Food and Agriculture Organization of the United Nations

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GLOBAL CENTER FOR AQUATIC HEALTH AND FOOD SECURITY

MTF/GLO/101/MSS
Terminal Report

FAO/MULTILATERAL TRUST FUND

AQUACULTURE AND RURAL COMMUNITIES: FARM DIVERSIFICATION STRATEGY THROUGH INTEGRATED AGRICULTURE-AQUACULTURE SYSTEMS AND NUTRITION-SENSITIVE VALUE CHAINS FOR BETTER NUTRITION OUTCOMES

GLOBAL

PROJECT FINDINGS AND RECOMMENDATIONS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ROME, 2024

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Report prepared for
the participating governments
by
the Food and Agriculture Organization of the United Nations

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 2024

The Food and Agriculture Organization of the United Nations expresses its great appreciation to all those who assisted in the implementation of the project by providing information, advice and facilities.

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LIST OF ACRONYMS AND ABBREVIATIONS

BP	-	Better production
CPF	-	Country Programming Framework
FAO	-	Food and Agriculture Organization of the United Nations
FIES	-	Food Insecurity Experience Scale
FIL	-	Feed the Future Innovation Lab for Fish
FMARD	-	Federal Ministry of Agriculture and Rural Development
GIS	-	Geographical Information System
GSAAP	-	FAO Global Sustainable Aquaculture Advancement Partnership
HDDS	-	Household dietary diversity score
HRBA	-	Human Rights-based Approach
IAA	-	Integrated agriculture-aquaculture
IER	-	Institute of Rural Economy, Mali
iREACH	-	Innovation Research, Extension and Advisory Coordination Hub, United States of America
IRF	-	Integrated rice-fish farming
MSU	-	Mississippi State University
MTF	-	Multilateral Trust Fund
NGO	-	Non-governmental organization
SIIL	-	USAID Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification
UGA	-	University of Georgia, United States of America
UI	-	University of Ibadan, Nigeria

USAID - United States Agency for International Development

WTP - Willingness to pay

A. OVERVIEW

A.1 PROJECT PROFILE

Country	Global, with activities implemented in Nigeria
Project symbol	MTF/GLO/101/MSS
Project title	Aquaculture and rural communities: Farm Diversification strategy through integrated agriculture-aquaculture systems and nutrition-sensitive value chains for better nutrition outcomes
Resource partner	Mississippi State University
Actual EOD	1 June 2021
Actual NTE	12 September 2023
Participating organizations	
Implementing partners (list):	

Name	Type (non-governmental/civil society/community-based organization/Government, etc.)
University of Ibadan (UI), Nigeria	University
University of Georgia (UGA) United States of America	University

Contribution to Programmatic Framework *Indicate the title of each higher-level result to which the project contributes*	
Sustainable Development Goals (SDGs)	**Target 2.2:** By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under five years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons. **Target 2.3:** By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and nonfarm employment. **Target 14.2:** By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.
Organizational Outcome(s)	**Better production (BP) 2:** Blue transformation.
Regional Priorities/Regional Initiative(s), if applicable	N/A

UNDAF/UNSDCF Outcome(s) (or those from an equivalent UN common country programme document), if applicable	N/A
Country Programming Framework (CPF) Output(s), if applicable	**Output 3.2.2:** Increased capacity of Government to implement the Youth Employment in Agriculture programme. **Output 5.1.3:** Improved capacities of vulnerable households, communities, national, states, and key stakeholders to implement absorption, prevention and mitigation measures to reduce the impacts of threats and crises in the context of the humanitarian development nexus.

A.2 FINANCIAL DATA in USD[1]

Latest Approved Budget	USD 215 445

A.3 EXECUTIVE SUMMARY

The project initiated a process of farm diversification through integrated agriculture-aquaculture, introducing aquaculture-related technologies in pilot sites within rice-growing communities in the Kebbi and Ebonyi states of Nigeria. The overarching goal was to generate knowledge transferable to similar agricultural landscapes in Nigeria and globally. The technologies included the co-cultivation of rice and fish, fish seed production, fish feed production, and value-addition to farmed fish through smoking.

A total of 727 individuals, comprised of farmers, graduate students and extension workers, underwent training in various farm diversification processes. This inclusive group consisted of 232 women, 495 men, and 54 youths. The project's key outcome was the development of entry-level advice for rice farmers with limited aquaculture knowledge to transform their fields into more productive and biologically diverse agroecological landscapes. Lessons learned from the project's implementation documented insights into transforming agrifood systems in rice-growing communities, focusing on improved production, nutrition, environment, and livelihoods and related improvements to resilience.

The project was coordinated by FAO and worked closely with Mississippi State University (MSU) – the Management Entity of the Feed the Future Innovation Lab for Fish (FIL), funded by the United States Agency for International Development (USAID). It was implemented by three agencies, with the University of Ibadan (UI) responsible for on-

[1] Data source: FPMIS/Data Warehouse.

the-ground implementation and training, and the University of Georgia (UGA) focusing on the socioeconomic and market access components.

The project successfully integrated aquaculture into traditional rice farming. A total of six pilot demonstration plots were established, based on a mapping exercise and stakeholder consultation to identify suitable areas, one each in the Argungu, Kimba and Wawu communities of Kebbi state, and others in the Onicha, Ikwo and Nwannu communities of Ebonyi state. Two institutional plots were sited at UI and Usmanu Danfodiyo University in Sokoto for research and demonstration. Positive results demonstrated from two production cycles informed recommendations and further guidance to farmers regarding field modification, water management strategies, planting and stocking schedules, feeding regimes, and general management considerations for rice-fish farming. Initial results suggest that communities experienced increased fish availability and earned additional income through fish sales, indicating the potential for replication and scaling up through participatory approaches.

The diversification of rice-based systems with fish proved to be a viable strategy for diverse agroecosystems in Nigeria, suggesting its applicability in other areas across sub-Saharan Africa. Stakeholder consultation, engagement, and the adaptation to localized needs were underscored, empowering farmers to adapt and tailor the model to their conditions. After two cropping seasons, these integrated systems provided higher economic returns compared to rice monocropping, with reduced agrochemical use. Positive outcomes included increased fish availability, and improved household dietary diversity. Ancillary practices were fundamental, including addressing blocking issues of feed and seed supply. The reduced use of agrochemicals also directly contributed to increased biodiversity, enhancing valuable ecosystem services.

Overall, the lessons learned from the process of farm diversification showed that this suite of practices presents a viable farming strategy and provides valuable insights into how to best shape interventions in the region and around the world, leveraging the knowledge generated to benefit farmers globally.

B. RELEVANCE

The problem

Rural small-scale rice farmers often face challenges related to insufficient productivity, hindering their capacity to generate sufficient income for their livelihood needs. Typically dependent on a single crop, these farmers lack viable options for intensification beyond the use of agrochemicals. Suboptimal resource utilization is evident in rice field agroecosystems, where untapped potential lies in optimizing productivity by integrating additional crops such as fish within the same land and water originally designated for rice production. Although the integration with aquaculture holds a clear solution, the absence of tailored advice and guidance for specific conditions prevalent in these rice-producing communities remains a significant hurdle. Furthermore, it is crucial to acknowledge that mere production is inadequate; strengthening the entire value chain, encompassing upstream components such as fish feed and seed, as well as downstream aspects like processing and marketing, must be in place and functional before expanding aquaculture production.

At the national level, Nigeria is a clear example of this situation, where the majority of rural small-scale rice farmers lack the knowledge of integrating fish into rice farming to maximize farm productivity. This issue is part of broader development challenges reported by the Federal Ministry of Agriculture and Rural Development (FMARD), which has highlighted a high prevalence of food insecurity, undernourishment, and undernutrition among rural farmers, influenced by limitations in the farm production capacity needed to generate income to meet livelihood needs. These situations thus presented the need to generate knowledge on best practices for managing aquatic life in rice fields, and considerations to build capacity at the individual, community and institutional levels, in line with Nigeria's economic diversification agenda according to its Country Programming Framework (CPF) Priority 3 (*Support to Nigeria's economic diversification agenda and the promotion of decent employment for youth and women in agricultural value chains*), and improving food and nutrition security conditions through the development of nutrition-sensitive and climate-resilient food systems stipulated in CPF Priority 1 (*Strengthen national food security and nutrition*), inclusive of promoting meaningful employment opportunities in agricultural value chains for youth and women, and addressing key barriers in agricultural production in rice field agroecosystems.

While integrated agriculture-aquaculture (IAA) is well established and documented in numerous countries, particularly in Asia, there is a dearth of documented interventions from sub-Saharan countries, despite the prevalence of rice farming and increasing government

prioritization of aquaculture development. As a relatively new practice, the process of diversifying rice monocropping is not well established outside of Asia. Limited farmer adoption has been observed due to a lack of technical knowledge and reluctance to assume associated risks. Previous attempts to promote the farming system were confined to experimentation in universities and research stations, yielding little to no large-scale adoption by farmers.

The response

At global level, the success of implementing farm diversification through IAA (rice-fish) in various agroecological zones is dependent on addressing the aforementioned problems, tailoring solutions to the prevailing local conditions of the region or locality where the practice is being considered. Therefore, the project was designed to refine the existing methodology of farm diversification to be more appropriate for agroecosystems and socioeconomic conditions in sub-Saharan Africa and other regions beyond Asia. This involved identifying important steps that addressed the identified issues, developing templates and technological packages for adapting rice fields for integration with aquaculture, and formulating adaptation and mitigation measures for potential challenges, which can be applied and adapted to specific contexts of different countries or areas.

Given the success stories of livelihood transformation in rice-fish communities in Nigeria, integrating rice and fish farming could offer a viable solution for enhancing food security and economic sustainability, and consequently promote it as a farm diversification strategy focused on sustainable livelihoods and agrifood systems transformation in a wider context. This approach aligns well with the principles of sustainable agriculture by efficiently using resources, reducing environmental impacts, and potentially improving the livelihoods of farmers through diversified and increased production. The integration of fish and rice farming, or rice-fish culture, could be a key strategy in global agricultural sector transformation.

At national level, the project aimed to deliver lasting, culturally acceptable results with a focus on sustainability. To achieve this, the project team collaborated closely with farmers, supported by extension workers in Ebonyi and Kebbi states, to co-create a process for integrating fish farming into existing rice fields. The initiative commenced with preliminary rural community appraisals in selected sites, gathering insights into local agricultural practices and identifying farmers' specific needs. Using participatory methods, the project characterized the existing farming system, considering youth and gender roles, to determine the optimal entry point for integrated rice-fish farming (IRF) systems.

Subsequently, action research was conducted to build a knowledge base on agroecological wetlands suitable for integrated fish and rice farming in Ebonyi and Kebbi states. Pilot rice-fish demonstration plots were established in communities including Argungu, Kimba and Wawu in Kebbi state, and Onicha, Ikwo and Nwannu in Ebonyi state. These pilots served as tangible examples of locally adaptable integrated rice-fish systems, providing practical training to farmers. In parallel, socioeconomic studies were conducted to evaluate financial profitability, resource management, and the impact of food and nutrition security within the newly introduced farming system.

The project implemented a series of capacity-development activities, including specialized training sessions on fish seed and feed production, as well as value addition through smoking. Promotion and advocacy activities, such as the national workshop on rice-fish farming, were organized to raise awareness and garner support among rice farmers, extension workers and government officials. These efforts culminated in the development of user-friendly technological packages (knowledge products) for sustainable rice-fish farming, which were tailored to address the specific management needs, knowledge and skills required by farmers to successfully implement rice-fish integration and access markets for their agricultural products.

C. ACHIEVEMENT OF RESULTS

Methodology of introducing aquaculture to existing rice-growing communities informed

The project aimed to foster sustainable agricultural practices and development by utilizing a participatory approach, engaging local communities, particularly community leaders and farmers in a series of activities to develop a knowledge-base and methodology for adapting rice fields to include aquaculture. This methodology, actively involving local stakeholders and integrating practical training with research to build a foundation for long-term agricultural success and development, aimed to create a model for sustainable agricultural development that could be replicated in new areas.

The process started with a participatory consultation phase, organizing meetings with stakeholders to discuss their agricultural needs, challenges, and expectations. This was followed by a community mapping exercise to identify key agricultural areas, practices and resources, as well as existing gaps so that interventions could be tailored to each community's specific needs.

Several rice field modification models were proposed to the farmers during stakeholder engagement. Subsequently, the farmers selected their preferred rice field modification systems. Site selection was a critical step, recognizing that each location was unique and farm diversification needed to be tailored to local conditions. The diversification parameters slightly varied across project sites as a result of different needs and situations on the ground. Key factors considered for introducing fish into rice fields included site selection, focusing on soil suitability and avoidance of flood-prone areas; seasonality and water availability; farm modification decisions by farmers; rice variety, with a preference for disease and pest-resistant varieties; fish feed options, including the cost-effectiveness and non-conventional feeds, like feed formulated with rice bran and fish offal; and fertilization, aiming towards 0 percent mineral fertilizer use, encouraging the use of organic manure. Access to fish seed and the size of fish to stock were considered, with options ranging from on-farm hatcheries to purchasing from suppliers. In response to predatory birds, solutions like stocking larger fish or using protective nets were proposed.

The selected sites were used as the pilot on-farm demonstration plots to showcase the technology to the farmers. Rice field modification training and processes were conducted. This was followed by rice transplanting and the stocking of fish. Training sessions were paired with research activities, providing practical training to farmers on field modification, water management, rice transplanting, fish stocking, feeding regimes, and general cultural practices for managing fish in rice fields. The pilot demonstration plots were managed by the farmers themselves so they could have hands-on experience of the diversification process before replicating the process on their fields. Data collected on water primary production, fish and rice growth performance and costs were processed and evaluated. The results were positive and indicated that the integration led to increased availability of natural “free food” for fish, which reduced costs for fish feed. In addition, rice yield was higher than similar yields from monocropping on an equal land area.

Figure 1: Farmers working on a rice field. (Credit: ©FAO/Femi Ajayi).

Figure 2: A small-scale rice field prepared for rice-fish farming. (Credit: ©FAO/Femi Ajayi).

Figure 3: A farmer inspecting the integrity of the fish trench. (Credit: ©FAO/Femi Ajayi).

Figure 4: A farmer feeding fish on a rice-fish farm. (Credit: ©FAO/Femi Ajayi).

The involvement of extension workers and students in providing technical support for the research and development of the process was crucial to localizing the knowledge of diversification to local stakeholders. Promotional materials were developed to educate the beneficiaries on the best management practices. Community field days were organized for farmers to showcase their work, share experiences, and learn from each other, promoting community bonding and knowledge exchange. Findings from these activities were documented to share lessons learned and best practices. This documentation formed the basis for outlining how the pilot projects could be expanded and how IAA contributed to the development objectives of the target areas.

Prior to its completion, the project had already begun to demonstrate its global impact through the receipt of a knowledge-transfer request from the Mali Institute of Rural Economy (IER), supported by the FIL and the Innovation Research, Extension, and Advisory Coordination Hub (iREACH), an initiative of the USAID Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) under the management of Kansas State University in the United States. A factsheet based on the project's results and lessons learned was developed and tailored to the needs and prevailing conditions to promote a similar process there. While the process to test the tailored approach to Malian conditions (location: Satouba, Bamako) was being planned at the time of writing, pending funding, it is anticipated that by following the processes outlined in the factsheet, rice farmers in Mali could easily modify their fields and successfully undertake rice-fish farming.

The UI, as part of this project, became a member of the FAO Global Sustainable Aquaculture Advancement Partnership (GSAAP). The GSAAP serves as a collaborative platform for discussing critical topics, challenges, and innovations in aquaculture development. It also facilitates the transfer and implementation of aquaculture advancements

in science and technology, aiding in the development of holistic solutions to address obstacles to sustainable aquaculture development.

Participatory wetlands mapping identified areas suitable for rice-fish farming in Kebbi and Ebonyi states

Working closely with UI and two local educational institutions, Usmanu Danfodiyo University (Sokoto) and Michael Okpara University of Agriculture (Umudike), the project organized a series of stakeholder consultations to gather information regarding the agroecology of the potential sites using participatory rural appraisal methods, including participatory mapping techniques. Engaging with over 300 farming families from six communities, these consultations comprised representatives from various state government departments.

The consultations, combined with analysis carried out with Geographical Information System (GIS) technology, led to the creation of six wetland maps and informed the identification of pilot sites. The process also facilitated dialogue with the communities, enabling a more in-depth exploration of the intricacies of local agroecology, including challenges and opportunities.

Farming systems analysed to identify entry points for the introduction of integrated rice-fish

The participatory rural appraisal and stakeholder consultations revealed key evidence about the existing farming systems and potential entry points and additional considerations during the intervention. Two distinct rice farming systems were identified: lowland rice production in Kebbi, and rainfed/upland rice production in Ebonyi. Although no existing IRF activities occurred in the area, many farmers expressed interest in the approach. The seasonal calendar for rice farming (e.g. schedule of planting and harvesting), provided valuable insights into the opportunities for introducing aquaculture and showed differences between the two areas.

Pilot test plots established, and capacity-development training conducted

Eight on-farm adaptive research sites were established, and a total of 727 farmers and extension workers were trained, consisting of 232 females, 495 males, and 54 youth, forming a total of six farmer training groups. User-friendly guidance notes were prepared based on activities observed during farmer training and exchanges at the on-farm rice-fish demonstration plots.

The participatory learning approach provided valuable knowledge to the farmers, equipping them with the skills necessary to understand and implement the operational and management procedures required for converting rice production into integrated rice-fish production. These capacity-building actions covered all aspects of rice-fish farming, including farm record-keeping, value addition, and marketing. A range of training and communication materials were developed to support the training efforts. These materials were designed to enhance understanding and facilitate effective learning among participants. Some of the materials included: fish breeding and seed production; a case study of farm diversification using Kimba as an example; feeding fish in rice-fish systems; instructional care for rice-fish farming; and a water management technological package.

In parallel, the project involved the training of eight graduate students from UI, who were trained on integrated rice-fish production and fish feed experimentation and who conducted experiments at the pilot sites.

The active engagement of experts from collaborating institutions (Usmanu Danfodiyo University in Sokoto and Michael Okpara University in Umudike) played a vital role in implementation. This collaboration enabled the provision of essential technical support in close proximity to the farmers in Ebonyi and Kebbi states. The high level of knowledge brought by these experts significantly enhanced the success of the project and the effectiveness of the training programmes, fostering a stronger connection between academic resources and practical agricultural applications.

The project produced a business manual, elucidating production costs and profitability outcomes. The manual indicated the financial profitability of IRF was higher than rice monocropping in similar plot areas. The manual detailed the risk-rated financial analysis, break-even analysis, and sensitivity analysis of the IRF system. For further details, please refer to the Investment and Business Manual (see Appendix 2 for details and link).

Promotion and adoption of cost-effective, sustainable and innovative approaches and practices to support agroecologically sound aquaculture operations in rice farms of targeted communities

The promotion of IRF began during stakeholder consultations and community sensitization events and continued through community days at the pilot farms. These community days demonstrated the viability of integrating fish farming with rice cultivation.

One hundred and eight farmers were recorded as having applied the knowledge and training they received from the project to initiate rice-fish farming practices on their farms. Some of these farmers were motivated to adopt this practice after witnessing the success of

their friends who had already ventured into rice-fish farming. The total area of rice farming converted into rice-fish farming, based on the training provided by the project, encompasses approximately 10 hectares.

Considering that the project dedicated two years to developing evidence for converting rice fields into integrated rice and fish systems under locally prevailing conditions (equivalent to two production cycles), it is anticipated that more farmers will recognize the benefits of this approach and express their willingness to adopt it in the upcoming rice farming season. While the project's administrative activities concluded in September 2023, local stakeholders, notably the government of Kebbi state, expressed interest in continuing to promote and implement the rice-fish system as an empowerment package for smallholder farmers. Rice-fish farming clusters emerged in Wawu and Argungu communities in Kebbi state, as well as in the Abakaliki area in Ebonyi state. More farmers in these areas and beyond expressed their willingness to engage in rice-fish farming. The acceptance of rice-fish farming within these communities is so significant that even their children have begun to playfully replicate the field modifications made by their parents by scratching the soil, forming prints to mimic the shape of rice-fish fields beside their parents' own.

Anticipating that farmers will continue to adapt to their local circumstances and master the technology, the status and level of implementation by those who have already adopted the IRF technology suggested that the knowledge generated from the first and second production cycles is sufficient as a foundational guideline. This knowledge serves as entry-level advice for any farmer, even those with limited or no prior knowledge of aquaculture, who may wish to make the transition from rice monocropping to IRF.

Research conducted on pilot sites provided evidence base and knowledge products

The established pilot sites were closely linked with research, including through graduate research by students at UI, and by professors at UGA.

Highlights of the graduate research include studies on: (i) evaluation of water quality and soil properties of the IRF system in different agroecological zones in Nigeria; (ii) water utilization, nutrient assessment and water quality performance under IRF; (iii) water primary productivity and macro-invertebrate diversity of IRF; and (iv) rice and fish yield optimization under IAA. The experimental findings shed light on the intricate biological interactions within rice-fish systems that promote the growth of both rice and fish.

An analysis provided compelling evidence of the cost-effectiveness of rice-fish farming and suggested higher profitability of rice-fish systems compared to rice monocropping on plots of similar size. Regarding the impacts on productivity, the studies suggest a 5 percent

increase in rice yield, and a monetary value increase of up to 48 percent compared to rice monocropping.

Regarding end-market opportunities, the project assessed potential markets for the agricultural products and identified risk factors essential for informed decision-making and risk management for embarking on IRF. Integrated rice-fish production technology presents several promising end-market opportunities. Diversifying end-market opportunities helped to mitigate vulnerability to market fluctuations. One challenge was that catfish produced in rice fields were smaller at harvest than the market preference and thus commanded a lower price. To address this, value addition through smoking was introduced (while the market prefers large fresh fish, smoked fish maintains a good price regardless of size preference).

All stakeholders indicated that catfish performed exceptionally well under the integrated rice-fish system, reinforcing its popularity as the primary choice for fish culture in these regions. The results of the fish consumption survey also revealed that catfish is the preferred fish species in Kebbi and Ebonyi states, followed by tilapia. The limited availability of fish seed is another challenge, and the project addressed this through training on fish breeding; however, there is a need for a more comprehensive programme to support large-scale adoption.

Two locally available feedstuffs, namely rice bran meal, fish offal meal, and their combination, were tested for suitability in an integrated rice-fish system. This testing resulted in the development of three test feed ingredients, ultimately leading to the recommendation of two specific options: one incorporating fish offal meal and the other combining fish offal meal with rice bran. The performance of the feed formulated using these recommended ingredients demonstrated comparable results to that of conventional feed, highlighting their effectiveness in promoting fish growth and development and reducing costs to the farmer.

In addition, the project produced several technological packages:

- Water management technological package: Water management was one of the challenges identified during the adaptation process. For this reason, a water management technological package was developed to inform farmers, extension workers and other practitioners of the adaptation strategies to water management issues in Kebbi and Ebonyi states, and most importantly how water management regimes and the application of organic manure into the water influences primary production of phytoplankton serving as natural food for fish, and the control of pests.
- Instructional care for rice-fish farming technological package: An easy-to-follow and step-by-step process for converting rice fields into a rice-fish system was developed. This will be particularly useful for farmers to consult or follow during the adoption

process (please see “Instructional Care for Rice-Fish Farming” in Appendix 2 for more).

Innovation platform on integrated agriculture-aquaculture system established in Ebonyi and Kebbi states

The project organized meetings across the six geopolitical zones of Kebbi and Ebonyi states during the community appraisal phase. Following the appraisals, two innovation platforms focused on IAA were established, one each in Ebonyi and Kebbi states. These platforms serve as vital forums to facilitate discussions, and for the sharing of information among diverse stakeholders, including farmers, community leaders, civil society representatives, government extension workers, hatchery operators, and other aquaculture stakeholders. Discussions within these platforms centred on best management practices for rice-fish farming, addressing challenges, and collectively devising solutions for successful adaptation. Each innovation platform consisted of a minimum of 20 members, promoting collaboration and knowledge exchange across a wide range of stakeholders. The forum is expected to remain functional beyond the project’s life.

Food security and nutrition analyses

The result of the food security and nutrition survey at the onset of the project provided crucial insights regarding the extent of food security and nutrition challenges in the communities. The Household Food Insecurity Experience Scale (FIES) (12-month recall) of the sample studied indicated severe food insecurity. A large proportion of the population reported worrying about running out of food, compromising on quality and variety of food, reducing quantities, skipping meals and/or experiencing hunger within the last 12 months.

At the conclusion of the project, selected farmers in Ebonyi and Kebbi states were interviewed. They reported notable improvements, including increased food availability, more financial resources to purchase different types of food, and enhanced dietary diversity as a direct result of their involvement in the farm diversification project, underscoring the project's positive impact on food security and nutrition. These farmers expressed a strong willingness to continue practicing these methods and volunteered to share their knowledge with other farmers in their respective communities. This result highlighted the importance of the project's intervention, which aimed to enhance local food production, promote better nutrition through increased fish availability, and contribute to a healthier environment by reducing reliance on chemical fertilizers.

Enhanced entrepreneurship or business skill of farmers, especially youths and women, evaluated

Questionnaires focusing on the socioeconomics of IRF agricultural products, covering production, consumer preferences, and marketability, were designed and administered. These surveys aimed to gain insights into the local market dynamics for rice and fish, understanding the respondents' inclinations toward purchasing and consuming products from integrated rice-fish systems, and to assess rice farmers' interest in transitioning to rice-fish farming.

The adoption of the rice-fish system led to the emergence of approximately 50 entrepreneurs. Among the 312 farmers who participated in entrepreneurship training, around 10 percent expressed their intention to become rice-fish entrepreneurs, primarily focused on selling the fish from their fields for profit. The remaining 90 percent indicated that they would both sell and consume the fish at home, depending on their personal needs.

Furthermore, the value-addition training on fish smoking created promising entrepreneurship opportunities for women and youths. The results of the fish consumption survey underscored a substantial consumer demand for smoked fish and other fish products. This heightened demand is expected to translate into profitable business ventures, delivering significant economic benefits to women and youth engaged in this aspect of the project.

Partnerships between local research and development communities promoted to address challenges along food production-nutrition value chains, and to establish connections for continued support to farmers beyond the project's life

Partnerships were established with local research institutions and civil society organizations. These partners were instrumental in facilitating connections between the project team and the beneficiaries. They were also actively engaged in capacity-development activities for the beneficiaries, especially in administering food security and nutrition surveys, and securing connections with participants along the value chains, hence facilitating the marketing and business analysis studies. In terms of sustainability when the project ends, the proximity of these institutions to the beneficiaries, and their involvement in project implementation activities is crucial for providing continuous support to both current and future adopters of the rice-fish farming system beyond the project's life.

The key institutions and organizations with which the project team established partnerships include:

- Rice Farmers Association of Nigeria (Kebbi and Ebonyi chapters);
- Catfish Farmers Association of Nigeria (Kebbi and Ebonyi chapters);
- Usmanu Danfodiyo University, Sokoto (collaborating institution for activities in Kebbi state);

- Michael Okpara University of Agriculture, Umudike (collaborating institution for activities in Ebonyi state);
- State Ministry of Agriculture and Rural Development (Kebbi and Ebonyi states); and
- FAO – GSAAP.

National conference on rice-fish farming organized

The national conference on rice-fish farming, held in December 2022, drew 45 participants, including farmers, extension workers, researchers, students, journalists, and government employees. Key outcomes and recommendations from the discussions centred on strategies to encourage more farmers to adopt rice-fish farming.

The recommendations prepared by the participants of the workshop include:

- Creating enabling policies, and advocacy and awareness efforts to promote IAA systems.
- Enhancing the dissemination of information on the benefits of rice-fish technology through extension services.
- Ensuring access to quality and affordable feed.
- Facilitating the availability of seeds for rice and fish.
- Conducting capacity-building sessions on entrepreneurship for youths interested in rice-fish farming.
- Promoting policies that integrate entrepreneurship training into higher education curricula, particularly for final year students.
- Providing access to credit facilities to support farmers in the adoption and expansion of the farming system.
- Offering financial support through credit facilities or revolving funds.
- Subsidizing and enabling access to inputs for farmers, such as machinery, power tillers, excavators and pumping machines.

The recommendation to NGOs, universities and international development organizations include:

- They should consider establishing accessible demonstration sites for hands-on learning and pilot studies near farms.
- Providing technical support to farmers to address challenges that may arise during the diversification process.
- Developing a business plan manual to assist farmers in production planning.

- Organizing field days for rice-fish farmers to facilitate interactions and learning from one another, both within and across different areas.
- Undertaking further research on non-fed rice-fish systems to reduce production costs for resource-poor farmers.
- Conducting research to compare rice yields between agroecological (non-chemical fertilizer) rice-fish systems and conventional rice production systems (with chemical fertilizer use) to demonstrate the benefits of the agroecological approach to rice-fish farming.

These recommendations collectively aim to create an enabling environment for the widespread adoption of rice-fish farming and address the challenges faced by farmers in this field.

D. IMPLEMENTATION OF WORKPLAN AND BUDGET

Workplan and budget

The outbreak of the COVID-19 pandemic hampered the delivery of project activities at the start, owing to consecutive lockdowns imposed by the Government of Nigeria, while international air travel and inter-city travels were placed on stringent conditions, barring FAO personnel from making backstopping trips to the project sites. Several meetings and workshops at the initial stage of the project were therefore held online. However, in spite of these constraints and by following national COVID-19 protocols, UI mobilized to physically kickstart project activities, including face-to-face stakeholder meetings, training sessions, and other capacity-development activities. Project activities were completed within the scheduled timeline and budgets, therefore no requests for extension or extra-budgetary allocations were made.

Resource partner contribution

This Multilateral Trust Fund (MTF) project had a budget of USD 215 445. It was funded by Mississippi State University (MSU) as the Management Entity of the USAID FIL.

Coordination

FAO coordinated and led the overall project, overseeing the complete portfolio of all participating institutions, monitoring progress, and ensuring compliance with donor

requirements. Effective partnerships with UI and other local partners guided field activity implementation in close consultation with UGA.

The UI connected with other tertiary institutions near the project sites: Usmanu Danfodiyo University (Sokoto), and Michael Okpara University of Agriculture (Umudike), to jointly implement the on-farm adaptation trials, and farmer and community liaison training sessions. The local support of these collaborating institutions also addressed language barriers and provided translation from English to Hausa in Kebbi, and English to Igbo in Ebonyi. Additionally, graduate students from these tertiary institutions were involved in project implementation, on-farm research, and received concurrent training.

The research group from UGA provided training throughout the project's lifecycle, including on fish breeding, fish feed development, and entrepreneurship skill development. The UGA team also played a vital role in co-supervising graduate students from UI and collaborating institutions.

Selected private fish hatchery practitioners in Ebonyi and Kebbi states were involved in the fish breeding training component of the project, aimed at enhancing the availability of fish seed for rice-fish production.

Risk management

The proposed actions were rated as having a low possibility of environmental and social risks. Other risks, such as civil conflict and strife and potential increases in operational costs and price fluctuations did not negatively impact the project. Measures to mitigate risks included: the implementation of environmental best management practices for agriculture and aquaculture; providing farmers with training and guidance for properly modifying existing rice fields to include aquaculture; training farmers on best management practices for rice-fish co-culture; and raising the dikes of the adapted rice fields to prevent the escape of fish.

The risk of farmers discontinuing the practice after the project's conclusion was mitigated through various measures. These included establishing an innovation platform on IAA where farmers could convene to discuss different aspects of the farming system and propose solutions to challenges encountered. Additionally, training sessions on fish seed production were conducted to address the issue of limited access to fish seed. Furthermore, local stakeholders, such as state extension workers and collaborating institutions were engaged to ensure continued provision of technical support and extension services to farmers, ensuring continuity beyond the project's end.

Regular meetings were held with the host country partner to review the progress of activities and mitigation measures to manage risks, such as gaps in communication regarding the state of project implementation, beneficiary feedback, and data collection and interpretation.

The onset of the COVID-19 pandemic posed a risk at the beginning of the project as there were restrictions in personnel movement. Technical backstopping to project sites by FAO was delayed for two years. Despite these challenges, the host country partner – UI – was able to carry out activities with FAO providing support virtually through Zoom calls, emails and WhatsApp messaging.

Visibility

- A simple-to-follow video demonstrating the conversion of rice fields into rice-fish farming was produced with the assistance of the Resource Partner. The video can be accessed here: https://www.youtube.com/watch?v=76HOEettjEs.
- At the Aquaculture African Magazine webinar held in 2022 where the project team made presentations, awareness of the potential and benefits of the system was raised. Unofficial calls by farmers, agencies, and academic researchers (institutions) from new countries followed, requesting to test and replicate the system in their countries. The primary limitation hindering this endeavour has been funding.
- Project activities were featured on the following national and global news and blog outlets, among others.
    - Farmers access magazine: https://www.facebook.com/farmersaccessmagazine/photos/a.104963394646039/137758591366519/?type=3;
    - The Nation: https://thenationonlineng.net/tackling-hunger-through-integrated-farming/;
    - TheFishSite: https://thefishsite.com/articles/nigerian-integrated-aquaculture-trial-increases-health-and-wealth;
    - Champion Newspaper: FAO trains rice farmers on diversity, resilience for profitability - Champion Newspapers LTD;
    - Sustainable Aquaculture Research Networks in sub-Saharan Africa: https://www.facebook.com/193723127373/posts/nigeria-food-security-kebbi-farmers-get-training-on-combining-rice-with-fish-far/10157765560312374/;
    - Livestocktrend.com: https://www.livestocktrend.com/2020/10/farmers-get-training-on-combining-rice.html;

- Maritime first newspaper: https://www.maritimefirstnewspaper.com/food-security-kebbi-farmers-get-training-on-combining-rice-with-fish-farming/;
- The Herald: https://www.herald.ng/usaid-fao-trains-fish-farming/;
- FAO Aquaculture Newsletter: FAO Aquaculture News, June 2023 – No. 67: https://www.fao.org/3/cc6639en/cc6639en.pdf#page=24; and
- UGA College of Agricultural and Environmental Sciences Newswire: https://newswire.caes.uga.edu/story/8891/fish-and-rice.html.

E. SUSTAINABILITY

a. Capacity development

Capacity development was a fundamental aspect of the project, encompassing various training activities on aquaculture technologies for farmers, extension workers, university students and lecturers. Workshops and seminars were organized to facilitate these sessions, aiming to enhance participants' understanding and skills. Furthermore, students and staff at collaborating universities in proximity to research sites were familiarized with new rural development techniques, such as participatory mapping in testing and developing aquaculture technologies in collaboration with farmers. Knowledge sharing with relevant stakeholders was prioritized to ensure the long-term benefits and sustainability of the interventions. This emphasis on capacity development culminated in a national workshop on integrated rice-fish farming held in December 2022. The graduate students and extension workers engaged in project implementation, together with experts from the collaborating institutions in close proximity to the farming communities, will continue to provide technical support and advice to the farmers.

The implemented technology was co-developed with farmers, ensuring that knowledge remained within the farming communities. The adaptive research sites established for rice-fish farming will continue to serve as valuable resources for university research, providing opportunities to train students and demonstrate the technology to new farmers. Extension agents were actively involved in the project, acquiring knowledge to provide continuous support to both current and new farmers. Additionally, a forum comprising farmers, extension agents, community leaders, and other stakeholders was initiated for scheduled discussion sessions to address successes and challenges of the farming system, facilitating collaborative efforts to find solutions.

b. Gender equality

The project prioritized gender equality, ensuring at least 30 percent of beneficiaries were women and youth. Implementation was conducted with a gender-sensitive approach respecting social and ethno-religious norms of the participating communities, aiming for equitable benefits for all. Additionally, project implementation emphasized the equal participation and capacity building of both women and men, fostering an inclusive and supportive environment for all stakeholders.

c. Environmental sustainability

The rice-fish system promoted through the project adhered to agroecological principles, leveraging the symbiotic relationship between rice and fish. This approach significantly reduced the use of chemical fertilizers, herbicides, and pesticides by farmers, while still maintaining satisfactory rice yields and producing fish. The introduced aquaculture technology encouraged the adoption of organic fertilizers instead of chemical ones, further minimizing environmental impact. Notably, farmers abstained from using chemical pesticides and herbicides, contributing to sustainable agricultural practices and ecosystem health.

d. Human Rights-based Approach (HRBA) – in particular Right to Food and Decent Work

Equal opportunity was provided to all interested farmers and stakeholders to participate in and benefit from the project. Initially planned to target 200 beneficiaries, the project exceeded expectations, benefitting more than 700 individuals involved in various aspects of aquaculture technologies. Training on ancillary aquaculture technologies (fish seed, fish feed, and value-addition through smoking) provided to beneficiaries created entrepreneurship and income-diversification opportunities. The project contributed to growth in aquaculture employment, enabling increases in income and livelihoods. This outcome is consistent with the Expected Outcome of the FAO Blue Transformation roadmap 2022–2030 on achieving full and productive employment and decent work in the aquaculture sector. The farm diversification activities contributed to achieving access to adequate foods in a sustainable manner, aligning with the 'Right to Food Guidelines' adopted by FAO in 2004.

e. Technological sustainability

The farm diversification process was locally anchored and institutionalized through collaborative efforts involving farmers, extension agents, and local university experts, ensuring that valuable knowledge remained within the community. Adaptive research sites were established at universities to serve as demonstration sites and hubs for continuous

research, providing learning opportunities for both current and future students. Additionally, targeted training activities were conducted to address potential barriers hindering the farm diversification process, focusing on key areas such as fish seed production and fish smoking techniques. The state government of Kebbi expressed support and interest in promoting farm diversification initiatives, particularly in the adoption of rice-fish farming practices within the state.

The direct project beneficiaries are well-positioned to successfully undertake rice-fish farming without further technical assistance. There have been reports of new farmers who, by observing their neighbours' farms (i.e. those of project beneficiaries), have successfully implemented the rice-fish system on their own farms. However, for new farmers in different areas who have never come across the integration process, technical assistance might be required to initiate the process.

f. Economic sustainability

Nigeria received financial support from the GSAAP to research alternative fish feed using black soldier fly larvae, and FAO mobilized additional resources for follow-up and capacity-development activities in the same areas.

The project developed an Investment and Business Manual on rice-fish farming (see Appendix 2), which provided real-life scenarios on production processes, costs, and profitability margins under different production regimes (farm sizes), while considering risk factors that could negatively affect production. In all scenarios, the economic benefits of rice-fish farming to rice farmers were apparent when compared to rice monocropping.

F. LESSONS LEARNED

Lessons learned – *Elements of success*

The successful implementation of rice-fish farming greatly depended on its integration within local cultural contexts, confirming the notion that whilst it is common in Asia, it may be novel to farmers in other regions. For example, the project beneficiaries reported that it was an eye-opener that they could combine fish farming with rice farming. They became aware of the benefits of diversifying to include fish farming and expressed interest in adopting the practice.

Preferences for rice field designs to accommodate fish varied, depending on farmer preference and water availability. For instance, Nigerian farmers preferred digging a fish trench in a rectangular shape around their field, while consultation with experts in Mali during discussion for technology transfer informed of a preference for a fish refuge area at the centre of the rice field. This underscores the importance of engaging local communities and stakeholders in the planning and development stages of a project to identify entry gaps for the diversification process and to foster acceptance and sustainability. This is particularly noted as one of the important requirements/recommendations to undertake when replicating the practice in new areas.

Access to training and education for farmers was an important factor for success. Demonstrating the process through small-scale, farmer-managed pilot plots and adapting techniques to local farming practices fostered a sense of ownership among the farmers. The pilot demonstration trials, which showcased the ecological and economic benefits, convinced farmers of the superior profitability of rice-fish farming compared to traditional rice monocropping, increasing the likelihood of long-term adoption and success. These criteria are equally important for the global applicability of the process and should be considered by new adopters to ensure a successful implementation process.

The process of local anchorage and institutionalization of farm diversification was pivotal as a community learning experience. It involved co-creating knowledge with farmers, extension agents, and local university experts to ensure the knowledge remained within the community. Furthermore, adaptive research sites situated in universities proved useful for demonstrations and would provide continuous academic research opportunities for both present and future students.

Specific challenges were encountered while implementing the practice. Consequently, mitigation and adaptation measures were developed. These mitigation approaches are applicable in similar situations and can be adapted to closely related contexts globally.

The identified challenges and corresponding mitigation measures included the following:

- Water retention in rice field trenches: Leaching of water and rapid evaporation were observed during the dry season. In the absence of a working irrigation structure, the additional cost of pumping water for replenishment may not be sustainable for farmers with limited financial resources. The initial adaptation measure employed was to lay plastic bags inside the trenches to hold water for a longer period. However, in terms of environmental sustainability, the use of plastic lining was discouraged, and thus rice-fish farming is encouraged during the wet/rainy season.

- Fish seed availability: Limited access to fish seed was reported by the farmers. The measure adopted to address this challenge was to train farmers on low-cost fish breeding techniques, thus improving availability within their locality.
- Predation from birds: Loss of fish due to predation from birds was recorded. The use of net covering and stocking of fish of a bigger size were recommended to prevent the actions of predatory birds.
- Fish size at harvest: The fish were harvested at 250–350 grams after three months of co-culture with rice. Although the size was not competitive for the desired size in Nigeria's fresh fish market, value-addition through smoking was introduced to boost the economic value of the fish, noting that smoked fish commands a high market value irrespective of size.
- Expensive commercial feed: The cost of commercial fish feed was challenging to the farmers. The project therefore introduced alternative feeds, using locally sourced feed ingredients (rice bran, fish offal) for feed formulation. Also, there is an ongoing process to develop a training protocol for farmers on using black soldier fly larvae as an alternative fish feed.
- Knowledge sharing among project beneficiaries: Farm diversification processes slightly differ from plot to plot. Therefore, farmer-farmer knowledge exchange and experience sharing are considered an important aspect of knowledge transfer and information dissemination among practitioners.
- Use of organic manure: Farmers have started to report positive changes in aquatic biodiversity of rice fields. In other words, they can collect other aquatic foods in addition to rice from their farm. The regeneration of aquatic biodiversity is due to the reduced use of chemicals and the promotion of organic manure.
- This suite of adaptation measures was vital in developing a robust knowledge-base for implementing the process of diversification.

Lessons learned – *Impediments/constraints*

This project was heavily impacted by COVID-19, and FAO staff was unable to travel to participate in any of the inception events, participatory consultations or training activities. Travel restrictions were also imposed owing to security concerns, preventing FAO staff from traveling to the pilot sites for the majority of the project's lifespan. As a tripartite project, the other two institutions were less impacted by the travel restrictions. In an attempt to compensate, regular online meetings (via Zoom, WhatsApp and email) were held with partners to discuss the progress of project implementation and course-correction measures, to

ensure that the set objectives were achieved. However, poor internet connectivity in Nigeria made the virtual backstopping difficult, imprecise and time consuming.

Communication between FAO and the Government of Nigeria was initially hampered by the COVID-19 pandemic, owing to the fact that no one from FAO was able to travel and meet in person with government officials in the first two years of implementation. Increased communication would have been beneficial. That said, the project had good success engaging with local government officials and extension agents, mostly through UI.

Notably, a representative from FMARD made significant contributions and provided technical advice to farmers and extension workers in support of better field management for rice-fish farming at the National Workshop on Integrated Rice-Fish Farming in December 2022; however, identifying an operational-level focal point within FMARD would have also been beneficial to assist in awareness raising about the project among government officials.

The lesson in the above-mentioned two cases underscores the importance of engaging the federal and state governments at the inception of the project, and of establishing focal points within the government and within the FAO country office to facilitate communication and information sharing.

G. FOLLOW-UP ACTIONS FOR GOVERNMENT ATTENTION

Representatives of FMARD could consider engaging with counterparts in Kebbi and Ebonyi states to better understand the impacts of the project, and the plans of the state governments for follow up. For example, in July 2023, the Secretary to the Kebbi State Government conveyed the State’s keen interest in rice-fish farming, remarking that the government has seen positive impacts and expressing willingness to collaborate with the project team to widen the scope of the project to reach other local government areas of the state. To this end, the state’s Ministry of Animal Husbandry, Fisheries and Rural Development, in collaboration with UI and Usmanu Danfodiyo University (Sokoto) are working together to develop a proposal for the "Empowerment Package". Government engagement at all levels could serve to harmonize the work on sustainable aquaculture development and national priorities.

More generally, the project identified the following seven measures:

1. **Enabling policy support and advocacy:** Consideration to enact policies that incentivize and facilitate the adoption of rice-fish farming practices. This includes providing financial assistance, technical training, and access to resources for farmers transitioning to integrated systems. Through advocacy and awareness campaigns, stakeholders will be educated about the benefits of rice-fish farming for both agricultural productivity and environmental sustainability.
2. **Research and development actions:** Consideration to allocate resources for research initiatives aimed at optimizing rice-fish farming techniques, particularly in the area of farm-level fish seed and fish feed production, to support the overall productivity and sustainability of the farming system.
3. **Tailored extension services for rice-fish farming:** Consideration to establish extension programmes to disseminate knowledge about rice-fish farming practices among farmers. The programme could be in the form of educational workshops, demonstration farms, and outreach campaigns to raise awareness about the benefits of integrated farming systems.
4. **Ensuring access to quality feed and seeds:** Access to quality and affordable feed and seeds is essential for the success of rice-fish farming. The government is encouraged to intensify their current efforts to continue to promote measures that enhance access to these essential inputs, either through state-sponsored hatcheries and fish feed plants and supplying these inputs to farmers at a subsidized rate.
5. **Market access:** Fostering linkages between rice-fish farmers and markets to ensure fair pricing and distribution channels for both rice and fish products. This could involve strengthening existing farmer cooperatives by opening up additional hubs for trading and supporting local markets with stalls and necessary infrastructure, such as good road networks.
6. **Capacity-building for youth entrepreneurs**: The potential for youth involvement in rice-fish farming was recognized by the project, and capacity-building initiatives focused on entrepreneurship are recommended. By offering capacity-building programmes for young farmers, the next generation of agricultural leaders can be empowered.
7. **Enhance access to credit facilities for the farmers:** To support farmers in adopting and expanding rice-fish farming systems, access to credit facilities is crucial. The provision of financial support through credit facilities or revolving funds is proposed,

enabling farmers to invest in the necessary infrastructure and resources for successful integration.

H. HUMAN INTEREST STORY

From Rice to Fish: Boosting Productivity and Nutrition through Farm Diversification

Amarachi Nweke is a 27-year-old farmer in Ikwo Community of Ebonyi State, Nigeria. She was away on a trip when the project team first visited her community to discuss with farmers and community leaders the possibility of converting rice fields to incorporate fish farming. Upon her return, she learned about the activity from family and neighbours, which piqued her interest, and she reached out to the research team, requesting to learn more about rice-fish farming.

Figure 5: "The fish from the rice-fish system has better taste than the fish we normally collect from water bodies around us which are often dirty." Valuable comment shared by farmer Amarachi Nweke. (Credit: ©FAO/Femi Ajayi).

"When I heard about the activity, I was delighted to learn that I can combine my rice cultivation with fish farming," Nweke said. "I could tell it would bring benefits to me and other people who decide to participate. The possibility of combining rice and fish production brings hope to me and my people that we can produce more in our fields."

The project team provided training for smallholder Nigerian rice farmers like Nweke, who had little to no knowledge of aquaculture or how to implement climate-friendly rice-fish farming using an agroecological approach. This method promotes ecological processes in agriculture, such as using organic manure and reducing the need for pesticides. By combining rice and fish production in the same area, farmers were able to maximize their yields.

Nweke actively participated in managing the pilot demonstration plot in her community. She took charge of daily fish feeding and growth monitoring, learning about various technical aspects of modifying rice fields for fish farming. This included constructing sumps and trenches, managing water in the rice fields, establishing a fish feeding regime and caring for rice using only organic manure.

Figure 6: A project beneficiary working on her rice-fish farm. (Credit: ©FAO/Femi Ajayi).

She observed that "the panicles (i.e. clusters of rice grains on the plant) were larger" under the new rice-fish practice compared to the traditional farming system in her community. She credited this to the rice having more space between plants than a traditional system. She noted that because the panicles were larger, she was not surprised that the output of rice was more than what she would have obtained from a traditional plot of similar size. She confirmed that spacing rice plants at specific intervals, as was done in the activity, boosted rice production.

At the community level, Nweke said that one of the activity's major achievements was the quality of fish that comes from the integrated rice-fish system. Before the initiative, she said it was difficult to get fish, and the ones that were gathered were frequently from contaminated, dirty water where people had disposed of waste, making the fish taste unpleasant and discouraging people from eating them.

"In the Ikwo community, which is already well-known for rice cultivation, the new farming method presents an opportunity to increase farm productivity and profitability at the individual farm level," she said. "After seeing that it is possible to adapt rice fields to also grow fish, more farmers in the community have shown interest in adopting the combined rice-fish system. This will be highly beneficial because in addition to rice, we can sell fish, which is better-tasting and of higher quality."

According to Nweke, rice-fish farming is a straightforward way to make more money and provide more food to consume at home. Additionally, the challenge of lacking constant electricity for fish cold storage has been resolved through the recommendation and training component of the activity on fish smoking. This allows farmers to preserve and store fish without worrying about spoilage or waste.

"There are several other areas in Ebonyi State, and in Nigeria as a whole, where adapting rice fields for integrated rice-fish farming would significantly change the farmers' life for the better," Nweke said. "I hope this type of work continues, so more farmers learn about this farming practice, and it continues to add value to farming families."

Rice-Fish Farming Increases Yield, Improves Household Nutrition and Income for Nigerian Families

Nnanna Hyacinth Chuckwu, a rice farmer in Ebonyi State, Nigeria, tended to his family's financial needs from his earnings after the rice harvest, but in recent years, he reported low revenue due to seasonal drought and dry spells that affected yield and led to a shortage of food. However, since he participated in the first phase of the farm diversification through the IAA project, Chuckwu now farms rice and fish together.

Figure 7: A project beneficiary preparing his rice field for integration with aquaculture. (Credit: ©FAO/Femi Ajayi).

With the support of extension workers, the project team worked closely with farmers in rural communities in Nigeria and held a series of pilot trials to modify rice fields to include fish farming. By harvesting two food commodities within the same area of land, there is the added benefit of having another commodity from which to make a profit if rice crops fail or if there is loss in fish.

"I was pleasantly surprised when I was told I can combine fish farming with my rice farming," Chuckwu said. "I joined the activity because of the benefits I envisioned it would bring to me. I have been getting income from rice alone in the past, but now, I see the possibility of getting income from both rice and fish.

"Surprisingly, my expected rice yield did not reduce after I modified my farm to grow fish. In fact, at the end of the last farming season when I started rice-fish farming, my profit was larger, and my family's nutrition has also improved from eating both rice and fish instead of rice alone."

The project team provided entry-level training for smallholder Nigerian rice farmers like Chuckwu, who had little to no knowledge of aquaculture or how to implement rice-fish farming at the farm level. One discovery made by the implementers was the high rate of fish growth seen in the rice-fish co-culture. The fish grew to eating size within three to four months of production, and this was largely due to the feed formulation used, where rice bran and fish offal were sourced locally to replace the high-cost of commercial fish feed ingredients, especially fish meal. The farmers also had the choice to periodically harvest for home consumption when needed and continue to nurture others to bigger-size fish.

The research team analysed different combinations of feed ingredients in the laboratory to arrive at the best formulation for optimum yield outcome while considering both fish and human health. The use of this feed in the pilot plots not only reduced the cost of fish feed for farmers but also increased fish yield within the given timeframe for rice harvest. In other words, rice and fish could be harvested simultaneously, instead of harvesting rice and leaving fish to continue to grow to a farmer-desired table size, which is the desired size to sell fish. While it is possible to leave the fish in the trenches to continue to grow, harvesting the two food commodities together could save farmers the time and labour costs of continuing fish farming after harvesting the rice.

Chuckwu said the activity increased his knowledge of how to modify rice farming to be more profitable. He learned how to dig trenches for fish farming, manage the water, feed the fish for optimum growth and how to care for rice within the new system.

"The knowledge impacted not just me, but also the people in my community because we came together at the rice-fish pilot plot and learned together," he said. "Some people thought combining rice and fish culture together was not possible, but now, they see that it is. When the fish was harvested last season, they were happy and surprised to see that this is possible, and they are eager to participate next season."

Chuckwu emphasized that rice-fish farming is a doable way to make more money and provide more food to consume at home. He emphasized that what he learned from the project is providing more opportunities for him and his family.

"In my home, we don’t eat rice alone anymore," Chuckwu said. "We combine it with fish, and the health of my family has improved because we now eat a more balanced diet."

Appendix 1

LOGFRAME MATRIX - ACHIEVEMENT OF INDICATORS

Results chain	Indicators				If not achieved, explain why	If applicable, follow-up action to be taken
	Indicators	**Baseline**	**End target** ***(expected value at project completion)***	**Achieved**		
Impact: Improved food security, enhancement of economic opportunities, and improved resource use for food production.						
Outcome 1: Development of suitable integrated rice-fish production technology through participatory research actions.						
Output 1.1 Action research is conducted to develop a knowledge base on agroecological wetlands suitable for integrated fish and rice farming.	Number of wetland identified Number of stakeholder meetings conducted with communities	0 wetland map 0 stakeholder meeting	1 wetland map 2 stakeholder meeting	Wetland maps of Ebonyi and Kebbi state produced. Three stakeholder meetings conducted (one each in Kebbi and Ebonyi states; one national workshop in Ibadan).		
Output 1.2 Farming Systems are analyzed to characterize the prevailing rice-fish farming practices and gather evidence on how to introduce innovative and high performing farming system through appropriate management options.	Number of rice farming systems identified No of needs of farmers for intensification of fish production in rice fields gathered from survey and group discussion Number of research site selected Number of project beneficiary selected, 30% of which must be women and youths	0 systems 0 needs assessments 0 research sites 0 project beneficiaries	1 system 1 needs assessment 2 research sites 200 project beneficiaries	Two systems identified. One needs assessment conducted. Eight plot sites selected (three each in Kebbi and Ebonyi states, two institutional sites in UI and one institutional site in Usmanu Danfodiyo University Sokoto). More than 700 beneficiaries selected.		

Results chain	Indicators				If not achieved, explain why	If applicable, follow-up action to be taken
	Indicators	**Baseline**	**End target** ***(expected value at project completion)***	**Achieved**		
	Number of Participatory farmer field school (discussion and training group) conducted	0 farmer field school training	2 farmer field schools (discussion and training group)	Six season-long training courses on all aspects of production were conducted (including farmer discussion and training groups).		
Output 1.3 Evidence-based and locally adaptable cost-effective integrated rice-fish system, including market access development are piloted in the target communities.	On-farm adaptive research to obtain information on cost of production, rice and fish yield, resource use, and fish performance under different feeding regimes in each system	0 on-farm adaptive research	2 on-farm adaptive research	Eight on-farm adaptive research studies.		
	Number of participation farmers, disaggregated to gender and age (youth and adults)	0 participating farmers	6 participating farmers	Eight participating farmers.		
	Number of hectares under farm diversification process	0 hectares under farm diversification	2 hectares under farm diversification	Ten hectares under farm diversification.		
	Number of cluster farms established	0 farm cluster	2 farm clusters	Three farm clusters.		
Output 1.4 The promotion and adoption of cost-effective, sustainable and innovative approaches and practices to support agroecologically sound aquaculture operations in rice farms of target communities are evaluated.	Number of farmers (women, men, youth) that take up the technology and applied the farm diversification process	0 farmer technology adoption	100 farmer technology adoption	A total of 108 farmers adopted the technology.		
	Percentage increase in yield of rice of the participating farmers percentage of project participants with increased dietary diversity	0 percent increase	5 percent increase	Five percent increase in rice yield.		

Results chain	Indicators				If not achieved, explain why	If applicable, follow-up action to be taken
	Indicators	**Baseline**	**End target *(expected value at project completion)***	**Achieved**		
	Percentage increase in the monetary value of sales (rice and fish) of project participants	0 percent monetary value increase	10 percent monetary value increase	Up to 48 percent monetary value increase.		
Output 1.5 Production technological packages for sustainable integration of rice-fish farming in the participating states through adaptive research are developed.	Number of rice-fish technological package is developed	0 technological package	1 technological package	Three technological packages.		
Output 1.6 A functional Innovation Platform on IAA system is established.	Number of Innovation platform established Number of participating farmers and other stakeholders disaggregated according to gender and age	0 innovation platform	2 innovation platforms	Two innovation platforms.		
Outcome 2: Understanding convenient market access approach and nutrition contributions of rice-fish farming products						
Output 2.1 Situational analyses of markets before, during and after intervention process are conducted and analyzed.	Number of Market access survey is conducted	0 survey conducted	3 surveys conducted	Two surveys conducted.		
Output 2.2 Situational analyses of nutrition status, gender and youth involvement before, during and after intervention process. Designed and implemented fish surveys (see Project Document Section 3 for description of surveys).	Number of surveys conducted when administering the food/fish consumption, HDDS, FIES survey questionnaires.	0 survey conducted	3 surveys conducted	Two surveys conducted.		

Results chain	Indicators				If not achieved, explain why	If applicable, follow-up action to be taken
	Indicators	**Baseline**	**End target** ***(expected value at project completion)***	**Achieved**		
Output 2.3 Enhanced entrepreneurship or business skill of farmers, especially youths and women and end market opportunities from the farm outputs identified and supported through the project are evaluated.	Number of Entrepreneurship training is conducted Number of new entrepreneurs among the project beneficiaries disaggregated according to gender and age Rice-fish business manual development is initiated	0 entrepreneurship training 0 new entrepreneur	1 entrepreneurship training 10 new entrepreneurs	Three entrepreneurship training sessions. Fifty new entrepreneurs. Manual completed (see Appendix 2).		
Output 2.4 Partnership between scientists and the development community for improving food production-nutrition linkages to address undernutrition (malnutrition) are strengthened.	Number of partners and other development partners involved in the project The number of organizations (farmer groups, market stakeholders) with increased performance improvement through the project	0 partners 0 number of organizations	2 partners 3 number of organizations	Three partners. Six organizations.		
Outcome 3: Capacity development and enhancement of co-learning among all stakeholders (academics, farmers, extension workers and other development partners).						
Output 3.1 Best performing and preferred species suitable for sustainable rice-fish production in the two states (Kebbi and Ebonyi) are identified and evaluated.	Number of preferred fish species by consumers Number of best performing fish species	0 preferred fish 0 fish species	1 preferred fish 1 best performing fish species	Two preferred fish. Two best-performing fish species.		
Output 3.2 Locally available feedstuffs as suitable supplemental feeding for *Clarias gariepinus* and *Oreochromis niloticus* are tested.	Number of low cost but good quality feed developed Number of locally feedstuff ingredient tested	0 feeds developed 0 feed ingredients tested	1 feeds developed 2 feeds ingredient tested	Two feeds developed. Three feed ingredients tested.		

Results chain	Indicators				If not achieved, explain why	If applicable, follow-up action to be taken
	Indicators	**Baseline**	**End target** ***(expected value at project completion)***	**Achieved**		
Output 3.3 Manual for small-scale rural farmers that helps development of an investment and business plan is developed.	Number of business plan developed for rice-fish farming through grower's profitability margins, grower's acceptability and consumer purchasing behavior and Willingness to Pay (WTP) analyses.	0 business plan	1 business plan	One business plan (in press at the time of reporting).		
Output 3.4 National conference on rice-fish farming is organized.	Number of National conference on rice-fish farming organized Number of participants and key stakeholders in that attended the National conference disaggregated according to gender and age Number of recommendations and key messages from the National conference	0 National conference 0 National conference attendee 0 key recommendation	1 National conference 30 National conference attendees 5 key recommendations	One national conference. Forty-five national conference attendees. Twelve key recommendations.		
Output 3.5 Policy brief as an informed guide to influence policies and practices for the inclusion, promotion, and implementation of IAA in future food policy designs and/or national agricultural programmes, as a nutrition-sensitive approach are published.	Number of knowledge products produced and published At least four policy brief developed before project completion	0 knowledge products	2 Knowledge products	Four policy briefs drafted. Seven manuscripts in development.		

Appendix 2

DOCUMENTS PRODUCED DURING THE PROJECT

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Appendix 3

PROJECT STAFF

	Dates of Service	
Function	**Starting Date**	**Concluding Date**
Principal Investigator	June 2021	September 2023
Co-principal Investigator	June 2021	September 2023
Liaison Technical Officer	June 2021	September 2023
Administrative Support	June 2021	September 2023
Project Coordinator/Scientific Investigator	June 2021	September 2023

Appendix 4

TRAINING AND STUDY TOURS

Number of Participants	Title of Study/Training Tour	Place	Date
107	The long-term benefits of introducing aquaculture into rice-based agroecosystems: Regeneration of aquatic biodiversity	Wawu and Argungu, Kebbi state	1–8 August 2023
		Ikwo, Onicha, and Abakaliki, Ebonyi state	
26	Value addition through integrated rice and fish farming	Sokoto, Sokoto state	16–25 July 2023
		Abakaliki, Ebonyi state	
14	Fish breeding training in Ebonyi state	Umudike, Ebonyi state	10–14 December 2022
46	National workshop on rice-fish farming: A farm diversification process	Ibadan, Oyo state	6–7 December 2022
26	Fish breeding training in Kebbi state	Sokoto, Sokoto state	5–10 November 2022
77	Integrated Fish Farming – Benefits, Operational and Management (Biological and Economics) Procedures	Onicha, Ebonyi state	22–23 July 2022
46		Ikwo, Ebonyi state	21–22 July 2022
52		Kimba, Kebbi state	19–21 July 2022
122		Argungu, Kebbi state	18–20 July 2022
5	Training of farmers on on-farm data collection and recording	Ebonyi state	22 October 2021
7		Kebbi state	14 October 2021
300	Community sensitization and exchange at the adaptive rice-fish research sites	Multiple sites in Kebbi (Argungu, Kimba, Wawu) and Ebonyi (Onicha, Ikwo, Nwannu) states	7–24 August 2021
		Institutional sites at the UI, Oyo state, and Usmanu Danfodiyo University, Sokoto, Sokoto state	