total cost and total benefit values transferable to the policy site. Based on the available information, Table 3.4 describes the types of costs/benefits included in the primary valuation for the study sites.

Table 3.4: Description of total costs and total benefits from primary studies

Study Ref.	Factors included in calculation	
	Total Cost	**Total Benefit**
Berg 2002	Seed, fertiliser, pesticides, labour, tax, fish fingerlings, fish feed	Income from rice, cultured fish, wild species.
Ahmed et al. 2011	Variable costs – fish fingerlings, rice seeding, fish feed, fertiliser, labour, harvesting and marketing, miscellaneous. Fixed costs – depreciation, interest, land-use costs.	Rice, rice straw, fish.
Berg 2017	Seed, fertiliser, pesticides, labour, fingerlings, fish feed, chemicals	Income from rice, cultured fish.
Berg & Tam 2018	Seed, fertiliser, pesticide, labour, fingerling	Income from Rice, farmed fish, wild fish.

It is important to note that there are some benefits or ecosystem services of RF systems that are not captured in the market prices mentioned above. Ecosystem services (ES) are the benefits humans obtain from nature or ecosystems, and are generally categorised according to supporting services, regulating services, cultural and provisional services (MA 2005). For example, RF systems may improve soil quality and water regulation (regulating ecosystem services), compared to rice monoculture, which can increase crop productivity. Depending on the type of RF system and the practices conducted on the field, supporting, and regulating services (e.g., biodiversity and natural pest management) and general improvement to human wellbeing (due to increase in nutrition intake and reduced exposure to chemicals) may be generated (Berg et al. 2017). Utilising a holistic ecosystems approach will allow for the identification of all ecosystem services generated from the RF system that may impact socio-economic outcomes (Ahmed et al. 2014; Berg et al. 2017). Loc et al. (2017) used such an approach to assess soil quality and water regulation in a rice-prawn rotational/alternate farm, which highlighted the contribution of ecosystem services to the local economy.

In addition, there are other costs associated with RF systems that have not been included in the total cost calculations above. As more farmers adopt integrated RF there may be costs to the community with changes in access regimes and alterations to water regulation, which are not included in the total cost of implementing RF. The values in this study can be considered a prelude to understanding and valuing all costs and benefits from RF systems, as it identifies some of the nutritional and environmental aspects from other studies (see below). However, further research is needed to fully account for these in total cost and total benefit calculations.

3.1.3 Total Cost and Total Benefit of RF Systems at the Township Level

Using the values transferred from other studies, an aggregation is presented below to understand the cost and benefit at the township level in the Ayeyarwady Delta (Table 3.5). The suitability model (developed by WorldFish) has identified areas within townships that are *most suitable, suitable, moderately suitable and least suitable* for RF cultivation systems. Assuming the *most suitable* areas in each township can be converted to integrated RF systems, an indication of the total cost and the total benefit is provided in Table 3.5. For example, the potential total benefit of integrated RF in Zalun Township is 206 million USD/year. However, these values do not include the initial costs associated with converting rice fields to integrated rice-fish systems in addition to the other types of costs and benefits mentioned above.

Table 3.5: Total Cost and total benefit of potential RF systems at the township level

District	Township	Most suitable land area per township for RF (ha)	Total Cost of integrated RF (USD/year)*	Total Benefit of integrated RF (USD/year)*
Hinthada	Hinthada	94418.46	155,601,622	346,893,422
Hinthada	Zalun	56081.97	92,423,087	206,045,158
Maubin	Danubyu	68324.31	112,598,463	251,023,515

Myaungmya	Myaungmya	99908.64	164,649,439	367,064,343
Pathein	Kyaunggon	66296.88	109,257,258	243,574,737
Pathein	Kyonpyaw	78310.80	129,056,198	287,713,879
Pathein	Pathein	102081.06	168,229,587	375,045,814

* Market exchange rate 1 USD = 1381.6 MMK in the year 2020

For the townships that have *most suitable* land for integrated RF, Table 3.6 depicts the area that is currently being utilised for rice cultivation (DoA 2019). Using the cost and benefit figures for rice monocrop cultivation from the World Bank (2019) (1107.6 USD/ha/year and 1658.8 USD/ha/year respectively), the current values in each of these townships is provided (Table 3.6). For example, the total benefit from rice monocrop cultivation in Zalun Township is 51.5 million USD/year.

Table 3.6: Total cost and total benefit of rice monocrop cultivation in the selected townships in the Ayeyarwady region

District	Township	Paddy land area (ha)	TC of Rice (USD/year)	TB of Rice (USD/year)
Hinthada	Hinthada	52254.00	57,876,530.40	86,678,935.20
Hinthada	Zalun	31102.40	34,449,018.24	51,592,661.12
Maubin	Danubyu	52679.60	58,347,924.96	87,384,920.48
Myaungmya	Myaungmya	111541.20	123,543,033.12	185,024,542.56
Pathein	Kyaunggon	46091.60	51,051,056.16	76,456,746.08
Pathein	Kyonpyaw	51813.20	57,388,300.32	85,947,736.16
Pathein	Pathein	53497.60	59,253,941.76	88,741,818.88

The potential additional benefit from adopting integrated RF systems (or comparison of benefits between integrated RF and rice monocrop) in each of the townships is depicted in Table 3.7. For example, an additional benefit of 154.5 million USD/year can be achieved in Zalun Township if integrated RF is cultivated in the *most suitable* land areas.

Table 3.7: Additional benefit of integrated RF systems for selected townships in the Ayeyarwady region

District	Township	Potential additional Benefit from RF (USD/year)
Hinthada	Hinthada	260,214,486.84
Hinthada	Zalun	154,452,496.66
Maubin	Danubyu	163,638,594.46
Myaungmya	Myaungmya	182,039,800.80
Pathein	Kyaunggon	167,117,991.04
Pathein	Kyonpyaw	201,766,143.04
Pathein	Pathein	286,303,995.56

3.2 Nutrition

Of the studies that were similar to the policy site, only 4 included information on nutritional aspects. Household consumption of fish as a percentage of the total catch were reported for 3 studies and this is presented in Table 3.5 along with the equivalent in kg per household per catch. The study by Rahman et al. (2012) presented nutritional value of integrated RF in grams of fish consumed per day per family (245 gm/day/family) and this was adjusted to match the units of the other studies (Table 3.8).

On average a household consumes 33% of fish production, or approximately 99.12 kg of fish per year, from an integrated RF system. Based on the average of 4.4 persons per agricultural household in Myanmar (Harper et al. 2017), it can be estimated that integrated RF can provide a potential of 22.5 kg of fish per person per year, which is 75% of the current fish consumption per person in the country[2].

Table 3.8: Nutritional benefit of integrated RF systems

Nutrition			
Study Ref.	**Fish Yield (kg/ha)**	**Percentage of fish catch for HH consumption (%)**	**Quantity of fish consumed (kg per HH)**
Ahmed & Garnett 2011	259	40%	103.60
Gupta et al. 1998	417	25%	104.25
Rahman et al. 2012	-	-	89.5
Average		**33%**	**99.12**

3.3 Environment

Four of the studies similar to the policy site included information on pesticide and fertiliser use in RF systems. The use of pesticide, fertiliser and outputs generated between RF systems and Rice monocrop were compared (Table 3.9). The study by Gupta et al. 1998 was excluded as it reported total pesticide use in kg per hectare, whereas the other study sites reported pesticide use as active ingredient (a.i.) in kg per hectare. The quantities of pesticide reported include herbicide, fungicide and insecticides, and fertiliser includes nitrogen, phosphate and potassium (NPK). Pesticide use in rice-fish systems is 1.2 kg per ha of a.i., which is slightly less than the average pesticide use for rice monocrop (1.7 kg per ha, a.i.). The average fertiliser use in RF systems is 142 kg/ha which is less than fertiliser use in rice monocrop cultivations (153 kg/ha). The difference in the average rice yields of rice monocrop and RF systems is under 500 kg/ha, with RF producing less than rice monocrop.

Table 3.9: Comparison of pesticide and fertiliser use in RF systems and Rice monocrop

	Rice Monocrop			Rice-fish			
Study Ref	**Pesticide use in Rice a.i. kg/ha**	**Fertiliser kg/ha**	**Rice Yield (kg/ha/ season)**	**Pesticide use in RF a.i. kg/ha**	**Fertiliser kg/ha**	**Rice yield (kg/ha/ season)**	**Fish Yield (kg/ha/ year)**

[2] Current average consumption of fish in Myanmar is 30 kg per person per year (WorldFish 2017).

Berg 2002	1.8	144.4	4844	1.01	144.4	4209	367
Berg and Tam 2018	1.26	144.2	7043.5	1.18	88.6	6668	793
Berg et al. 2012	1.52	125	5732	1.24	168.1	5744	444
Berg et al. 2017	2.16	196.9	7629	1.38	165.9	6806	966
Average	**1.7**	**152.6**	**6312.1**	**1.2**	**141.8**	**5856.8**	**642.5**

RF systems have shown to increase farmer income compared to rice farmers (through income from fish yield), without decreasing rice yields and the income can be further increased if rice-fish farming practices are optimised (Berg et al. 2012). In the study by Berg et al. (2012) RF farming and pesticide use was compared between two provinces (Can Tho and Tien Giang) in Vietnam and it was found that RF farmers in Can Tho used significantly less amounts of pesticide and had higher fish yields, and therefore higher income than RF farmers in Tien Giang. The decreased use of pesticides also reduces cost of production and provides benefits in terms of farmer health. Pesticide residues have caused more than 7000 cases of food poisoning, leading to 277 deaths in 37 provinces of Vietnam in the year 2002 (Berg et al. 2012) which indicates the need to significantly reduce pesticide use. Overuse of pesticides may also lead to pest resistance and outbreak (Berg et al. 2012; Berg et al. 2017). RF systems have the potential to be economically and ecologically beneficial (compared to rice monocrop) as the integration of fish enables farmers to understand the negative impacts of pesticides and the role of fish as natural pest controls (Berg et al. 2012).

3.4 Equity Considerations

There is very little quantitative information available on equity aspects of RF systems to conduct comparisons across the different study sites and transfer values to the policy site in Myanmar. Equity considerations would include for example, the types of landownership or levels of household income and its effect on adopting rice-fish cultivation. However, a few of the selected studies and some others in the region have qualitatively assessed certain aspects that affect adoptability of RF, and 7 of the selected studies have included information on farmer and farm characteristics (Table 3.10). This section provides a description of these findings, and how it may relate to the context of the Ayeyarwady Delta.

The costs associated with rice-fish cultivation seem to be a key constraint in the adoption of the system. Costs in terms of inputs, seeds, fingerlings, machinery and equipment, water availability, labour etc. may significantly affect a smallholder farmers' decision to adopt rice-fish cultivation or to switch from rice monocrop to RF systems (Ahmed et al. 2011; Rahman et al. 2012; Dey et al 2013). In the study by Ahmed et al. (2011) 34% of farmer respondents cited high production costs as a barrier to adoption and in the study by Gupta et al. (1998), 21% of farmers had to take out loans to establish the RF system. In Mymensingh Bangladesh, rice farmers were reluctant to adopt RF because of climate risk (e.g. flood and drought) and it was found that better off or wealthier farmers were more likely to make the switch (Ahmed and Garnett 2011; Ahmed et al. 2011). This corresponds with the study by Gupta et al. (1998) which found that the average landholding of the farmers who adopted RF was 1.97 ha which was much higher than the national average of 0.9 ha at the time. However, in some of the selected studies it is observed that the average land size of RF farmers is below 1 ha (Table 3.10). Further research is required to understand the relationship between household income levels, farmer perception of risk and willingness to adopt RF. As demonstrated in the selected studies, farmers who have already adopted RF, recognise the benefits in terms of increased income and nutritional value.

Technical knowledge has been identified as another key factor affecting the adoption of RF (Ahmed et al. 2011). Gupta et al. (1998) reported that adoption of RF was more likely among literate farmers as 74% of new RF farmers had education beyond primary level. Two of the selected studies found positive correlations between income and yield from RF systems and the educational level of the farmer as well as farming experience (Dwiyana & Mendoza 2008; Ahmed & Garnett 2011). The average level of education of RF farmers across the study sites is 7.7 years with 7.3 years of RF farming experience (Table 3.10). The availability of family labour (household size) and age of the farmer were also identified as reasons that can affect the outputs (yield) of RF systems and may influence the adoption of RF systems in some of the study sites (Gupta et al. 1998; Dwiyana & Mendoza 2008; Ahmed & Garnett 2011)

Similar reasons can be seen in the Ayeyarwady Delta itself when it comes to farmers' ability to adapt agricultural practices. The study by SeinnSeinn et al. (2015) assessed farmer adaptation to rainfall and salinity through agronomic practices, and found that farm size, farm income and access to training and credit were among the most influential factors for adaptation of agricultural practices. Therefore, it is important to develop suitable interventions that address these factors in the promotion of integrated RF in Ayeyarwady Delta. Providing institutional support, improving extension services, training facilities and access to low interest credit are some of the areas highlighted by the studies on integrated RF (Ahmed et al. 2011; Islam et al. 2015).

Table 3.10: Integrated RF farmer and farm characteristics

Study Ref	Average Farm Area (ha)	Age of farmer (years)	Household Size (number of family members)	Educational level of farmer (years)	Experience in RF farming (years)
Berg 2002	1.3	48	5.9	5.5	3.6
Gupta et al. 1998	1.97	40.5	9.44	-	-
Dwiyana & Mendoza 2008	0.23	43.6	4	8	19*
Kabir et al. 2020	0.63	46	-	8	-
Berg & Tam 2018	2	48.5	4.8	7.8	2.9
Berg et al. 2012	1	50.3	4.8	8.7	5
Berg et al. 2017	1.1	-	4.6	8.4	5.8
Average	**1.2**	**46.2**	**5.6**	**7.7**	**7.3**

*Does not specify if RF farming experience or total farming experience

4. Conclusion

Rice-fish systems have proven to generate more benefits, in terms of food security, poverty alleviation, and ecological functioning, than its intensive counterpart rice mono-cultivation and aquaculture. This study has identified the benefit and cost values associated with RF in primary studies conducted in the South and Southeast Asian region in order transfer such values to the context of the Ayeyarwady Delta in Myanmar. Using a value transfer approach does have its limitations as there may be inaccuracy when transferring values from one context (and one country) to another, generalisation, difficulties in finding relevant studies or information, and difficulty in assessing the quality of the primary study (Brander 2013; Ecosystem Valuation 2021). However, the method undertaken in this value transfer approach, where the characteristics of the study sites and the policy site were compared and suitable studies selected and values of more than one study were transferred to the policy site, lessened the generalisation of data and inaccuracies as much as possible. It is important to keep in mind that the approach was used because primary data collection in Myanmar was not possible at the time, and the unit value transfer approach provided a means to build on the existing momentum in informing agricultural policy and planning in the country.

The study found that the potential yields for RF in Myanmar are 5039 kg per ha per season for rice and 543 kg per ha per year for fish with the average total cost of 2.4 million MMK per ha per year and the average total benefit of 5.5 million MMK per ha per year, providing a net benefit of 3.1 million MMK per ha per year per farmer. Integrated rice-fish has the potential to increase the level of nutrition in Myanmar. Where current consumption of fish is 30 kg per person per year, integrated RF can contribute 22.5 kg per person per year. It can also generate environmental benefits that contribute to farmer health. Rice-fish systems require less pesticide use and make farmers more aware of the quantity used, thereby reducing farmer exposure to toxic chemicals and improving water quality. The study also identified the main factors affecting a farmers' decision to adopt rice-fish systems, which include education level, access to training, household wealth (income and land size) and access to credit.

Current land use policy limits the diversification of cultivation practices for farmers in Myanmar thereby preventing the widespread adoption of integrated rice-fish farming (Dubois et al. 2019). The Myanmar Agriculture Development Strategy and Investment Plan (2018-2023) integrates and coordinates various agricultural plans and programs created by different stakeholders, creates a systematic approach in the implementation of agricultural policy, and maintains dialogue with local and foreign investors (FAOLEX 2018; MOALI 2018). While the main objectives of the Plan include, (1) increased food and nutrition security; and (2) poverty reduction, among others (FAOLEX 2018; MOALI 2018), there is no explicit mention of the promotion of integrated RF systems. However, with the efforts of WorldFish and other partners, the implementation of RF trials and development of the RF suitability model (Dubois et al. 2019) is changing the policy landscape (e.g. Naypyitaw Agreement, WorldFish 2019). It is envisaged that the findings generated by this study will enable further policy discussions and targeted investment to promote the adoption of RF.

It is important to bear in mind that in the studies reviewed, different socio-economic factors or combinations of factors have been assessed, and a systematic, comprehensive analysis of all the socio-economic aspects related to rice-fish systems is lacking. As described in the study, there are other benefits of RF systems that can be identified and quantified through further research, such as the impact on biodiversity, soil quality and water regulation. Another important consideration is the trade-offs associated with utilising different agricultural systems and the impacts of transitioning from one system to the other. For e.g., understanding how the transition to RF systems may affect access regimes/ rights to fish. It is therefore important that the findings of this study be complemented with primary valuation and impact analysis in the Ayeyarwady Delta.

5. Moving Forward: Initial Framework for a Business Plan for Rice-Fish systems in Myanmar

This section considers some of the initial information required for the development of a business/investment plan for the implementation of rice-fish systems in the Ayeyarwady Delta, Myanmar. Investment or Business Plans for agriculture come in different forms and are dependent on the administrative level that is being targeted (country level or farm level), the owner/initiator of the plan (producer, buyer or intermediary) and the target audience (Private sector, Government, Donors etc.).

National Agricultural Investment Plans or country investment plans (CIPs) consist of an overall strategy for the allocation of resources toward a common set of goals (e.g., food security and nutrition). These plans also create synergy between international financing mechanisms and country programmes or objectives for the agricultural sector (Young 2012). There are different guidelines set out for the development of CIPs, however, they more or less consist of the same information (FAO 2021). For example, the investment planning process for the Comprehensive Africa Agriculture Development Programme (CAADP) includes broad sections on engagement with stakeholders and public, evidence-based analysis, development of investment programs and partnerships, assessment and learning from process, and adapting and re-planning (Young 2012).

Business plans can be created by individual farmers or groups of farmers, for their farms or for types of crops, and these are referred to as producer driven business models. The objectives of this type of business model are to "*serve new markets, achieve better market prices, stabilize market position, supply larger volumes, increase bargaining power and access inputs and services*" (Kaminski et al. 2020, p.1885). In contrast, buyer driven business models are generally initiated by processors, exporters and retailers in order to maximise benefits through contracts with farmers and are mainly driven by market demand (Kaminski et al. 2020).

Most of these business models focus on the extraction and the economic gain from production rather than the social and environmental impact. Research has also demonstrated that in certain types of business models, smallholder farmers most often lose out and are trapped in contracts that are exploitative (for e.g., in sharecropping and tenant farming where rewards may not be distributed fairly) (Kaminski et al. 2020). However, an inclusive business model considering all aspects with the cooperation of all stakeholders is needed to ensure the sustainability of an agricultural business. Business plans initiated by Government agencies or NGOs (also called intermediary driven models) tend to be more inclusive as they consider food safety, quality, and sustainable supply. The level of inclusivity depends on who is creating the business model or plan and who it is made for. Bearing this in mind, the general aspects to be included in a business plan are outlined below so that it may be tailored subsequently (Box 5.1).

IWMI developed a catalogue of resource recovery business models which provides a guideline into the kind of information required to promote a particular agricultural model and develop an investment plan. These models include details on the key partners, activities, value propositions, consumer segments, key resources and channels, cost structure and revenue streams, including social and environmental costs and benefits, and potential risks and mitigation (Otoo and Drechsel, 2018). Based on the examples from agriculture business models and/or investment plans, Box 5.1 includes an outline of the details that may be required for a Rice-fish business/investment plan. This is an initial version of a framework and is kept broad so that it may be adapted to suit different locations, RF systems and target audiences.

Box 5.1: Details for a Rice-fish Business Plan

1. Selection of a Suitable Area
- Consider Bio-physical characteristics such as soil quality, water availability, rainfall patterns, climate, biodiversity etc.
- Consider Socio-economic characteristics such as farmer age, gender of household head, experience in RF farming, household size and income, land area, nutrition level etc.
- Consider institutional and value chain aspects such as transport networks, extension services etc.

2. Selection of a Suitable Rice-fish System
- Based on the information above and history of agricultural practices adopted in the area – the type of RF system can be determined – alternate, integrated, community fish refuges etc.
- Accordingly, fish species and rice varieties can be selected.

3. Required Construction and Inputs – altering fields by creating ponds, canals etc., identifying machinery and equipment needed, fertiliser and pest management needs.

4. Assessing Market Demand
- Local market – household consumption, proximity of economic centres/local markets, prices.
- Export market – identifying buyers, packaging, and processing requirements.

5. Economics – costs of production (fixed and variable costs), expected revenue and income, ecosystem services generated, nutritional and other socio-economic benefits.

6. Risk Management – disease prevention, pest management, climate risk, risks to farmer health and wellbeing, social risks, and trade-offs such as changes to access regimes.

Based on the RF trials, the RF suitability model and decision support tool, the socio-economic results generated by this study and the research conducted by the CGIAR FISH program to date, several key initial details of the business plan may already be available, however this may need to be complemented with further primary studies in the Ayeyarwady Delta.

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Annexes

Annex 1: Availability of socio-economic information from RF studies in the region

Study/ Article	Type of RF System and data	Productivity					Nutrition	Environment/Sustainability			Equity				
		Fish Yield	Rice Yield	Total Cost	Total Revenue	Net Income	HH Consumption of Fish Catch	Pesticide Use	Biodiversity	ES – soil quality & water regulation	HH Income	Age of farm owner/ HH head	Gender of Farmer	HH Size	Area of RF per farmer /HH
Ahmed & Luong-van. 2009; Ahmed & Garnett 2011; Ahmed et al. 2011	Rice-fish integrated and alternate. Data collection from 80 farmers	x	x	x	x		x								x
Ahmed and Garnett (2010)	Rice-prawn integrated. Review of other studies	x	x	x	x										x
Berg et al. 2012	Rice-fish with and without IPM. Data collection from 87 farmers.	x	x	x		x		x				x		x	x
Berg et al. 2017	Rice-fish integrated with IPM. Data collection from 20 farmers	x	x	x		x		x						x	x
Berg and Tam 2018	Rice-fish grouped according to pesticide use. Data collection from 80 farmers	x	x	x		x		x				x		x	x
Berg 2020	Rice-fish with and without IPM. Data collection from 40 farmers	x	x	x	x	x		x				x		x	x
Dey and Prein 2005; Dey et al. 2005	Rice-fish integrated and alternate. Data collected over three years 1998 - 2000	x	x	x		x									

Dey et al. 2013	Rice-fish integrated and alternate. Secondary data from 475 Dept. of Fisheries officers and primary data from 138 farmers			x		x									x
Dwiyana and Mendoza 2008	Rice-fish integrated, alternate, and 3 other types of RF. Data collection from 217 farmers	x	x	x	x							x	x	x	x
Freed et al. 2020b	Community Fish Refuges (CFR). Data collection from 40 CFRs and 400 HHs	x					x		x			x	x		x
Goswami et al. 2004	Rice-fish integrated. Data collection from 100 farmers	x	x	x		x									x
Gupta et al. 1998	Rice-fish integrated. Data collection from 256 farmers.	x	x	x		x	x	x				x		x	x
Halwart and Gupta (2004)	Rice-fish integrated, alternate. Review of other studies	x	x	x	x		x								
Haque. 2007	Rice-fish seed production. Data collection from 60 households	x	x				x				x		x	x	x
Kabir et al. 2020	Rice-fish and Rice-shrimp. Data collection from 73 households	x	x	x		x					x	x			x
Loc et al. 2017	Rice-prawn alternate. Data collection from 50 households	x	x	x						x		x	x		
Nair et al. 2014	Rice-prawn integrated - conventional and organic. Data collection from 8 farms	x	x	x	x										
Rabbani et al. 2004	Rice-fish alternate. Data collection from 80 farmers	x	x	x		x									
Rahman et al. 2012	Rice-fish integrated. Data collection from 100 farmers			x		x	x								

Annex 2: Comparison of study site characteristics to the policy site, Ayeyawardy Delta

Location	Rainfall	Soil	Elevation	Climate	Population density	Avg farm size (ha)	Farm household size	Avg Farmer Age
Ayeyarwady Delta, Myanmar	**2887 mm** **Range – 1500 – 3500mm (BOBLME 2013)**	**Meadow gleyey clay soils, meadow swampy soils and saline gleyey soils.**	**1.52 m (Labutta)** **10 m (Myaungmya)** **17m (Hinthada)**	**Tropical monsoon with distinct dry and rainy seasons**	**Ayeyawardy region – 230 inhabitants/km^2**	**4.2 ha (World Bank 2019)** **But high percentage of landless especially post cyclone Nargis (e.g. 71% in Labutta).**	**4.4 (Harper et al. 2017)**	**45 - 55**
Tonle Sap region, Cambodia	1200 – 1900 mm	Sandy soils high permeability	10 – 30m	Dry and wet monsoon climate	53 per km^2	1.6 ha		Fisher range: 6 -65
Mymensingh district, north-central Bangladesh	area is located within the monsoon tropics with an average annual rainfall of 2,500 mm (FAO 2000).	All soils were acidic and textural classes were sandy loam, silt loam, loam, and clay loam. Organic matter and total N contents low to very low. (https://ageconsearch.umn.edu/record/235281/files/6.%20JBAU%20745-15.pdf)	19 m	Tropical monsoon	1,029 per km^2 https://en.banglapedia.org/index.php/Mymensingh_District	1.97 ha (256 farmers average) 0.31 ha (80 farmer average different study)	9.4	40.5

Comilla, Bangladesh		Alluvial plain. Grey loam on the ridges and grey to dark grey clay in the basins. Non calcareous floodplain soil.	15 m	Monsoonal, high humidity.	1490 per km^2 https://en.banglapedia.org/index.php/Comilla_District			
Khulna District, Bangladesh	1630 mm average annual rainfall	The thickness of the alluvial sediment layers (alternating fluviatile and marine deposits) amounts to some hundreds of metres. Generally the depositing power of the rivers is such, that in most cases a fluviatile subsoil is found. (https://edepot.wur.nl/109954)	90 m	Humid, monsoonal	860 per km^2 https://knoema.com/atlas/Bangladesh/Khulna	Large farm HHs = 4.59 ha Medium = 1.73 ha Small = 0.63 ha		46 - 48
North West Bangladesh	150 – 138 mm? (https://link.springer.com/article/10.1007/s40808-016-0089-7) 2400 mm (Rangpur) https://en.climate-data.org/asia/bangladesh/rangpur-division-2266/	Sandy loam, sandy clay loam, silty loam (https://www.researchgate.net/figure/Categorizes-of-soil-texture-in-Bangladesh_fig1_320732506)	34 m (Rangpur)	High humidity, Subtropical monsoon climate	3872 per km^2 (Rangpur)	1.15ha	5.6	

Two districts of Assam, North-East India	1524 mm	Broadly, Alluvial soil, piedmont soil, hill soil and lateritic soils	450 – 1000m	Tropical monsoon	398 per km^2	1.54 ha		
Kerala, India	2817 mm	soils of Kerala can be broadly grouped into coastal alluvium, mixed alluvium, acid saline, kari, laterite, red, hill, black cotton and forest soils.	9 m	Tropical monsoon	860 per km^2			
Magelang, Central Java, Indonesia	2255 mm (Central Java)	Red and Yellow Podzolic soils, Latosols, Grumusols, and Mediterranean soils (central Java)	350 m	Tropical rainforest	1128 per km^2	0.23 – 0.31 ha	4	43.6
Tien Giang province, Viet Nam	966 – 1325 mm (Mekong)	Alluvial soils (Mekong delta)	0.8 m (Mekong Delta)	tropical	704 per km^2 (Tien Giang)	1.3 – 1.6 ha	5 -6	43 - 48
Kien Giang, Vietnam	Same as above	Same as above	Same as above		271 per km^2			46

Annex 3: Unit Value Transfer – Total Cost and Total Benefit

Study Ref.	Study Site Values				Value in the US at the time of the study			Value in the US in 2020				Values in the policy site, Myanmar			
	Unit	**Year of Data Collection**	**Total Cost (local currency /ha/year)**	**Total Benefit (local currency/ha/year)**	**PPP Conversion Factor, private consumption (LCU per international $) for year of the study**	**Total Cost USD per ha per year, in the year of the study (adjusted for PPP)**	**Total Benefit USD per ha per year, in the year of the study (adjusted for PPP)**	**PPP conversion factor, private consumption (LCU per international $) for 2020**	**Growth rate**	**Total Cost USD per ha per year for 2020**	**Total Benefit USD per ha per year for 2020**	**Total Cost in Myanmar Kyat/ha/year (adjusted for PPP)**	**Total Benefit in Myanmar Kyat/ha/year (adjusted for PPP)**	**Equivalent TC USD/ha/year (Market Exchange Rate)**	**Equivalent TB USD/ha/year (Market Exchange Rate)**
Berg 2002	VND/ha/year	1999	10,198,451	25,961,798.00	4191	2,433.42	6,194.65	8,123.90	0.94	4,716.97	12,007.82	1,968,864.85	5,012,062.27	1,425.06	3,627.72
Ahmed and Garnett 2011;	VND/ha/year	2007	14,951,310	43,298,215.58	4796.4	3,117.19	9,027.23	8,123.90	0.69	5,279.75	15,289.87	2,203,765.90	6,381,991.53	1,595.08	4,619.28
Rahman et al. 2012	Tk/ha/year	2009	135,780	166,470.00	21.5	6,315.35	7,742.79	32.90	0.53	9,663.95	11,848.27	4,033,733.73	4,945,468.07	2,919.61	3,579.52
Kabir et al. 2020	Tk/ha/year	2014	121,470	176,500.00	26.8	4,532.46	6,585.82	32.90	0.23	5,564.11	8,084.83	2,322,457.56	3,374,609.03	1,680.99	2,442.54
Berg and Tam 2018	VND/ha/year	2012	28,413,000	82,781,000.00	7568.5	3,754.11	10,937.57	8,123.90	0.07	4,029.60	11,740.20	1,681,955.40	4,900,360.74	1,217.40	3,546.87
Berg et al. 2012	VND/ha/year	2007	18,800,000	58,600,000.00	4796.4	3,919.61	12,217.50	8,123.90	0.69	6,638.83	20,693.38	2,771,048.16	8,637,416.08	2,005.68	6,251.75
Berg et al. 2017	VND/ha/year	2014	36,200,000	86,200,000.00	8013.3	4,517.49	10,757.12	8,123.90	0.01	4,579.84	10,905.59	1,911,625.35	4,551,991.84	1,383.63	3,294.72
											Average	**2,413,350.13**	**5,400,557.08**	**1,746.78**	**3,908.92**

Values in blue – values available in the study doubled to present an average total cost per hectare per year for integrated RF, assuming 2 crops per year.