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Rice-fish scoping report for AICCRA Mali

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1. Executive summary

Rice and fish are important foods and products in Mali that face challenges from the effects of climate change. To identify gaps and needs, as well as opportunities for improving climate resilience and livelihoods through integrated rice-fish production, we conducted a scoping study that consisted of a literature review and interviews with key informants. This study was done in the focal regions of Segou, Mopti and Koulikoro as part of the Accelerating the Impact of CGIAR Climate Research for Africa project in Mali (AICCRA Mali).

The report provides context that includes the following points: (i) the agroecosystems of these focal regions and the water and climate challenges faced, (ii) the state of production for rice and fish, (iii) the hazards and vulnerability of farmers and food systems, (iv) policy and strategies for supporting or improving integrated production systems and (v) potential approaches for integrated production of fish and rice in Mali.

The report also provides responses from key informants on production practices, farmer preferences, opportunities and challenges. This data provides further insight into suitable approaches for integrating fish and rice, gender- and youth-specific opportunities and constraints, and the gaps and needs in terms of infrastructure, finance, management, value chains and markets.

Key findings include the extensive nature of fish production that is integrated with rice production in the study areas. Capture fisheries are still active in rice producing areas, as is production (both managed and "wild") of aquatic plants and other aquatic animals. Concurrent rice-fish culture is also practiced, primarily with tilapia or catfish (Clarias sp.) as the fishstock. Key informants among women, men and youths reported relatively similar participation in production tasks for rice and fish and similar needs for financial capital and training, though preferences differed on financial investment in production. All the respondents reported the same primary constraints for integrated rice-fish production: (i) land ownership, (ii) water supply, (iii) access, price and quality of fish feed and (iv) the price and quality of fingerlings. Preferences among respondents on management arrangements for integrated rice-fish production were roughly equally divided between individual farm-level management and cooperative management, with youths preferring the latter. Norms for women's participation and the timing of fish production practices require gender-sensitive approaches.

The report concludes with recommendations for potential training in the AICCRA Mali project to support gender-sensitive and climate-resilient approaches to rice-fish production.

2. Introduction

Mali is a rice basket in West Africa, providing a substantial amount of the region's rice supply. But it is also highly vulnerable to climate variability and change. To help Mali become more climate-resilient, AICCRA Mali aims to strengthen the technical, institutional and human capacity required to accelerate the wide-scale adoption of climate smart agriculture (CSA) and climate information services (CIS) packages by hundreds of thousands of men and women farmers in the country. In this report, we define CSA as the technologies, practices or services that sustainably increase productivity, enhance resilience to climatic stresses and reduce greenhouse gas emissions (FAO 2010), while CIS is defined as the production, translation, transfer and use of climate information for both individual and societal decision-making (Carr et al. 2017). Ensuring maximum gains from agricultural investments requires targeting the limited available resources in a systematic way to promote the CSA technologies that are best fit to the local social, economic and cultural contexts.

In Mali, a stakeholder workshop was held to prioritize CSA technologies based on CSA performance indicators (increase in yield and resilience, and reduction in greenhouse gas emissions), as well as implementation feasibility (technical feasibility, cost of investment, gender inclusivity and market demand) (Dossou-Yovo et al. 2021). One of the CSA technologies that received the highest score was the integrated rice-fish system. However, little is known about current rice-fish farming practices, land use and climatic stresses in Mali, and their relevance for underrepresented groups within beneficiaries, such as women, youths and minorities. As such, the goal of this baseline study was to describe Mali's rice-fish systems and identify interventions to improve the systems' environmental, social and economic sustainability.

The project focuses on the rice-producing areas of the Inner Niger Delta and Koulikoro regions. For rice-fish production, the focus was initially on the submergence rice systems of Segou and Mopti, but it has since been extended to the irrigated rice systems of Selingue and Barguineda located in Koulikoro because of security issues in the Inner Niger Delta. National Agricultural Research and Extension Systems selected these regions as priority intervention areas for integrated rice-fish systems. However, this scoping report covers the broader project region in order to identify further potential for rice-fish integration.

3. Mali and the Inner Niger Delta

Mali is a landlocked and low-income country with a population of about 20 million. Agriculture plays an important role in the country's growth and food security. The sector contributes an estimated 50% to Mali's gross domestic product (GDP) and employs about 75% of its population (Ministry of Foreign Affairs of the Netherlands 2018).

3.1. Climate and climate change features

Mali is located in West Africa. The north of the country has a warm desert climate, the central part has a warm steppe climate, and the southern regions have a wetter and more tropical climate.

There are four main climate types in the country, from north to south:

- the Saharan climate, which receives less than 200 mm of precipitation per year
- the Sahel climate, with annual precipitation between 200 and 600 mm
- the Sudanese climate, with annual precipitation between 600 and 1000 mm
- the Sudano-Guinean climate, with annual precipitation over 1000 mm.

The Inner Niger Delta and focal areas of the project (the regions of Selingue and Koulikoro) fall primarily within the southern Sahelian agroecological zone, also known as the Sahelian-Sudanian area, with some extension into the northern Sahelian and the Sudanian zones. Average annual precipitation in the Inner Niger Delta is 200 mm (CIAT et al. 2020). Koulikoro lies within the Sudanian zone, with average annual precipitation of 600–800 mm (SPFS 1999).

Mali is influenced by the Inter-Tropical Convergence Zone, which creates winds from the Atlantic Ocean and the Sahara region, causing the annual West African Monsoon. The climate in the north is drier than in the south and has three main seasons: rainy, dry and Harmattan. The rainy season is from June through October, Harmattan is November through March, and the dry season occurs between March and May. In the south, the dry and wet seasons each last about 6 months. During the dry season, there is almost no rainfall, so the country suffers from recurring drought. As agriculture and fisheries are highly dependent on rainfall, productivity varies with changes in rainfall and water availability (MET 2017).

Although the annual mean temperature for the whole country is 28°C, there can be large variation between minimum and maximum temperatures, and average temperatures are higher in the north than in the south. The absolute maximum temperature is 51°C, whereas the minimum is not below 10°C. Mali is highly vulnerable to climate change and variability. The mean temperature has increased by 0.7°C since 1960, for an average rate of 0.15°C per decade. But temperatures in the north have increased at a much higher rate, at 0.5°C per decade. Drought, storms, strong winds, increased temperature variability, and reduction in the length of the growing season are the climate risks of greatest concern.

Mali's climate change vulnerability is intensified by socioeconomic and environmental factors. These include the dependence on rainfed agriculture, a high poverty rate and low human development index, and people settling in floodplains, combined with weak land use planning and environmental degradation (Ministry of Foreign Affairs of the Netherlands 2018). Yet, the level of climate vulnerability differs from region to region because of different exposures, sensitivities and adaptive capacities. Northern Mali is more vulnerable to climate change than southern and central Mali. The southeast, an agriculturally productive region, was classified as medium to medium-high vulnerability, while the Bamako region was classified as low vulnerability because of high adaptive capacity and relatively low sensitivity (USAID 2014).

Climate extremes and climate change heavily influence Mali's economy, local livelihoods and food security, because each depend on the agricultural sector, which is exposed to increasing temperature and drought, declining rainfall, and floods. These climate change effects exacerbate the situation of many Malians, who already face chronic food insecurity (Ministry of Foreign Affairs of the Netherlands 2018).

The result of projections conducted by the African and Latin American Resilience to Climate Change project indicated that overall vulnerability will change across the country in 2030, and the large area in northern Mali will shift from medium-high to high vulnerability in 2050 (USAID 2014). Projected changes in rainfall and temperature are expected to significantly impact crop yields in both the drier and wetter regions of the country. Model simulations predict a decrease in yield of the major food crops produced in the country, namely millet, sorghum, maize and rice (Ministry of Foreign Affairs of the Netherlands, 2018). Climate change is also expected to impact pastoralists and fisheries negatively, reducing the availability and quality of fodder and water resources. In addition, increased heat waves are expected to cause greater spread of diseases, like rift valley fever (MET 2017).

3.2. Hydrology and water availability

There are three main river basins in Mali: the Niger River (47%), Senegal River (11%) and Volta River (1%). The Niger River is the longest and most important river in the country and flows from west to east. This river receives water from the Guinea Highlands, with an average of 40 million cubic meters annually. Koulikoro is situated to the northeast of Bamako along the Niger River. The Senegal River, located in the southwest, also originates in Guinea and delivers approximately 8 million cubic meters per year (FAO 1997). The Niger and Senegal rivers both play a critical role in the agricultural and fisheries sectors, as well as for food security.

In the center of Mali is the Inner Niger Delta, a unique ecological area with important wetlands for wildlife and wild fish that contribute significantly to food security. It is the third-largest Ramsar site in the world. This inland delta is a critical fishery domain in the wet season and an important pasture area in the dry season. Over 1.5 million people live in the Inner Niger Delta region and rely on waterways for transportation and shipping. The Office du Niger, an irrigation system that draws from the Inner Niger Delta, is by far the largest water user in the delta (Kassambara et al. 2018). The system covers nearly 19,500 km^2 of irrigable land and a gross area of 24,500 km^2 (Kassambara et al. 2018). As of 2015, the Office du Niger irrigated 1380 km^2 of cultivated land (Kassambara et al. 2018).

3.3. Agroecological features

Similar to the climate zones, there are four agroecological zones in Mali: the Saharan, Sahelian, Sudanese and Sudano-Guinean. An estimated 44 million ha of land are suitable for agriculture and livestock, yet only about 5 million (12%) are used. Less than 300,000 ha are equipped with irrigation infrastructure, and there is no significant source of either groundwater or surface water (DLEC 2018). The Niger and Senegal rivers and their tributaries provide water to potentially over 2 million ha of agricultural lands, while the Inner Niger Delta extends more than 30,000 km^2. The irrigated areas of the Office du Niger have experienced growth in total cultivated area, most of the expansion being for rice and sugarcane cultivation (Kassambara et al. 2018).

Agroecological zone	Geographic location	Area (% of country)	Annual rainfall (mm)	Primary livestock and crops
Saharan Zone	North	51%	<150–200	**Livestock:** cattle, sheep, goats, camels **Crops:** rice, wheat
Sahelian Zone	Center	26%	250–550	**Livestock:** cattle, sheep, goats, camels **Crops:** rice, wheat, vegetables
Sudanese Zone	South	12%	600–1200	**Livestock:** poultry, cattle, sheep, goats, bees **Crops:** sorghum, millet, rice, wheat, peas, onion, peanuts, sweet potatoes, tomatoes, fonio (a grain), corn, beans, potatoes, mango, citrus, cashew, shea, nere, sugarcane
Sudano-Guinean Zone	Far South		>1200	**Livestock:** cattle, sheep, goats, bees **Crops:** mango, peach, millet, sorghum, fonio, corn, rice, beans, potatoes, peanut, cashew, shea, nere, onion, cotton

Source: DLEC 2018 and Republic of Mali 2013.

Table 1. Four main agricultural zones in Mali.

4. Rice and fish production

4.1. Rice cultivation

Rice production systems in Mali are classified into four main categories: irrigated system with total water control (25%), rainfed upland without water control (18%), rainfed lowland with partial or no water control (45%) and uncontrolled river flooding (12%).

Irrigated lowland rice is typically grown in bunded fields with one or two crops of assured irrigation per year (Saito et al. 2013). Dam-based irrigation, water diversion from rivers, and pump irrigation from wells are major sources of water in the irrigated system (Saito et al. 2013). Rainfed upland rice is typically grown on fields that are unbunded, flat or in sloping areas (Saito et al. 2013) with freely draining soils, deep groundwater levels and high percolation rates (van Oort 2018). Rainfed lowland rice is grown on level to slightly sloping, unbunded or bunded fields in lower parts of the toposequence and in inland valleys (Rodenburg et al. 2014). Uncontrolled river flooding rice is found in the floodplains along the major rivers. Water depth remains high (up to 3 m) for as many as 5 months (Saito et al. 2013).

About half of Mali's rural population lives below the poverty line (CIAT et al. 2020). Most farms are less than 1.5 ha in size, and subsistence agriculture is common (CIAT et al. 2020).

Within the Inner Niger Delta region, the region of Mopti and Segou comprise over half of the nation's rice farming area, at 27% and 26% respectively (Andres et al. 2020). In areas with large or small irrigated perimeters, yield can be quite high (8 t/ha), while areas with rainfed systems, controlled or uncontrolled flooding have much lower yields of 3 t/ha for the Nerica variety in rainfed systems, and 1–1.5 t/ha for other systems and varieties (Andres et al. 2020).

4.2. Inland fisheries

The Inner Niger Delta extends up to 40,000 km^2 of flooding area, stretching more than 350 km from Ke-Massina to Tombouctou. With seasonal flooding, many tributaries and critical ecosystems, it provides the majority of fish catch in the country (Rurangwa et al. 2013).

Fisheries productivity in Mali has high interannual variability, with estimates ranging from 77,199 t to 199,390 t between 2005 and 2018 (Andres et al. 2020). The floodplain area of the Inner Niger Delta, in the regions of Segou and Mopti, to downstream of Lake Debo is estimated to yield 36% of national inland fish catch (Acosta-Alba et al. 2022). Fisheries productivity of the Inner Niger Delta is recorded in official statistics based on the catch marketed in Mopti, but the total catch of the Inner Niger Delta is likely four to five times more than this amount (Morand et al. 2012). The productivity of floodplain fisheries depends highly on surface water, as even the slightest water level connected to the river can allow fish to gain access to new areas for feeding and breeding (Acosta-Alba et al. 2022). During the low water level season in the Inner Niger Delta, other regions, including Koulikoro, which has a concentration of tilapia cage farms, play an important role in providing fish for local food security (Andres et al. 2020).

Inland fishery production accounts for approximately 3.5% of the country's GDP, at an estimated 40,000–120,000 t of fish catch annually, most of it from capture fisheries rather than aquaculture. Based on Breuil's finding in 1996, fish catch accounted for 1% of the country's exports in terms of value in 1995–1996. Fish catch was more stable and on the higher estimates during the early 2000s (Rurangwa et al. 2013).

Mali is among the top-13 countries globally for inland fish production per capita (Funge-Smith and Bennett 2019). The number of fishers is difficult to estimate, but fishing is generally classified as a small-scale enterprise. As of 2010, an estimated 35,000 households within the Inner Niger Delta depended on fisheries (WorldFish 2010). National estimates indicate that the inland fisheries and aquaculture sectors directly employ about 354,000 people, with the Inner Niger Delta being the main production zone for fish (FAO 2014). These sectors either directly or indirectly employ an estimated 500,000 people (CIAT et al. 2020), whether full time, part time or long-term migrating (fisheries camps). As of 2009, the dominant livelihood of the Inner Niger Delta was a diversified one of farming, fishing and rearing livestock, while some minorities remained specialized in traditional practices of river-based fishing (Bozo) and herding livestock (Fulani) (Sheriff et al. 2010). The fishery camps start in November and last until May or June, which is the peak period of fish landing. This delta is rich in inland fisheries, providing about 60 kg, and up to 100 kg in surges, of fish per hectare annually in the productive flooded area (Joffre and Lajaunie 2010). Fishers have established sedentary camps near Koulikoro, as well as other locations along the Niger River (Andres et al. 2020).

For decades, however, there has been a gap between demand and supply of fish protein because of population growth, over-exploitation and environmental degradation. Improved fisheries management and aquaculture, including rice-fish culture and rice-field fisheries, are required to fill this gap as well as to expand aquaculture and maintain a common pool of resources, such as rivers, water bodies, mares, lakes and channels. Fish production and trade from capture fisheries depends on floods (Arnoldus et al. 2012). Annual fisheries production increased from 55,000 t in 1985 to 130,000 t in 1995 and stabilized at 100,000 t after 2003. About 84% of the fish are produced in the Inner Niger Delta, while only 3% are produced in Selingue and 2% in Manantali, with the remaining 11% produced in other regions. Most of the fish caught are Nile tilapia (30%), North African catfish (25%) and other freshwater fish (19%) (Arnoldus et al. 2012).

4.3. Aquaculture and fish value chains

Aquaculture is not well developed in Mali because there are many constraints. These include limited water availability, wide temperature swings, lack of technical knowledge, insufficient financial resources, inadequate aquaculture extension and management services adapted to the local context, and either poor or nonexistent aquaculture infrastructure, such as ponds, hatcheries and road access to farms. In addition, aquaculture practices and developments are poorly documented for the Inner Niger Delta and across the country.

In the late 1980s, the French Association of Volunteers for Progress funded a few experiments and development projects that implemented integrated rice-fish culture. Later, a project that focused on integrating aquaculture into larger irrigated perimeters was implemented by the Food and Agriculture Organization (1987–1992) and then the FAO Special Program for Food Security (1996–2000). Over the past two decades, the United States Agency for International Development has funded fishery and aquaculture improvements, focusing on pond culture, rice-fish culture and fisheries planning. Aquaculture production has increased since the early 2000s and produces mainly Nile tilapia and African catfish (Rurangwa et al. 2013).

Women are mainly involved in selling and processing (Andres et al. 2020). Only 10% of production is traded in fresh fish during the fishing period, January through May, while 90% is processed and traded in different forms, such as smoked fish, dried fish, roasted fish and fishmeal/fish oil (Rurangwa et al. 2013). Tilapia is common, and it is popular to trade both fresh and processed; other species, such as African Characidae (*Alestes* sp.), African tigerfish (*Hydrocynus* sp.), Nile perch (*Lates niloticus*), catfish (*Clarias*) and African schilbid catfish (*Schilbe* sp.) (*ngari*), are also commonly used for processing and trading (Rurangwa et al. 2013). There are three types of aquaculture systems: extensive, semi-intensive and intensive systems, largely based on the level of input and/or labor involved (Peterson et al. 2006). Section 7 further details how such systems can be implemented in an integrated manner for rice and fish.

5. Hazards and livelihood vulnerability

The Inner Niger Delta floodplain area is vulnerable to two major environmental changes: increased variability in interannual rainfall, and change in flows from dam operations upstream (WorldFish 2010; Morand et al. 2012). The dams have already suppressed peak flows within the region, and changes in rainfall variability affect flood patterns and the timing of connectivity and flows that in turn affect both fish and rice production (WorldFish 2010).

Livelihoods of both fishers and farmers are vulnerable to these impacts, especially with little opportunity for further adaptation beyond the already important and consistent seasonal livelihood adaptations, such as alternating fishing and farming and seasonal migrations for fishing (WorldFish 2010; Morand et al. 2012). Even for households that undertake both fishing and farming, the opportunity for adaptation by switching between activities is low for two reasons: (1) a dry year would suppress production in both activities, and (2) the activities are conducted complementarily, with fishing done primarily for income and rice farming for income and subsistence (WorldFish 2010; Morand et al. 2012).

It is important to note that vulnerability is not necessarily livelihood specific (Mills et al. 2011). One study found that the top-five contributors to vulnerability were similar across fishing and non-fishing households and included food insecurity, health issues, lack of cash or access to money, lack of access to drinking water, and lack of access to school (Mills et al. 2011). Such vulnerabilities can lead to conflict, and development projects, if not careful, can exacerbate them (Ranieri 2020). Conflicts in the Niger River Delta can arise over land use and ownership rights, availability of land for cultivation or grazing, and other natural resource conflicts (CIAT et al. 2020). In addition, there is gender inequity in resource access, especially land, which is upheld through customary laws that limit women and youths from accessing productive assets and from participating or being represented in decision-making arenas (CIAT et al. 2020).

Previous efforts to alleviate vulnerability have included various livelihood approaches. Dry season rice farming and eucalyptus plantations that employed laborers for charcoal production are capital intensive activities that relatively few households use, and these can lead to land use conflicts (Morand et al. 2016). Many households can raise poultry or small livestock and grow small-scale vegetables, but these only supplement their main livelihoods (Morand et al. 2016). Ecotourism was a relatively short-lived option because of the region's insecurity (Morand et al. 2016). Diversifying crop cultivation during the dry season can be more profitable than continued rice or sugar cropping, but several constraints limit the farms that diversify. These include a lack of access to irrigation systems for small-scale farmers, barriers to delivering fresh produce to the markets during the harvest period, and low market value for crops during harvest (Kassambara et al. 2018). Integrating vegetable horticulture can engage women, in particular (Morand et al. 2016; CIAT et al. 2020). Although these activities are small-scale, they are done typically to relieve some household vulnerabilities, such as health issues and access to education for children (Morand et al. 2016).

In terms of food security and nutrition, although Mali achieved its target of halving hunger (both proportionally and by number of people) in 2015, food insecurity still occurs in about a quarter of households and disproportionally affects certain groups, such as transhuman pastoralists (CIAT et al. 2020). Food access and affordability remain issues. In 2015, two-thirds of households were indebted to informal parties to buy food (CIAT et al. 2020).

6. Policy and strategic opportunities

Historically, local customs and regulations governed access to and use of land, floodplains and fisheries (Russell and Couliaby 2009). Mali's historical changes in political architecture have resulted in an accumulation of institutions (including traditional/pre-colonial, national/centralized and communal/decentralized) that influence local political organization and development (Russell and Couliaby 2009). Support for irrigated farming associations, including both women's and men's associations, from nongovernmental organizations (NGOs) has developed the capacity of local leadership (Russell and Couliaby 2009).

The fragmented and accumulated approaches to governance are a key challenge to effectively planning and designing climate smart and sustainable agriculture. In the Mopti region, the Inter Collectivite du Sourou is a recent model for more collective governance suited to the environmental scale on which planning is needed (Molenaar and Nooteboom 2020). This model could greatly support rice-fish implementation through the coordination needed among farmers to manage water and resources. At a more local level, inclusive community governance of natural resources has the potential to improve the production of both rice and fish. During a trial of community-based fish culture, community members noted greater cooperation among the different stakeholders to manage their collective water body and fishery resource, including fewer infractions during the fishery closure period and fewer incidents of livestock feeding in rice paddies or entering the water body (Sheriff et al. 2010).

In terms of livelihoods, humanmade reservoirs are an opportunity for additional adaptation of fishing livelihoods (Morand et al. 2012). However, policy must accompany them to support the arrival of fishers through social integration and provision of public services and to address the sustainability of resources and livelihoods (WorldFish 2010; Morand et al. 2012). This review did not uncover any existing policies or strategies in Mali to support or improve rice-fish culture or rice-field fisheries livelihoods. This is an important gap to fill.

7. An overview of potential rice-fish approaches

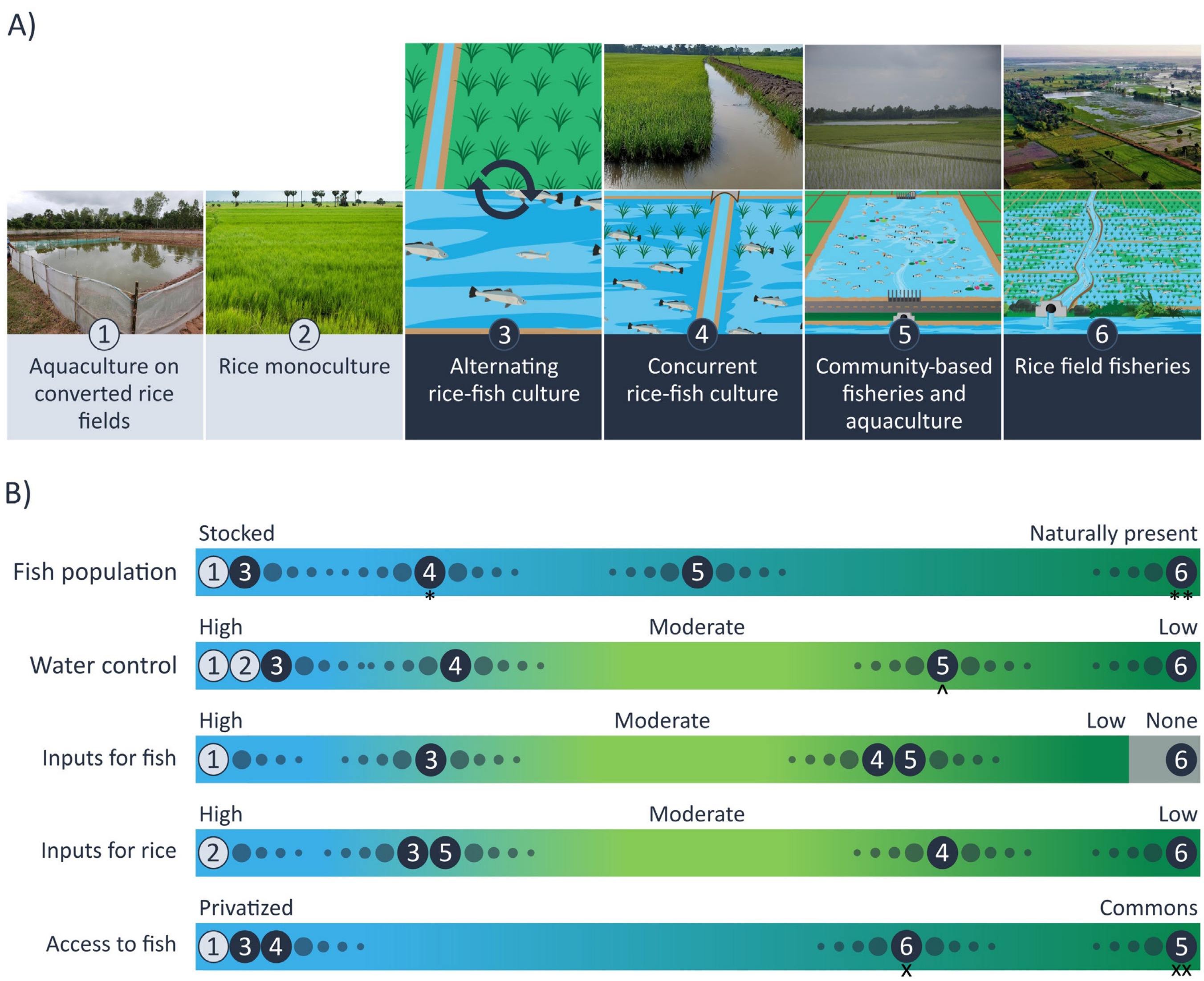
There are many options for modes of rice and fish co-production.

Fish and other aquatic species can be naturally present as wild populations or introduced through aquaculture, or a combination of the two (Figure 1A). In addition to this variable of fish source, production options are often determined by variables such as water control, inputs (for fish and rice), and the rules and means of access to the fish (Figure 1B).

The hybrid approach of community-based fish culture, in which fisheries and aquaculture are carried out through collective governance in a single water body, has already been trialed in the Inner Niger Delta. Community awareness and adherence to practices to conserve the common resource seemed to improve during the trial, but the environmental conditions prevented an analysis of the productivity results (Sheriff et al. 2010). Research identified the technical, environmental, market, livelihood and socioeconomic factors that influence the effectiveness of this collective management approach (Sheriff et al. 2010). These lessons can be applied to the current project to develop an approach with shared benefits that could reach marginalized groups, such as the landless, youths and women.

A community fish refuge (CFR) approach that improves perennial aquatic habitats within the floodplain could also provide further adaptation for fisheries and for fishing-farming households. In contrast to the approach of digging through river and tributary banks and levees observed in the Inner Niger Delta (Chamard et al. 1997), a CFR enhances the floodplain habitat that receives water during flooding. The CFR can be deepened to retain more water and prolong its suitability for fish throughout the dry season, while gates, inlet/outlets and spillways can be installed to control the flow of water and fish from the CFR. This practice can retain more broodstock fish during the dry seasons, thereby allowing more reproduction in the flood seasons and an overall increase in fishery productivity. The CFR can also maintain populations of aquatic plants and other aquatic animals.

These and other options for co-production of rice and fish will be analyzed in this report through local knowledge and experience as well as local stakeholder preferences. The analysis will explore options that use and enhance the existing wild fish resource as well as options that develop and strengthen a fish culture value chain. Activities that complement rice and fish co-production could also be explored, such as coupling rice-fish integration with vegetable horticulture, or value chain activities such as fish processing, with the potential to enhance engagement and benefits for women, youths and non-landholders.



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

Note: (A) Illustrations and photos that 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.

Source: Freed et al. 2020.

Figure 1. Typology of rice-fish production practices.

8. Local experience, preferences, barriers and opportunities

8.1. Methods

Key informant interviews were held with a range of actors to understand the local context and practices for rice and fish production. Respondents included government representatives, NGOs, village chiefs, farmers, farm managers, fishers and input producers. A total of 21 respondents were interviewed: 19% were women and 14% were youths between 24 and 37 years old. Respondents were primarily located in Bamako (43%) and Koulikoro (19%), with a few in Sikasso, Baguineda and Diola. Two respondents were from the focal region of Segou/Niono, while none were from the focal region of Mopti. It is important to note that not all of the respondents provided information on every topic.

Interviewees were asked questions on the following topics:

- current rice-fish production practices by rice-growing environment (i.e. rainfed lowland, irrigated, deep water/submerged) and social group (i.e. men, women and youths)
- biophysical factors in the production areas, especially flood regimen and drought
- preferences and strategies among rice-fish production options and variables
- aquaculture and rice monoculture production practices by rice-growing environment and social group
- species and uses for wild and cultured aquatic species
- barriers and opportunities in rice and fish production and value chains, including by social group
- aquatic food products and markets.

8.2. Findings on current rice-fish practices and other aquatic production in rice-growing environments

People living in the study areas primarily depend on rice and fish production for their livelihoods. The main source of water for farming is irrigation from reservoirs, rivers and floods; groundwater is not used to supply water to the farms. Most (94%) rice fields in the study areas are irrigated, while rainfed lowland rice is cultivated in the villages of the Diola region. Many (64%) farms in the rainfed lowland systems cultivate a single rice crop per year in the rainy season, while farms in the irrigated systems can cultivate rice twice a year.

The areas in this study practiced rice-fish culture, particularly the grow-out of wild fish. All the respondents said that the rice fields had fish during the rainy season, 50% of them said the rice fields had fish during the dry season and 28% said the rice fields had fish during Harmattan. Some farmers in the Koulikoro region said that fish are cultured almost year-round across all three seasons since those rice fields are irrigated. In addition to fish, respondents said that aquatic plants and other aquatic animals were available and used in rice-growing environments. Both aquatic plants and other aquatic animals contribute to farm production and to local household food security. The plants reported to be available in the rice fields include azolla, which is cultivated, and naturally occurring water lily and *demba sindji*. Azolla is mainly used for livestock feed, water lilies are eaten in local households and used to feed livestock, and *demba sindji* is used as traditional medicine. Aquatic animals such as frogs, lizards and snakes are also naturally present in rice fields and are all eaten in local households. Frogs are most abundant from July to December, while lizards and snakes are found primarily in September. Some fish species eat insects in rice fields, while snakes and lizards eat fish as part of their natural diet.

To collect wild fish seed, farmers allow rainy season floodwaters and the accompanying wild fish and fingerlings to enter their rice paddies. Another way of obtaining wild fish seed is to buy it from someone who has trapped a large quantity of fingerlings, often those entering a canal or another waterway through an opening that can be closed off with a net. Farmers can also maintain a small pond or trench in their rice paddy to store the fish. During harvest, the water is emptied from the paddy and the pond or trench so that the farmers can collect the fish. Some farmers leave the water inside the pond or trench for a bit longer and feed the fish to sell them later, though still before the dry season. These practices are carried out in both rainfed and irrigated paddies.

Farmers who practice rice-fish culture report that they normally reduce the number of applications of chemicals and apply some organic fertilizers in their paddy fields. In practice, they apply chemical fertilizer on their paddy before the water and fish arrive, and then use animal manure. According to the farmers, using pesticides results in lower fish harvests, so they try to limit the amount of pesticides they use in their fields.

For rice-fish culture that uses paddy land, an irrigated farm that has a reliable water supply for 8 months a year can produce two cycles of rice and one or two cycles of fish, depending on the initial size of the fingerlings. Fish species from the wild include tilapia and catfish, which are available mainly from April to May, and bonytongue (*Heterotis nilolticus*) and electric fish, which are available from June to September. Hatchery stations also supply tilapia and catfish fingerlings, which are available from April to May. Fingerlings supplied from wild catch tend to be larger, around 30–50 g each, while hatchery or domesticated fingerlings tend to be 5–10 g.

In terms of feeding practices, as shown in Table 2, farmers in the study sites feed their fish different types of feed, including pellets, fishmeal, rice bran, maggots, phytoplankton and aquatic plants. The pellets and fishmeal are bought from the market, while farmers obtain rice bran from their own or neighboring farms. Maggots are produced on-farm using cow dung or animal carcasses, and phytoplankton is produced in the paddy or fishpond by applying compost directly. Some farmers also rely on the naturally available fish foods in their rice paddy or pond, including insects and aquatic vegetation, such as azolla and water lily. These naturally available foods are most abundant during the rainy season, from June through October. Farmers also use other inputs for rice-fish culture, such as fish nets, fish containers, fertilizers, lime, medicines and water treatment supplies.

Farmers prefer raising tilapia because it grows quickly and has a high market demand with a high price. The average price for tilapia is XOF 2500/kg (USD 3.84), while the average price for catfish is XOF 1750/kg (USD 2.70). Although less preferred, catfish is also used for rice-fish culture because it can tolerate poorer water quality, including the use of insecticides and fertilizers. However, there is also a risk of market-size catfish escaping from the farm, as they are very mobile, even across areas with little to no water. As wild fish seed is often used for rice-fish culture, the wild tilapia grown out in rice paddies could reproduce. The additional fingerlings would then compete for food and slow the growth of the larger fish. Traditionally, some farmers release catfish, usually wild-sourced but also cultured, into their tilapia production systems after 4 months to eat the additional tilapia fingerlings and control the possible overpopulation of tilapia. Farmers consider this a way to reduce feed costs.

Feed type	Feeding frequency	Access to fish feed	Amount required for a production cycle per 100 m^2 (kg)	Price (XOF) of feed per kg
Pellet	Every 2nd day	Market	175	600
Rice bran	Every 2nd day	Self-production	70	50
Fishmeal	Every 2nd day	At the market	50	500
Phytoplankton (compost-based)	Daily	Self-production	-	-
Maggots (cow dung-based)	Daily	Self-production	-	-
Vegetation	Daily	From rice fields	-	-
Insect	-	From rice fields	-	-

Table 2. Fish feeds.

Aquaculture infrastructure in the study areas includes ponds, nursery ponds, dikes, drainage systems and hatchery stations, though it seems that few rice-fish farmers are aware of and/or have access to them. The Bamako-Koulikoro region has significant infrastructure, including a nursery station, nursery ponds, fishponds, fish broodstock and a fish feed factory. In the Segou region, three semi-modern fish hatcheries have been established within the past 3 years: the Touré, Kané and Mamadi Dambéle hatcheries. Each produces between 15,000 and 30,000 fingerlings of African catfish per cycle, with two or three cycles per year. Tilapia fingerlings are also produced in lower quantities, though the hatcheries could have the capacity to increase this production. Fisheries officials in Segou report that only aquaculture farmers, who work with aquaculture experts in the region's fisheries sector, are aware of these hatcheries. There appears to be limited interaction between the fisheries sector and the Office of Niger, which has resulted in a lack of awareness of the region's hatchery production among the rice-fish experts from the Office of Niger and rice-fish farmers.

The main challenge that famers face on their farms is seasonal flooding and poor flood control, particularly during the rainy season. For instance, seasonal floods occur in the Koulikoro region, affecting both rice and fish farming. When asked about droughts, one respondent noted they can occur in Segou, another noted they occur in places where water is not completely managed (but without further specification), and a third reported that maize, rather than rice, was grown in areas where drought occurs. All the other respondents said that drought occurred in zones outside the study area. As most of the respondents were reporting on conditions in irrigated systems, only one said it was difficult to access water in the dry season. However, all of them said that access to sufficient water was a constraint to integrated rice-fish production.

8.3. Findings on tasks, barriers and opportunities for women, men and youth farmers

Women, men and youths all reported being actively involved in rice and fish production.

8.3.1. Fish production

Respondents discussed the main fish production tasks for women, men and youths, all of whom shared the same primary tasks of transporting fish and feeding and harvesting cultured fish, as shown in Figure 2. Only 29% reported catching wild fish, none among youths.

A lack of financial capital and training were the main barriers restricting the respondents from participating in fish production (Figure 3). Reports were similar across ages and genders.

Other barriers mentioned included
- access and/or price of equipment/inputs (36%);
- transportation/infrastructure (29%);
- limited time (21%);
- norms (21%);
- access to land/property (7%);
- access to fingerlings (7%);
- human capital/labor (7%).

Most respondents said that financial capital and training were the main barriers for youths. Youth interviewees agreed that these were the main obstacles among their peers, though few cited training as a personal constraint.

Interviewees also reported the same two barriers as the main constraints for women. However, additional field observations indicated that land ownership could be a more substantial barrier for women than was reflected through the interview results and should be studied further. Women respondents also reported norms as a key barrier among their peers, though few cited them as a personal constraint.

Respondents said their own opportunities in fish production were primarily through norms and training, closely followed by networks. These were the same opportunities reported for women and youths.

8.3.2. Rice production

According to the respondents, the main rice production tasks varied for women, men and youths. For women, the primary tasks were tending the nursery, sowing and transplanting, weeding, harvesting and winnowing. For men, they were preparing land, nursery preparation, applying fertilizer and pesticides, and harvesting. Youths participate in the most activities, including preparing land, nursery preparation, sowing and transplanting, weeding, applying fertilizer and pesticides, and harvesting.

A lack of financial capital and training were the main barriers restricting the respondents from participating in rice production. However, there were some gender differences. Women cited a lack of financial capital and restrictive norms equally as their own personal barriers, followed by training and time. No men cited norms as a personal barrier.

Other barriers included
- limited time (21%);
- norms (14%);
- lack of involvement in the rice value chain (14%);
- access to land/property ownership (7%);
- lack of labor (7%);
- lack of equipment (7%);
- price of fertilizer (7%).

Respondents also reported a lack of financial capital and training as the main barriers for both youths and women. Women also said norms were key barriers among their peers, which aligned with their responses on personal constraints.

Few respondents said they had opportunities to participate in rice production. The main opportunities were primarily norms and training. Perceived opportunities were physical strength and training for youths, and physical strength, networks and training for women.

8.3.3. Integrated rice-fish production

When asked about barriers or challenges to adopting practices for integrated rice-fish production, all the respondents found the following challenges either "somewhat important" or "very important":
- owning land to raise fish
- access to a sufficient water supply
- access to fish feed
- price of fish feed.

More than 90% of the respondents found the following challenges either "somewhat important" or "very important":
- price of fingerlings
- quality of fingerlings
- quality of fish feed.

As shown in Figure 4, responses were similar when compared between women and men and between youths and adults.

8.3.4. Post-harvest and value chains

More than 90% of the respondents said fish are sold at local markets and to a buyer or financer. Other ways fish are sold such as to neighbors or other villagers (88%), at the roadside (88%), at a major/municipal market (88%), travel to other villages (63%) and WhatsApp (6%).

More than 90% of the respondents said that fish are sold dead/fresh (not on ice), dried or smoked. Others reported forms such as iced (88%), live (56%), as fish oil or fishmeal (6%) and fire-roasted as poisson brulé (6%).

According to the respondents, the main fish value chain tasks varied for women, men and youths. For women, the primary tasks were transportation, processing, packaging, marketing and smoking/drying. Transportation and marketing were the main tasks for men, and transportation, processing, packaging and marketing for youths.

A lack of financial capital and training were the main barriers restricting the respondents from participating in fish value chains. Interestingly, no youths reported a lack of training as a barrier. Other reports were similar across ages and genders.

Other barriers included
- time (14%);
- distribution, organization of distribution, adequate local markets (sales points, contact with customers) (14%);
- equipment/infrastructure (14%);
- access to inputs (14%);
- advising/training (7%);
- owning property (7%);
- market prices (7%);
- prices of fingerlings (7%);
- conservation of harvest (7%);
- capacity (strength) (7%).

Respondents said a lack of financial capital and training were the main barriers for both women and youths. Youths reported the same barriers among their peers, though none of them cited training as a personal constraint.

Respondents said their own opportunities in fish value chains were primarily norms, training and networks. For youths, specifically, they were norms and training, and for women they were norms and networks.

The main rice value chain tasks for women, men and youths varied among the respondents. For women, they were husking, parboiling and marketing. For men, they were transportation, packaging and marketing. Youths participated in the most activities, including transportation, husking, parboiling, packaging and marketing.

A lack of financial capital and training were the main barriers restricting the respondents from participating in rice value chains. However, 50% of men reported these barriers but only 25% of women.

Other barriers included

- norms (14%);
- lack of time (7%);
- financial insecurity (7%);
- lack of a modernized training center (7%);
- property ownership (7%);
- transformation infrastructure (7%);
- lack of access to sufficient water (7%).

Respondents said a lack of financial capital and training, followed by norms, were the the main barriers for both women and youths. Women and youths reported the same constraints among their peers. However, few women cited a lack financial capital and training as a personal constraint, and few women or youths cited norms.

Few respondents reported having opportunities to participate in rice value chains. The main opportunities were norms and training. Perceived opportunities for youth were norms, networks and training, while for women they were networks and training.

8.4. Management practices

According to the respondents, farms independently manage integrated rice-fish culture. Landowners or farmers also manage the wild fish present in rice paddies and must grant permission for others to catch fish from their paddies. Other key actors involved in managing rice fields and fish include village committees, local authorities and local fishery departments. Their roles are limited to informing local communities about the regulations to prevent conflicts from unpermitted fishing (stealing) and providing training on good fish production practices.

Rules and regulations are in place to manage fishing in other fish habitats and fishing grounds, such as natural ponds, rivers and floodplains. These include restrictions on species, size, gear and total catch. Some sites are open to fishing by permission only. Village committees, farmer associations, local authorities (such as a Maître d'Eau or a village chief), the Office du Niger and local fishery departments all play a critical role in setting up rules and regulations. Respondents said that by-laws were the main method to establish rules, followed by unilateral decisions by the rule-making authority. Voting and participatory processes were reported the least.

8.5. Findings on preferences for rice-fish species and approaches

Preferred control over rice paddy water levels and connectivity to floodplains and water bodies

Most farmers (67%) and respondents (63%) wanted to maintain the same level of control over water levels in their rice paddies. Sixty-seven percent of farmers and 50% of respondents wanted to keep the same level of connectivity to floodplains and water bodies.

Preferred time to add labor activities for fish production

Although most respondents (71%) preferred to add labor activities during rice cultivation, there were clear gender differences in this preference. All women respondents preferred to add activities during the season when rice is not cultivated because it is the season when they have more time available. In contrast, nearly all men respondents (92%) preferred to add activities during the rice cultivation season. The main reason for the men's preference was water availability, but also to reap the benefits of integrating fish and rice production as fish provide fertilizer for paddies.

Preferred location of dry season fish habitat

Forty-four percent of farmers and 59% of respondents preferred keeping a pond inside their rice paddy during the dry season. The second-most preferred location for dry season fish habitat was a pond outside of the rice paddy (reported by 22% of farmers and 18% of respondents).

Preferred level of inputs for fish

In terms of fish production, 67% of farmers and 69% of respondents preferred increasing inputs. The main reason for this choice was having an interest in increasing the productivity of both fish and rice.

Preferred time of initial total investment

The same percentage (56%) of farmers and respondents also preferred to increase initial investments in their farms, though nearly as many farmers (44%) preferred lower investment costs. The primary rationale for more investment was increased production, while for lowering investment it was retaining more profit.

Preferred source of fishstock

Every farmer and respondent preferred cultured fish as their source of broodstock and fingerlings because they grow and mature quickly. They are also able to choose the species, something they are unable to do with fishstocks sourced from the wild.

Preferred production management responsibility

More than half of farmers (56%) and respondents (58%) preferred that individual farmers or land owners manage production. However, nearly as many farmers (44%) preferred cooperative management by landholders, landless, fishers and farmers. Among youths, cooperative management was the preferred choice (67%). The rationale for farmer or land owner management of production was for more control over the production and because cooperatives could be difficult to manage and lacked land tenure. The rationale for cooperative management included to better mitigate risks, to have a support network among farmers, to have more opportunities, to enable organization around setting a market price for the products, and for strength and solidarity.

Preferred level of coordination for production practices

The same percentage (56%) of farmers and respondents preferred coordinating production practices at the farm level, while a third of farmers and a quarter of respondents preferred coordinating in a cooperative of farms. Only 19% of respondents and 11% of farmers preferred plot level (within a farm) coordination.

8.6. Findings on requested training and information

Some respondents were asked what kind of training or information was needed in their region. Responses included the following:

- raising awareness and conducting demonstrations on how to use fish that are too small to sell (e.g. how to make fish powder or to continue grow out in a tank)
- raising awareness and providing training on how to apply organic fertilizer, as using chemical fertilizers and pesticides makes it difficult to culture tilapia
- training on how to make fish feed
- training on feed for tilapia in rice-fish culture (from observations of vegetable protein-based feed used in Benin)
- training on alternative species and fingerlings, like the ones used in Ghana and Ivory Coast.

8.7. Analysis and discussion

Key findings mostly came from respondents in the regions of Koulikoro and Bamako, with a smaller contingency from the Inner Niger Delta. Details are as follows.

In terms of production practices, rice-fish production is considered extensive, and practices most often include wild fish that enter the rice paddies. Introducing cultured fish to grow out in rice paddies seems to be most common in irrigated areas and most often is practiced with tilapia and/or catfish. Irrigated farms are able to practice rice-fish culture year-round. However, many farms still are at risk of seasonal flooding, especially in Koulikoro. The observed rice-fish integrated production practices align most with the extensive models described in section 7, such as rice field fisheries and concurrent rice-fish culture.

In terms of managing fish resources, the land owner or farmer is the primary owner of the fish resource in the rice paddy, even the wild fish entering it. Areas where fish are considered a common resource include natural ponds, rivers, floodplains and other designated fishing grounds. Often, regulations are in place to govern species, size, gear, and/or total catch for these fisheries.

Aquatic production in rice-growing environments includes some aquatic plants, primarily used as livestock feed, as well as other aquatic animals, which are used mainly for household consumption. These practices could use further study to understand the extent to which they contribute to livelihoods and subsistence. They could also potentially be enhanced, along with fish production, through an approach similar to using CFRs.

Although national data shows that women are most active in processing and selling fish, data from the respondents revealed that tasks for fish production appear to be relatively gender and age neutral in comparison to those for rice production. As such, integrating fish production with rice culture could provide more opportunities for both women and youths. However, some work on norms for the participation of women might be needed, and financial capital and training barriers must be lowered for all participants, regardless of age or gender. In addition, the preferred time to add fish production activities had clear gender differences. This should be taken into consideration when developing interventions.

According to the respondents, the primary barriers to integrating rice-fish production were land ownership, water supply, fish feed access, price and quality, and fingerling price and quality. Cooperative arrangements for production could help overcome these barriers for more participants than individually focused interventions. They could also be useful in overcoming fish value chain barriers. These barriers include financial capital, inputs (feeds and seeds), training, time, distribution and sales points, and contact with customers. Cooperative arrangements could also enhance opportunities to access loans and to negotiate market prices for products.

Several trends were identified in terms of which farm practices respondents preferred. Most farmers do not want to change water management practices but do want to increase inputs for fish. All of the farmers preferred cultured sources of fishstock. Farmer preferences on investment are divided, with roughly half preferring greater investment and nearly half preferring less investment. Multiple investment options might be needed; again, a cooperative arrangement could accommodate this. Similarly, preferences on management arrangements were divided between individual farm-level management and cooperative management. Interestingly, the majority of youth respondents indicated a preference for cooperative management. Multiple management options might be needed. However, coordination of production practices had diverse responses. As production practice coordination across farms in an irrigated or flooded landscape can improve productivity and resource efficiency, raising awareness of these benefits might be needed to encourage this practice.

9. Recommended next steps

Based on the contextual analysis, responses on current rice-fish practices and preferences, and additional field observations and discussions, we recommend exploring the following five options as next activities for rice-fish integration in the AICCRA Mali project:

1. In Segou, improve interaction and exchange between the fisheries sector and the Office of Niger. Ensure that fisheries, aquaculture and rice-fish culture experts from all departments are aware of the fish capture and culture practices and resources in the region, including the recently established hatcheries. Encourage collaboration across departments and with farmers to develop local innovations in both capture and culture fisheries. Consider additional methods to raise awareness among rice-fish farmers of the practices and resources available to them. The approach developed to encourage cross-department and expert-farmer collaboration can also serve as a model for other regions.

2. Throughout the study areas, focus on improving existing hatcheries and developing new facilities for the production of quality tilapia seeds as well as local feed production. Integrating women and youths into these activities holds great potential and can be done in an individual or cooperative structure.

3. Once quality tilapia seeds are available, train farmers on rice-fish culture techniques to use these seeds and local feeds. In addition or alternatively, coordinate a farm cluster for rice-fish culture on water management, species selection and practices, such as grow-out or fingerling production only. The potential for involving women and youths in these activities is lower because of constraints to fish farming, such as land ownership, but women have shown great interest to participate in these activities. A cooperative style structure could lower some barriers for women's participation.

4. Provide training and connection to financial resources for farmers to empower them to maintain ponds where fish captured from rice fields can be grown out. The ponds could be located on homesteads or farms, though a homestead location could be more likely to include women and youths as participants.

5. Conduct further research on the following topics: (i) feasibility of training and other requests from the respondents (section 8.6), (ii) characterizing current rice-fish practices in the study sites using the rice-fish typology, and (iii) the feasibility (infrastructural and financial) and best practices (dimensions, soil type, water depth and source, maintenance) of developing ponds for fish grow-out inside rice fields.

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Annex. Data from interviews

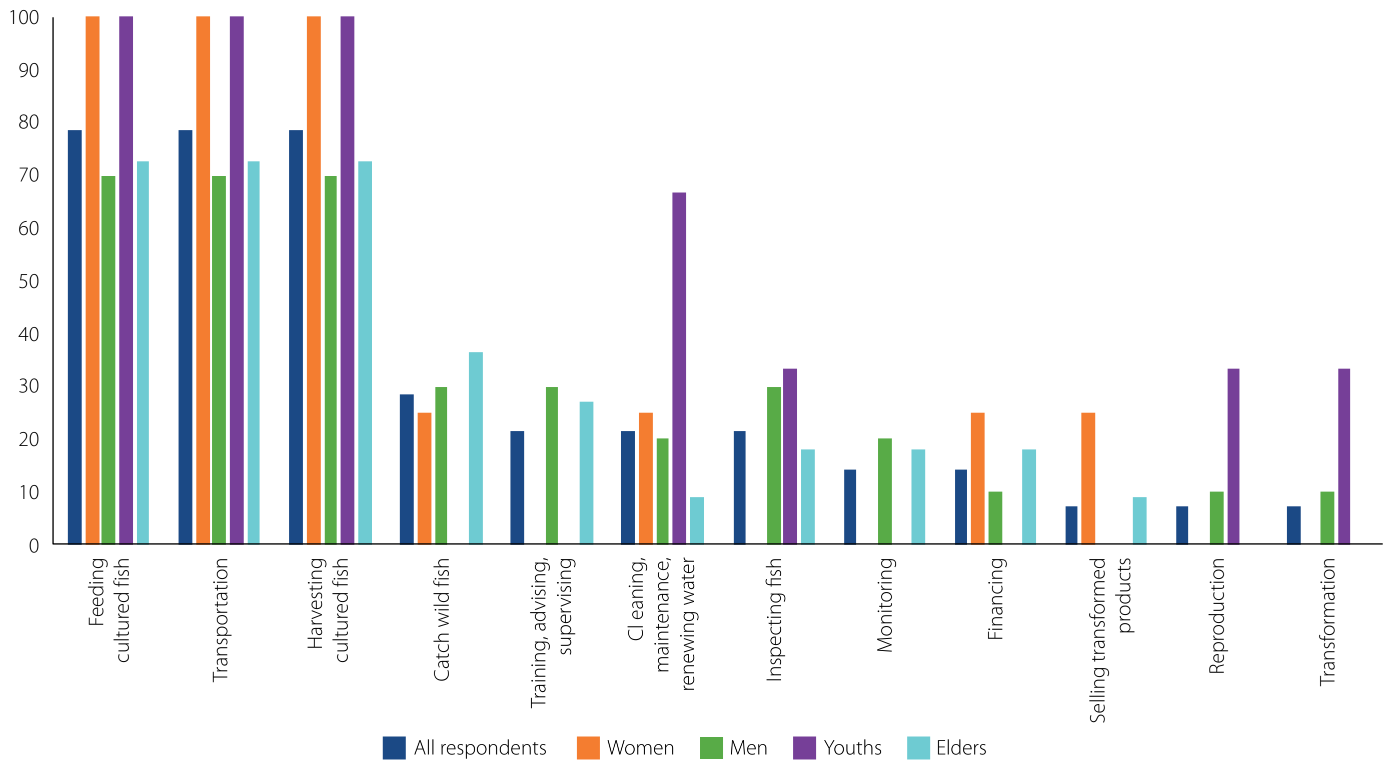

Figure 2. Fish production activities of respondents.

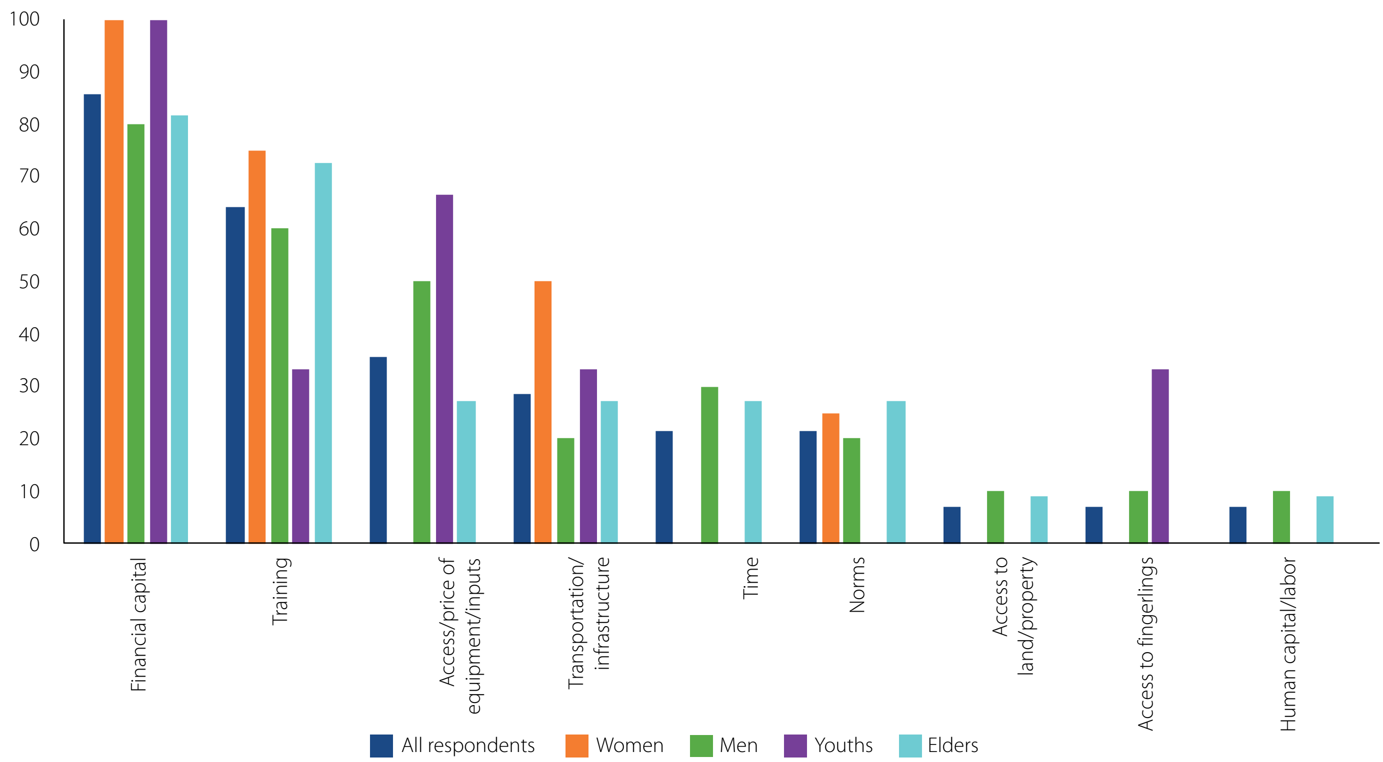

Figure 3. Barriers to fish production.

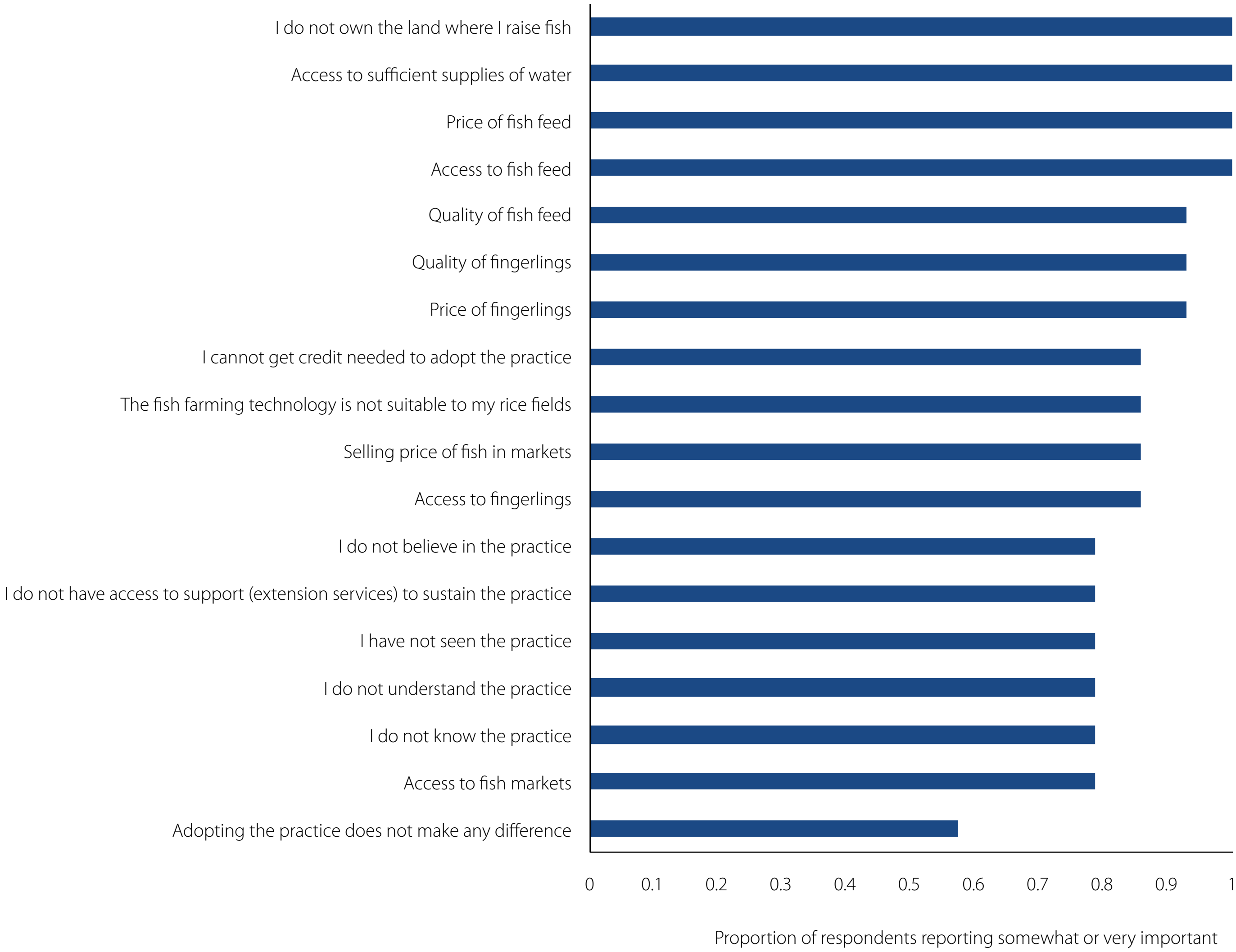

Figure 4. Barriers to adopting integrated rice-fish production practices.

About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving aquatic food systems, including fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world.

The WorldFish headquarters is in Penang, Malaysia, with regional offices across Africa, Asia and the Pacific. The organization is a member of CGIAR, the world's largest research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security and improving natural resources.

For more information, please visit www.worldfishcenter.org