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Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Annual project workshop report

November 6–9, 2023
Abuja and Lagos, Nigeria

In partnership with

icipe CORAF SLU Swedish University of Agricultural Sciences ALLER AQUA ZAMBIA Natural Resources Development College IITA Transforming African Agriculture

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA): Annual project workshop report

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About Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

WorldFish has partnered with the Norwegian Agency for Development Cooperation (Norad) on a 5-year project to develop low-cost and highly nutritious aquatic feeds based on novel ingredients. The project, known as Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA), will run from 2022 to 2027 with Norad funding the initiative through a NOK 80 million (approximately USD 8 million) grant. The project aims to enable 5000 smallholder aquatic food producers in Kenya, Nigeria and Zambia to test and use these feeds and ingredients, which will increase their income, improve their nation's food security as well as reduce waste and pollution. An estimated 30 and 40 percent of aquatic food producers engaged in the project will be women and youths, respectively.

Acknowledgments

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Contact

WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia. Email: worldfishcenter@cgiar.org

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Front cover, Neil Palmer/WorldFish; Yogeswary Chellapan, Ning Shahira Sharbini, Nurulhuda Ahmad Fatan Arthertone Jere, Gregory Kasanga/WorldFish.

Disclaimer

This report must be read, and the results considered, in conjunction with the climate and environmental analysis report as well as the country outcomes report for Kenya, Nigeria and Zambia under the FASA project.

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List of abbreviations

BSFL	Black soldier fly larvae
FASA	Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa
ILRI	International Livestock Research Institution
LCA	life cycle assessment

Executive summary

On November 6–9, 2023, the Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA) project held its most recent annual workshop at the Rockview Hotel in Abuja, Nigeria. Two days (November 7–8) were spent at the hotel in between two daylong field visits, one to a feed mill and fish farm in Abuja (November 6) and the other to the Nigerian Institute for Oceanography and Marine Research (NIOMR) in Lagos (November 9).

WorldFish representatives attended the workshop as well as FASA partners, consultants and stakeholders, such as the West and Central African Council for Agricultural Research and Development (CORAF), The International Centre of Insect Physiology and Ecology (ICIPE), The Natural Resources Development College (NRDC), Swedish University of Agricultural Sciences (SLU), Includovate, NAGI Enterprise, The International Institute of Tropical Agriculture (IITA), Aller Aqua Zambia Limited, The Agricultural Research Council of Nigeria (ARCN) and Nigerian Institute for Oceanography and Marine Research (NIOMR). The Norwegian ambassador to Nigeria officially opened the workshop. The objective was to bring together FASA partners to provide updates on the overall activities completed in Year 1 of the project as well as activities planned for Year 2 and tentatively Year 3 (the entire project runs from July 1, 2022, to June 30, 2027) The revised implementation plan for 2024 and tentatively 2025 of the project was the main outcome of the workshop. Through discussions in each presentation section, participants had the opportunity to address questions and update challenges pertaining to the project's activities. In each session, participants also helped generate new ideas and solutions, leading to new insights and approaches to problems.

Several activities were accomplished in the first year of the project. FASA partners completed scoping studies that provided information on the type, price and seasonality of local ingredients used in fish feeds produced in the project's three focal countries: Zambia, Kenya and Nigeria. The laboratory in Zambia was upgraded with a complete recirculating aquaculture system (RAS) for use in experiments on the nutrient requirements of an improved strain of tilapia. A gender and social assessment was done using the Automated Directives Systems 205 (ADS 205) framework, with an emphasis on policies, cultural beliefs, gender roles, resource access and decision-making. Climate change and environmental assessments using life cycle assessment (LCA) methods highlighted the potential of the project to improve environmental benefits within the novel feeds landscape across the three focal countries. Then, workshops on theories of change was held in Zambia, Kenya and Nigeria to investigate the impact of using novel feed ingredients in fish feeds.

In addition to providing updates on implementation activities in Year 1, project partners provided detailed workplans for 2024 and tentatively 2025. Among the activities planned are experiments on the nutrient requirements of improved strains of tilapia and African catfish using locally accessible ingredients. Other activities include conducting a digestibility experiment and biochemical analyses on ingredient samples obtained from each focal country, as well as creating an ingredient database. Finally, the project will submit the agreed upon implementation plan to donor for approval. The plan will be used to carry out the project on the ground in 2024 and tentatively 2025.

1. Introduction

1.1. Objectives

The purpose of the workshop was to bring together project partners to meet in person, provide updates on the project's overall activities implemented from July 2022 to September 2023 and plan activities for the subsequent year.

1.2. Dates and venues

The workshop was held in Abuja and Lagos, Nigeria, on November 6–9, 2023. The agenda of the workshop was as follows:

- November 6: Site visit to the TIDDO Fish Farms Limited and Flourishing Centre Fish and Agro Farms in Abuja.
- November 7-8: Workshop meetings and presentations in Gurara Hall at Rockview Hotels Classic.
- November 9: Site visit to the NIOMR in Lagos

1.3. Participants

A total of 30 people attended the workshop. They consisted of representatives from CORAF, ARCN, NIOMR, the National Institute for Freshwater and Fisheries Research (NIFFR), NRDC, ICIPE, SLU, Includovate, NAGI Enterprise, Aller Aqua Zambia Limited, IITA and WorldFish. A detailed list of attendees is available in Appendix 1.

Plate 1. Workshop participants, including the Norwegian ambassador to Nigeria, His Excellency Svein Bæra.

1.4. Activities

The workshop consisted of presentations at the Rockview Hotel, Abuja and field visits. A detailed agenda of the activities at the Rockview Hotel is included in Appendix 2. Details of the field visit are discussed in section 4.

Plate 2. Workshop participants.

2. Opening

Dr. Rodrigue Yossa, the project leader, welcomed everyone and provided an outline of the activities and program for the workshop. The workshop began with a welcoming speech from Dr. Musa Musa, assistant chief of the ARCN. In his speech, he welcomed all the participants and mentioned how important the FASA project is for WorldFish and its partners—both for the aquaculture sector in Africa and for people relying on farmed fish to make a living. Prerecorded welcome speeches were given by Dr. Essam Mohammed, WorldFish's director general, Dr. Lamien Nieyidouba from CORAF and Dr. Sunil Siriwardena from WorldFish Nigeria. Mr. Baera then delivered the opening speech, after which Dr. Yossa presented the objective and scope of the workshop.

3. Presentations: Updates on the implementation of Year 1

3.1. Day 1

Presentations were held at the Rockview Hotel. These included updates on the implementation of Year 1 and the perspectives of partners on the implementation. Each presentation provided an update on a specific component of the project in its first year of implementation of the FASA project. Additionally, WorldFish's finance team provided an update on the project's finances and financial reporting schedule, followed by an update from the project leader on the technical reporting schedule. Copies of the slides presentations for Day 1 are available in Appendix 3.

3.1.1. FASA in Nigeria

Presentation by Dr. Charity Obetta, CORAF

Overview

Although Nigeria is the largest aquaculture producer in Sub-Saharan Africa, it faces considerable challenges in supplying affordable, high quality feed to sustain fish farming in the country. The expansion of smallholder aquaculture faces limitations such as the scarcity and unsustainability of feed as well as the substantial economic and environmental costs involved. This is where FASA comes in. The project is a transformative initiative, striving to establish an inclusive, equitable and sustainable aquatic food system in Nigeria in order to pave the way for a more balanced and resilient industry.

Implementation

Scoping studies

Scoping studies were done on the type, price and seasonality of local ingredients for potential use in fish feeds in Nigeria. The focus was on collecting and sharing important data about local ingredients suitable for sustainable fish feeds. The aim was to fill the existing information gap and promote a better, more sustainable way of producing fish feed in Nigeria.

A total of 920 responses were gathered from 46 locations, averaging 20 respondents per location, with 5 at least respondents from each location. These locations spanned 6 distinct regional zones (Figure 1).

Figure 1. Location of the FASA study in Nigeria.

Results

Major ingredients were assessed across the country's zones: groundnut cake in North Central, soybean in North East, maize in North West, cassava and rice bran in South East, cassava in South , and cassava and maize in South West. From 2018 to 2022, cassava prices were highest in South East and increased over time. Rice prices trended upward across the country and were highest in South South, while yam prices, which were highest in South East, also increased.

The survey grouped the ingredients into five uses: (1) animal feeds, (2) animal feeds and human consumption, (3) animal feeds, human consumption and industrial use, (4) animal feeds and industrial use and (5) human consumption only. Findings showed that the largest share of ingredients serves both animal feeds and human consumption (50%), followed by those for animal feeds, human consumption and industry (21%). Some were solely for human consumption (15%) and just a small percentage for animal feeds (11%), while the least amount was used for both animal feeds and industry (3%).

Surveys showed that 20% of the ingredients are produced year-round, though most come during the dry season (51%) followed by the wet season (29%). According to the surveys, 94% of the ingredients are highly accessible in markets.

The following is the distribution of feed mills across the zones:

- North Central: 32% Niger, 28% Plateau, 24% Nasarawa, 12% Federal Capital Territory (FCT), 4% Benue
- North East: 72% Yobe, 20% Bauchi, 8% Taraba
- North West: 46% Kaduna, 40% Kano, 7% Sokoto, 7% Kebbi
- South South: 69% Akwa Ibom, 23% Rivers, 8% Delta
- South East: 71% Enugu, 23% Ebonyi, 6% Abia
- South West: 41% Ondo, 26% Lagos, 18% Ogun, 15% Oyo.

The survey also examined the daily capacity of feed mills based on how long they had been in business. Most feed millers from each zone are capable of producing no more than 4536 kg of feed daily.

FASA collected and packaged the following 16 ingredients and sent them to WorldFish and SLU for analysis and processing:

1. African locust bean (*Parkia biglobosa*)
2. African baobab (*Adansonia digitata*)
3. White cowpea (*Vigna unguiculata*)
4. Brown cowpea (*Vigna unguiculata*)
5. Bambara nut (*Vigna subtarranea*)
6. Brewery waste (*Hordeum vulgare*)
7. Roselle seed meal (after extracting oil from the roselle seed)
8. Tiger nut (*Cyperus esculentus*)
9. White yam (*Dioscoria rotundata*)
10. Shea nut seed cake (*Vitellaria paradoxa*)
11. Clupeidea fish (*Pellonula leonensis*)
12. Clupeidea fish (*Sierrathrissa leonensis*)
13. Lantern fish
14. Black soldier fly larvae (BSFL)
15. Chaya leaves
16. Plantain (*Musa sapientum*)

Experiments

Eight experiments will be conducted to investigate the nutrient requirements (methionine, lysine, vitamin C, calcium and phosphorus) for improved strains of tilapia and African catfish using locally available ingredients in Nigeria.

The project received approval of its research and human ethics protocols and rehabilitated an experimental system using Recirculating Aquaculture System (RAS). It also procured fish for the experiments and was acclimatizing the fish at the time of the workshop. Fish feed formulations, sampling and chemical analysis were also planned for the experiments.

3.1.2. FASA in Kenya

Presentation by Dr. Chrysantus Tanga, ICIPE

Implementation

Recruitment

Dr. Menaga Meenakshisundaram (postdoctoral fellow) and Mr. Isaiah Rachami (research assistant) were both recruited as new staff, while Mr. John Muia (MSc), Ms. Judy Kaguthi (MSc) and Mrs. Evalyne Wambui Ndotono (PhD) were recruited as students.

Startup workshops

On January 18, 2023, an online kick-off meeting engaged over 25 participants, setting the groundwork for year 1. Then on February 16–25, 2023, the first face-to-face gathering of stakeholders took place. Among the notable attendees were various fish farms, including the Kamuthanga farm in Machakos, the Kenya Marine and Fisheries Research Institute (KMFRI) in Sagana, and Bukani Aquapark, Hydro Victoria Fish Hatchery and Farm Ltd, and Bunyala Agro Industrial Park in Busia. Additionally, feed millers were represented by entities like Great Lake Feeds and Hatchery Ltd in Siaya County, Captain Feeds and the KMFRI Sangoro Center in Kisumu County, and the Kinyasaga group in Homa Bay County.

Literature review

A literature review was conducted to reveal new insights into Africa's emerging edible insect industry. In Kenya, an analysis of grain allocation revealed an interesting distribution: 62% is designated for animal feed, 23% for human consumption, 12% for industrial purposes and 3% for other uses. To tackle the competition between humans and animals for these grains, a strategic initiative aims to mitigate this rivalry, striving for a more equitable allocation.

References: Tanga, C. M., & Kababu, M. O. (2023).. New insights into the emerging edible insect industry in Africa. *Animal Frontiers* 13(4):26–40. (Impact Factor: 6.762)

Scoping review

A scoping review was conducted on the role of multilateral development organizations and both public and private investments in Kenya's aquaculture sector. It was devoted to (i) designing and constructing climate-smart culture systems, (ii) developing new species to guarantee the supply of high quality products, (iii) developing and scaling low cost and highly nutritious fish feeds based on novel ingredients and (iv) enhancing resilient livelihoods through innovative aquaculture practices and market links to create employment opportunities for youths and women.

References: Munguti, J. M. (2023). Role of multilateral development organizations, public and private investments in aquaculture subsector in Kenya. *Frontiers in Sustainable Food Systems*. (Impact factor: 5.005)

The following are the results from scoping assessments conducted in fish production zones:

- Out of 220 respondents interviewed, most kept tilapia (93.2%) while only a small percentage kept catfish (6.2%).
- Most farmers (70.7%) harvested their fish once a year.
- Some farmers get their fish feed from other farmers (15.2%) and private companies (10.8%), while others produce their own (5.8%).
- About two-thirds of farmers (66%) use compound feeds to feed their fish, while about a quarter (25.8%) reportedly used insect meal .
- Government is the biggest supplier of fingerlings (25.6%) to farmers followed closely by private companies (22.9%) and other farmers (22.4%).
- Most farmers use complete compound feeds (65.5%) and dry supplements (63.2%), while others (10.3%) use wet supplements to feed their fish.
- Farmers strongly agreed (20.6%) and agreed (47.5%) that the use of insect meal in fish production could help lower feed prices and overall production costs.
- The most used protein sources included freshwater shrimp (45.3%), fishmeal (17.9%), dry poultry waste (9.4%), sardines (*omena*) (6.7%), insects and earthworms (5.8%), legume residues (5.4%), sunflower cake (4.4%), bloodmeal (5.4%), soybean meal (3.1%), cotton seed cake (2.7%) and sesame seed meal (1.3%).
- Common homemade fish feeds are either single ingredients, such as maize bran or household food leftovers, used in feed formulations.
- Half of the respondents (50%) agreed that availability, information and reliability are the main factors in the use of insect-based feeds.
- The top 20 sources of protein are mango seed embryo, water fern, fishmeal, freshwater shrimp, wheat bran, maize bran, rice bran, arrowroot leaves, banana peel, banana stem, banana stem, banana leaves, cottonseed cake, sunflower seed cake, cassava leaves, papaya peel, papaya seed meal, sweet potato leaves, brewery by-product, and tilapia and catfish offal.

The biochemical composition of full-fat BSFL and defatted BSFL includes proximate composition, amino acids and minerals, the finding for BSFL oil was its contains 40% lauric acid and is rich in antimicrobial agents.

Experiments

An experiment was conducted at the National Aquaculture Research Development and Training Center in Sagana on the KMFRI-SAGANA strain (F-8). The aim was to evaluate the use of BSFL as a potential substitute for fishmeal in the production of Nile tilapia (*Oreochromis niloticus*). The experiment included four diets: T0 (Control), T25, T50 and T75. The results revealed that 25% and 50% replacement of fishmeal protein with black soldier fly meal (BSFLM) provides the best growth performance of Nile tilapia. Seven other tilapia experiments are ongoing, as well as seven others for catfish.

3.1.3. FASA in Zambia

Presentation by Dr. Arthertone Jere and Mr. Gregory Kasanga, WorldFish Zambia

Overview

On December 20, 2022, the FASA project was launched in Zambia. The two-hour ceremony, conducted virtually, was graced by the esteemed presence of Dr. Anna Songolo, the permanent secretary of the Ministry of Fisheries and Livestock. A total of 72 people were invited, resulting in robust participation from 59 stakeholders, including key project partners such as the SLU, Includovate, NRDC, Aller Aqua Zambia Limited and NAGI Enterprise. This gathering served as a pivotal moment, setting the stage for collaborative efforts among these stakeholders to successfully execution the project in Zambia.

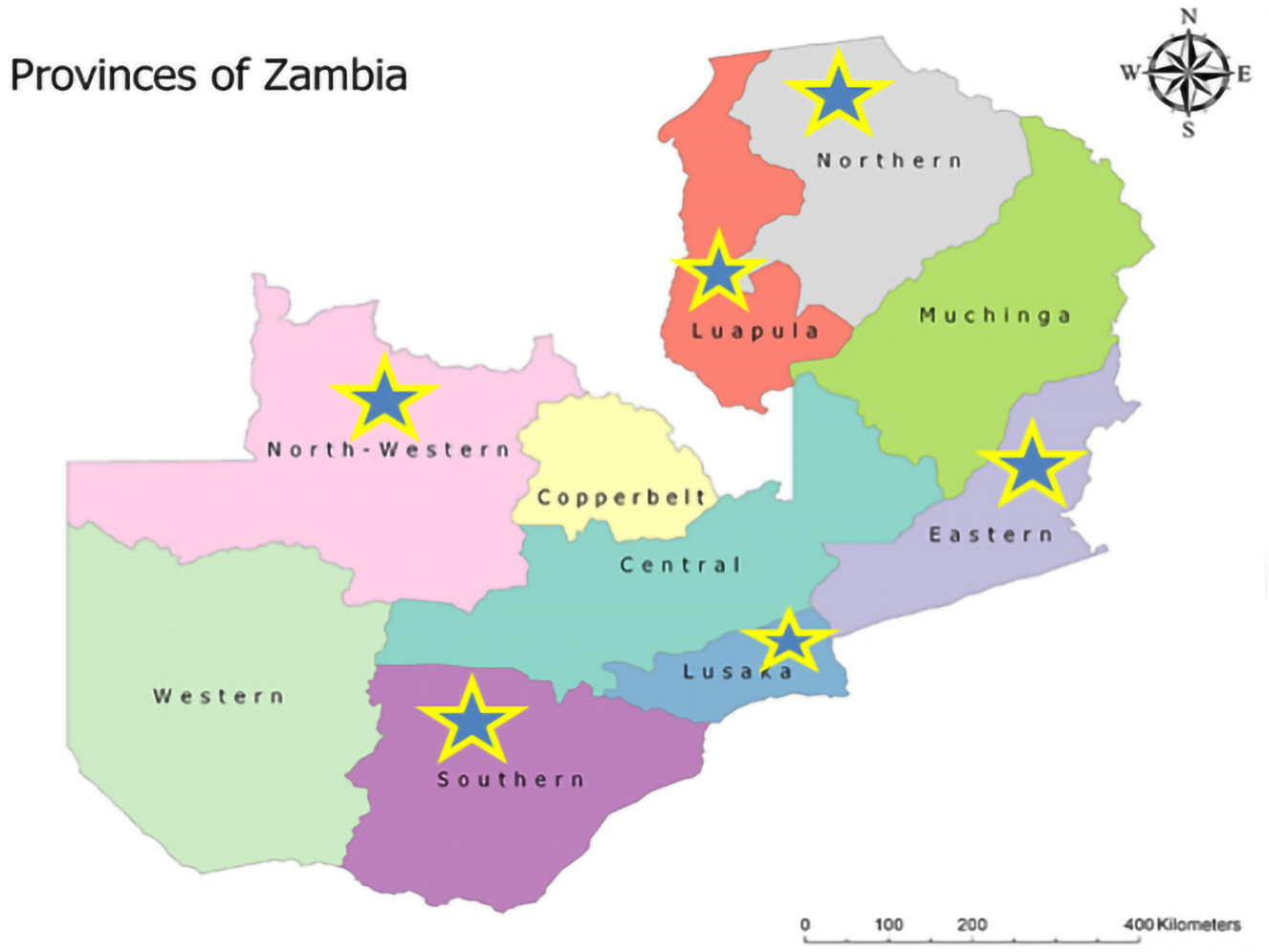


Figure 2. The scoping study sites.

Implementation

Scoping study

The aim of the scoping study was to provide information on the types, costs and availability of fish feed ingredients and to determine how the fish feed value chain affects the country's aquaculture industry. The study was conducted from March to May 2023. Five districts were chosen in each of six provinces—Eastern, North-Western, Southern, Luapula, Northern and Lusaka (Figure 2). For each district, three camps were visited, 15 per province. In total, across all six provinces, 90 camps were visited.

The scoping study identified three broad categories of ingredients: 70.4% were plant-based, 22.2% were animal-derived and 7.4% were from other sources. A variety of local ingredients in Zambia were considered suitable for aquafeed. Agriculture farmers primarily provided plant ingredients (56%), while processors offered by-products like maize bran and soybean cake (23%). Most farmers (85.2%) did not process their ingredients for feed. Animal-based ingredients were mainly used for human consumption (78.6%) rather than for fish feed. In Lusaka and Southern provinces, there was higher demand for commercial fish feed due to proximity to factories. Human consumption of ingredients (87.8%) was higher than for livestock use (12.2%).

To support the aquaculture feed industry, the findings recommended encouraging private sector participation in the production, supply and distribution of key local ingredients. Eleven dry samples, 6 kg each, were sent for proximate analysis and digestibility studies: *Siavonga Kapenta* (*Limnothrissa miodon*), Crayfish, *Kakeya* (assorted small fish), *Vinkubala* caterpillar , *Tukanja* caterpillar , *Chisense* (*Potamothrissa acutirostris*), sunflower cake meal (*Helianthus annuus*), velvet bean meal (*Mucuna pruriens*), velvet bean seed, tea waste (*Camellia sinensis*) and *chikanda* (Disa robusta). Two kilograms of each sample were also sent to the SLU.

Upgrade of NRDC fish laboratory

To conduct experiments on the fish nutrient requirements, the flow-through system at the NRDC laboratory in Lusaka was upgraded to a complete RAS (Plate 3). To do so, vital components had to be purchased and installed.

The components of the RAS setup included a mechanical filter, biological filter, sand filter, sump, aeration units, aquarium tanks, reservoir tanks, water pumps, UV lights and heaters. The work done outside the wet laboratory included securing the area and installing air blowers to ensure an adequate supply oxygen to both the fish tanks and biological filters, as well as installing an electrical switchboard to control the water heaters, air blowers and water pumps.

Plate 3. The new RAS at the NRDC lab in Lusaka.

Nutrient requirement experiment

Among all essential amino acids, lysine is necessary for many bodily functions, especially growth, but it is only found in limited amounts in plant-based ingredients. No previous studies were conducted to estimate the lysine requirement of three-spotted tilapia (*O. andersonii*). However, a study on a comparative estimation of the lysine requirements for the strains of juvenile three-spotted tilapia was conducted at the NRDC. The objective was to estimate the lysine requirement of the SUZ and Genetic improvement program (GIP) strains of *O.andersonii species*. Six diets were produced, consisting of a control diet and five experimental diets with various lysine inclusion levels.

Preliminary results showed that different replacement levels of lysine at 0%, 0.2%, 0.4%, 0.6% and 1.2% in the diet of these strains do not have any effect on growth parameters, except for 0.3%. Samples are still being analyzed at the lab. It is recommended that a similar study be carried out with similar lysine replacement levels on native fish species such as longfin tilapia (*O. machrochir*), Tanganyika tilapia (*O. tanganicae*) and redbreast tilapia (*Coptodon rendalli*).

3.1.4. FASA in Malaysia

Presentation by Dr. Rodrigue Yossa, Dr. Aaqillah Amr and Ms. Nurulhuda, WorldFish Headquarters

Overview

In Malaysia, the scope of project's work was divided into two parts:

1. Aquaculture work: research, extension and impact assessment.
2. Non-aquaculture work: project management, monitoring, evaluating and learning (MEL) and data management, communication, procurement, finance and accounting.

Implementation

Non aquaculture work

MEL plan

FASA published its MEL plan titled, Monitoring, evaluation and learning (MEL) plan: Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Africa (FASA) project 2022–2027. The intent is to continuously update and disseminate information on ongoing projects within the initiative, ensuring transparent communication about data progression and its updates. In addition, the project will streamline and adapt its plan to make it user-friendly, employing clear language, intuitive design and accessible formats to make it easier to understand and use.

Communication plan

FASA will also provide the scope and objectives of the project within its communication plan. This will include FASA's website, with detailed and comprehensive information about the project, such as progress updates, milestones achieved and deliverables. The website will contain transparent and regular reporting of deliverables to inform stakeholders about the project's progress.

Staffing plan

WorldFish has successfully completed its staffing plan for the project (Figure 3). The plan involves recruiting consultants who specialize in climate change from Includovate and in gender inclusion from NAGI Enterprise. At its headquarters in Malaysia, WorldFish also filled key positions such as a postdoctoral fellow, senior research analyst, two research assistants and two interns. Crucial roles at WorldFish Zambia were also filled, including a scientist and research assistant. The recruitment efforts also included enlisting a PhD student from Nigeria, while the process to recruit another PhD student from Zambia is underway.

Aquaculture work

Digestibility experiment

Research protocols and animal ethics

WorldFish Headquarters successfully developed protocols for research and animal ethics part of the first digestibility experiment. The objective of the experiment was to analyze nutritional content and digestibility, assess the growth and biochemical makeup of Genetically Improved Farmed Tilapia (GIFT) when fed sustainable local ingredients, and evaluate fish health. WorldFish Headquarters received 11 samples from Zambia that included animal-based ingredients (*Vinkubala* caterpillar, *Tukanja* caterpillar, *Siavonga Kapenta*, *Kakeya*, *Chisense* and Crayfish) and plant-based ingredients (velvet bean meal, velvet bean seed, tea waste, sunflower cake meal and *Chikanda*).

Feed production for digestibility experiment

The fish feed and nutrition team at WorldFish Headquarters has manufactured six diets of the first digestibility experiment, including a control diet with no test ingredients and five diets with one ingredient each from animal-based ingredients.

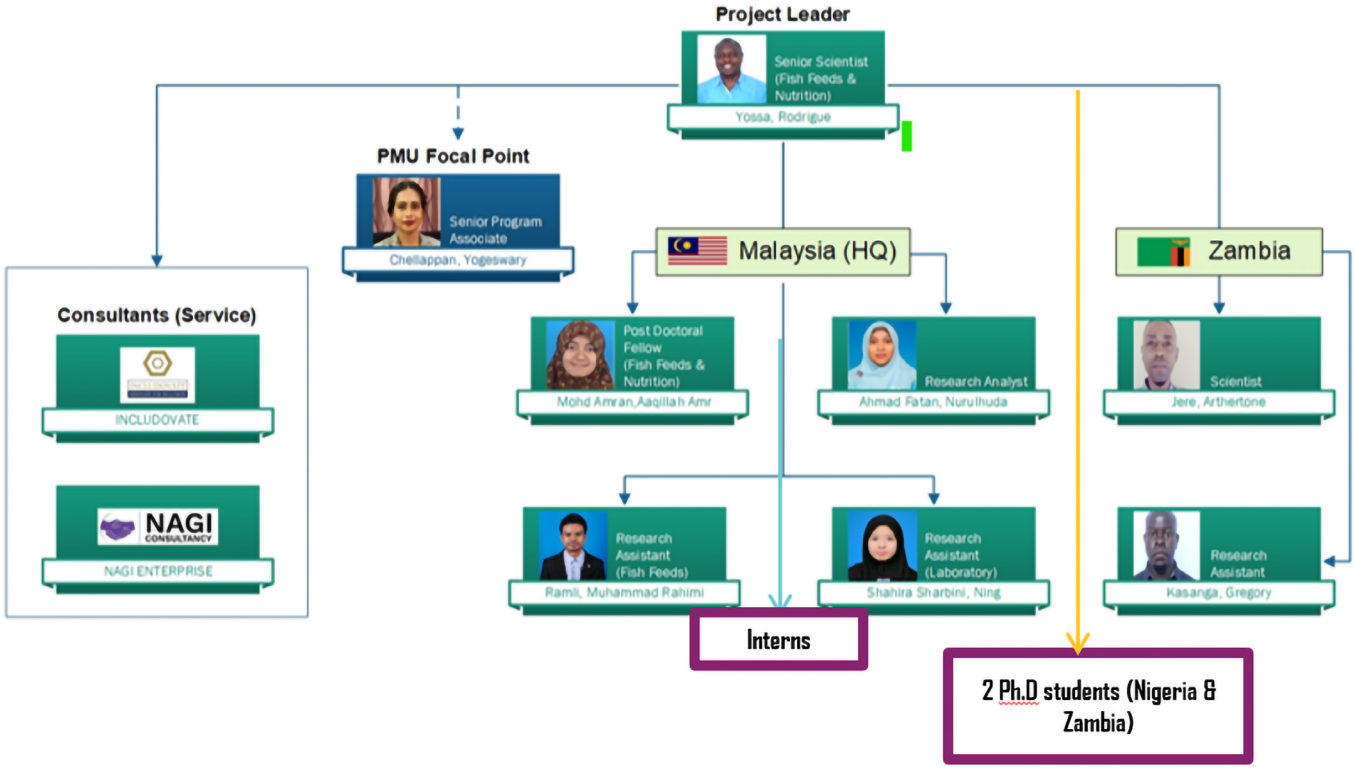


Figure 3. Updated organogram of the WorldFish staffing plan.

Meta-analysis review

The review paper focuses on meta-analyses that examined the effects of substituting fishmeal with insect meal across various fish species. The main goal of the review is to provide a detailed look at recent progress in creating fish feeds with different insect proteins and how they affect three important factors: (1) the apparent digestibility coefficient, (2) fish health as indicated by blood parameters and (3) an economic analysis associated with these alternative feeding practices. The outcomes of the meta-analysis revealed overall positive effects, indicating that including insect meal in fish diets did not display statistically significant adverse effects on fish digestibility, fish health or economic performance.

A cautious approach is recommended toward integrating insect meal into fish diets, one that prioritizes fish health. This entails advocating for a balanced approach. Avoiding excessive fat inclusion is best for partial replacement, while insect meal sourced from the larvae stage is best for total replacement to ensure optimal dietary balance.

Systematic review

The aquaculture industry faces significant challenges from its heavy dependence on imported ingredients. This prompted an exploration of alternative resources. To address these challenges, a focused effort is underway to develop effective strategies aimed at enhancing the nutritional content of alternative ingredients. The objective of the review is to compile current research focal points, nutritional strategies and management practices that collectively aim to tackle these pressing industry challenges.

According to the results of the review, fingerlings and juveniles are the most studied in the literature, but few studies have been done on broodstock. The review identified different methods like processing, enzymes, probiotics, plant extracts and hormones, all of which are frequently used to boost the nutritional value of alternative ingredients.

By prioritizing alternative energy sources and improving their nutritional value, the industry could take a more efficient, ecofriendly and nutritionally balanced approach to freshwater aquaculture. Exploring broodstock nutrition is recommended.

Establishment of fish feed and nutrition laboratory

On May 25, 2023, WorldFish board member Dr. Baba Yusuf Abubakar officially inaugurated WorldFish's fish feed and nutrition laboratory

in Penang, Malaysia. Ms. Ning Shahira Sharbini, with the help of interns under the supervision of Dr. Rodrigue Yossa, is in charge of the lab. The lab will help WorldFish scientists and partners in Penang and across Asia, Africa and the Pacific in the analysing of proximate composition, including analyzing dry matter, ash, crude protein, crude fat, crude fiber and gross energy. The first analysis successfully examined ingredients received from Zambia, while upcoming analyses will cover minerals such as calcium and phosphorus.

Solid-state fermentation experiment

There is an urgent need to identify and develop new sources of aquaculture feed, particularly those rich in nutritious and palatable protein. As such, it is important to repurpose or transform agricultural wastes into functional forms to be used in animal feed as sustainable alternative ingredients.

The overall objective of this study is to investigate the effect of solid-state fermentation on changes in the nutrient profile, particularly protein and fiber, and the reduction of antinutritional factors in agricultural waste. The aim is to optimize the parameters of the solid-state fermentation to produce functional products by the microorganisms on selected agricultural waste.

Solid-state fermentation activities was conducted at WorldFish Headquarters include a collaboration with the School of Technology Industry at USM Penang. The research protocol on solid-state fermentation for using bacteria, yeast and fungi has been completed, and a preliminary experiment on tea waste using lactic acid bacteria has been conducted. Expected outputs include changes in the nutrient composition of fermented tea waste, such as increased protein and reduced antinutritional factors.

3.1.5. Q&A

Q: Dr. Tanga advised using insect larvae and pupae as an alternative feed ingredient.
A: Dr. Aaqillah agreed, as there are many studies using insects in feed analysis. Recent studies suggest that using larvae is more feasible, as the lipid content is not high.

Q: Dr. Tanga questioned the feasibility of using the fermentation method for small-scale farmers and suggested using different types of bacteria and by-products for research into fermentation.
A: Nurulhuda explained that fermentation research is useful to small-scale farmers, as they can apply it using a simple bioreactor and tray. Fermentation can also be done using different types of waste, such as yeast, yogurt and tea.

Q: Dr. Tanga suggested comparing expensive options with new alternatives using different types of waste.
A: Nurulhuda took note of his suggestion.

Q: Dr. Baruah commented that tea waste is an interesting alternative in fermentation and that he has done work on fermentation as well. He suggested more discussion on such research.
A: Dr. Yossa added that for years WorldFish has been finding simple ways of using fermentation to increase the nutritional quality of local feed. As for improving ingredients in the antinutritional perspective, there is no single way to remove all antinutritional factors. Fermentation can reduce a few of them and may improve the protein content of the ingredient.

3.1.6. Climate change work

Presentation by Dr. Mzime Ndebele-Murisa, NAGI Enterprise

Overview

The objective of this activity is to identify opportunities for the project to enhance environmental benefits within the novel feeds landscape across the three project countries using life cycle assessment (LCA) methods. This involves not only identifying opportunities to improve the project's environmental contribution but also entails a comprehensive situational analysis of the climate and environmental factors.

The LCA analysis focuses on three areas:

1. finding weaknesses in the currently available data
2. contributing toward an improved and broadened understanding of the carbon footprint of aquaculture fish feed along value chains, wherever and however greenhouse gas emissions arise
3. identifying potential opportunities such as mitigation pathways within the novel fish feed landscape.

Implementation
Despite challenges during data collection in Nigeria, Kenya and Zambia, FASA was able to achieve a representative sample. The project now has a good sense of the industry and value chain processes, and it has successfully compiled and reviewed research reports and articles.

However, quantitative data was inaccessible, as solicitation was seen as intrusive. Travel to some sites was difficult, which delayed the kick off of activities. It was also difficult for the project to meet daily targets, as farmers were located far from one another.

As far as outputs are concerned, FASA was able to complete a climate and environmental assessment report, an LCA report and an outcomes report, which included three draft journal articles. For Year 2, it is recommended that the project update its climate and environmental analysis, conduct a comprehensive LCA based on modeling and increase capacity building.

3.1.7. Gender and social inclusion work

Presentation by Dr. Sujata Ganguly, Includovate

Overview
The objective of this study was twofold: (1) conduct gender and social assessments for developing sustainable feeds and (2) explore opportunities for advancing gender and social inclusion (GESI) within the emerging feed landscape. The research questions aimed to uncover the gendered and socially different needs, risks and opportunities related to novel feed ingredients. To understand GESI, the project used the ADS 205 framework, focusing on laws, policies, cultural beliefs, gender roles, resource access and decision-making. The study involved 28 key informant interviews and 420 survey responses across three countries, employing a mixed research approach.

Implementation

Gendered policy review of fisheries laws
In the gendered policy review across the fisheries sector in Nigeria, Zambia and Kenya, notable patterns emerge. In Nigeria, policies tend to overlook gender dynamics within fishing communities, favoring technical aspects over addressing the distinct needs of men and women. In Zambia, there are gender-responsive elements, especially in water management policies, but challenges persist in safeguarding women's access and tenure rights. In Kenya, some policies exhibit gender responsiveness, while inconsistencies hinder effective integration.

Across these countries, FASA can capitalize on opportunities to promote gender equality by integrating gender-sensitive approaches, advocating for better representation and adopting transformative strategies in alignment with national policies.

Fish feed ingredients and use
In Nigeria, both genders use maize powder, genetically modified plants (GMPs) and rice bran for fish farming, with slightly lower levels of use among women. Maize powder is popular due to its availability, especially among women, while men also value its affordability and nutrition. Men and women prefer GMPs for their availability and nutrition, and both use rice bran, depending on its availability. Women mostly buy these ingredients, but some process maize powder at home.
In Zambia, chicken manure, feathers and GMPs are all used, more so by women because of their availability. Women often process chicken manure at home and value GMPs for their affordability, mostly from local markets.
In Kenya, men and women use plant leaves and rice bran. Men prefer plant leaves because of their availability and they process them at home, while women prefer rice bran for its nutritional value and buy it from the market.

Gendered and socially differentiated needs and risks
- Gendered needs: Men more so than women strongly agree with the need to improve the quality of fish feed.
- Gendered skills: More men believe they have the skills needed to improve quality, while more women are either uncertain or disagree.
- Gendered resources and assets: Most respondents, regardless of gender, are unsure or disagree about whether they have the necessary resources to improve the quality of fish feed.
- Feed availability: More women are uncertain about the availability of ingredients, while more men disagree about the lack of access to them.

- Innovation: Both genders are open to trying new ingredients, but men show stronger agreement.
- Innovation barriers: Regarding experiments with new ingredients, women more so than men face barriers like lack of funds, input access, knowledge and services.
- Innovation risks/opinions: More women than men agree that trying new fish feeds would likely lead to a loss of money, while more women disagree with this idea.
- Information needs: Both genders express a need for additional information on all ingredients.
- Quality barriers: Women cite barriers such as finance, technology, skills, income and infrastructure for improving the quality of preferred ingredients.
- Information access: Men are more aware than women about how to access information on new ingredients.
- Information barriers: Both genders face obstacles like cost, technology, information location and land availability when accessing information on new ingredients.
- Youth barriers: Similar barriers, such as lack of funds, input access, and knowledge, hinder youths more than adults in experimenting with new feed ingredients.

Laws, policies, regulations and institutional practices

The study highlighted a significant gap in the participants knowledge regarding the formal laws and regulations governing fisheries in all three nations. The household survey identified grassroots organizations working to address barriers that women and youths face, bringing attention to the lack of awareness surrounding these organizations.

Kenya exhibits a higher level of awareness and a greater number of organizations than Nigeria and Zambia. However, the overall pattern reveals the need for improved efforts to inform communities about the existence and initiatives of these organizations.

Gender roles in agricultural and household tasks

- Building and digging ponds: In Nigeria and Kenya, this is mostly done by adult men, though some young men are involved in Zambia.
- Feeding: Men and women both feed fish across all three countries. In Zambia and Kenya, there is no significant age difference in this task between young men and women, while in Nigeria the responsibility is skewed toward adult women.
- Collecting water from the pond: In Nigeria, this is commonly done by adult women and men, though more men are involved and some young men also participate. This practice is less common in Zambia, but adult men take charge whenever it is done. In Kenya, about a third of men are involved, as well as some adult women and young men.
- Day-to-day management: In Nigeria, this responsibility is shared equally between men and women, but in Zambia and Kenya it is mostly done by men.
- Pond cleaning: In all three countries, half as many women as men clean ponds, with some young men involved.
- Unpaid domestic duties: Adult women primarily handle unpaid work across the countries. Some girls help as well as, as do some boys in Nigeria.
- Paid work: Across each country, men predominantly perform paid work. Overall, spouses tend to underestimate the amount of paid work their partner does.
- Fishing and harvesting: Male household members are the ones who mainly carry out these duties. Women are also involved, though to a lesser extent. In Nigeria, a significant percentage of women (62%) report being involved in harvesting.
- Selling fish products: Women mostly do this, with a notable percentage of men in Nigeria and Zambia also involved. Spouses are not accurately aware of each other's involvement in sales.
- Processing: In Nigeria and Zambia, a significant portion of fish farmers do not process fish. When done in Kenya, it is mainly women who do so, with no significant age difference.
- Selling surplus produce at markets: In Nigeria, men and women equally share any surplus sales. Younger women tend to do so more than men in both Zambia and Kenya.
- Food shopping at markets: Women primarily handle this. Men self-report their involvement, but it is not always acknowledged among women.

Time use
Most respondents express satisfaction with the amount of leisure time they have, feeling it is sufficient for personal activities and relaxation. Both male and female respondents of all age groups should have time for any activities related to the project. In Kenya, however, a significant majority of respondents from both genders indicate having only 1 hour of leisure time.

Access to and control over resources and information
Cultural norms impact interactions with extension officers, often necessitating spousal approval to attend training. Key channels include farmer cooperatives, digital platforms like SMS and WhatsApp, local leaders and television.

In Nigeria, women rely on friends and group meetings. In Zambia, women value information from local leaders, and young people use the internet more than adults overall. In Kenya, 50% of young women prefer local leaders for information, compared to 35% of adult women. Conversely, 62% of adult men and 36% of young men rely on local leaders. These age differences were not significant the countries.

Norms and beliefs
In rural fishing communities in all three countries, deeply rooted cultural norms sustain gender disparities, especially regarding women's access to technology and opportunities for them within the fishing industry. The study highlighted prevalent norms, such as women predominantly handling unpaid domestic work, which limits their involvement in paid and physically demanding tasks. Although some communities expressed approval for sharing tasks between genders, significant portions believed their societies would disapprove. Particularly in Kenya, young women exhibited strong disapproval, emphasizing deeply ingrained societal norms. Despite theoretical acceptance of sharing tasks, these beliefs often did not translate into household practices.

Patterns of power and decision-making
The survey shows a preference for sharing decisions in households and communities, stressing the value of collaboration. Gender disparities are more evident in Nigeria but less so in Zambia and Kenya. Young individuals express a desire for more involvement in decision-making, emphasizing the need for initiatives that engage youths.

In Nigeria and Kenya, women seek greater participation in decisions about earnings, highlighting the importance of empowering women economically. Comfort in public speaking varies across the three countries, with notable gender differences, suggesting a need for communication and confidence-building programs. Zambia stands out for higher comfort levels in public speaking. Most respondents stress the importance of consulting spouses when making decisions.

Recommendations
The study consolidated eight gender equality and social inclusion (GESI) recommendations to shape the Gender and Inclusive Development Action Plan (GIDAP):

1. Amend policies, laws and regulations for equal opportunities and rights in fisheries.
2. Support women's groups to diversify fish feeds and enhance their skills.
3. Ensure equal access to resources for women and marginalized groups.
4. Increase the participation of women and disadvantaged groups in decision-making.
5. Provide tailored extension services for women and youths in fish feed innovation.
6. Introduce time-saving technologies and involve men in domestic workloads.
7. Extend support from male-run businesses to reach more women and youths.
8. Establish a monitoring system to assess the action plan's progress and effectiveness.

3.1.8. Organization, team, experience in market assessments and scaling, and the workplan

Virtual presentation by Dr. Murat Sartas, IITA

Overview
IITA brings expertise in innovation, scaling and impact management, all of which contribute to WorldFish strategies for scaling and establishing hubs within FASA. Operating from Norrsken, Africa's largest innovation hub in Rwanda, IITA collaborates with entities like Katapult and Kivu Choice to fulfill its role for the project.

Analyzing and Accelerating Use of Sustainable Feed at Scale
Results and approach
On the lead side, this included market studies, scaling strategies and workshops. Support for the lead included providing intelligence and facilitate innovation platforms, designing and disseminating communication products, building the capacity of the FASA team and partners on scaling, building infrastructure to support co-design as well as co-development of solutions, and integrating FASA into the business ecosystem.

As the team leader, Dr. Sartas is responsible for strategy and enabling, while Bruno Tran measures the readiness of innovative solutions as well as co-deployment, and Pat Udomkun ensures research rigor and field experience. Field researchers and facilitators produce high quality data and maintain continuous engagement, while support experts handle facilitation and communication.

The following list is the timeline for the implementation activities for year 1 and Year 2:

- August 2023: Finalize the contract
- September 2023: Design the team and develop the approach.
- October 2023: Draft the workplan.
- November 2023: Update and finalize the workplan.
- December 2023: Complete the recruitments.
- April 2024: Conduct market research.
- June 2024: Produce scaling strategies.

3.1.9. FASA in Sweden

Presentation by Dr. Kartik Baruah, SLU

Overview
Within the FASA project, the SLU plays an integral role as an academic partner alongside prominent entities such as ICIPE, CORAF, Aller Aqua Limited Zambia, and National Agricultural Research Services agencies in project countries, as well as local feed millers and fish farmers. Its contributions are multifaceted. The SLU focuses on capacity building while actively engaging in research and development endeavors, particularly in overseeing two PhD research projects in Nigeria and Zambia dedicated to sustainable feed. It also contributes to various other pertinent activities within the project.

Implementation
The SLU hired two PhD students for the project. The one from Zambia will carry out experiments on tilapia, while the one from Nigeria will do the same on catfish. PhD advisory members include Dr. Baruah, Dr. Torbjörn Lundhrof, Dr. Mette Sørensen (Norway), Dr. Christos Palaiokostas, Dr. Aleksendar Vidakovic, Dr. Parisa Norouzitallab and Dr. Yossa, as well as partner country members.

As part of the project, Sweden will import 11 ingredients from Zambia: *siavonga kapenta* fishmeal, *kakeya* fishmeal, grinded crayfish meal, *tukanja* caterpillar, *vinkubala* caterpillar, *chisense* fishmeal, sunflower cake meal, velvet bean meal, velvet bean seed, tea waste and *chikanda* powder.

3.1.10. Q&A

Q: Dr. Nieyidouba asked what is the progress is on the shipments of ingredients from Nigeria.

A: Dr. Yossa explained that we have completed the scoping study and have gone through many rounds of selecting and reselecting ingredients for analysis. The ingredients have already been transferred to WorldFish's office in Ibadan, Nigeria, and will be shipped to Sweden and Malaysia soon.
A: Yogi added that the Malaysia team will work closely with Dr. Siriwardena and Dr. Charity on the shipment of ingredients.

Q: Dr. Timothy Manyise congratulated Dr. Baruah on recruiting the two PhD students and hoped that they are adaptable to issues in Africa, not in Sweden.

A: Dr. Baruah explained that the project is well defined and that each student has an individual study plan that the research supervising team has approved. Therefore, the scope of the work is clearly stated. Dr. Rodrigue also added that during their 4 years fellowship the students will spend half of their time in Sweden and the other half in Nigeria. He also explained that the students will work with the ingredients they get from Nigeria. His role as co-supervisor is also to make sure that their work supports the overall scope of the project.

3.1.11. Theories of change and annual outcome monitoring studies

Presentation by Dr. Timothy Manyise, WorldFish Headquarters

Overview

This update focuses on each country's theory of change (TOC) and annual outcome monitoring studies. Emphasizing integration within larger systems, each TOC unveils the interconnectedness of intervention activities. Embracing a systemic view, the MEL team guards against underestimating impacts, and helps anticipate and manage potential negative repercussions. This holistic perspective enables the effective navigation of complexities and maximizes positive intervention outcomes.

Implementation

In the three focal countries, a workshop was organized to explore the impact of innovating fish feeds using new ingredients in each country. The workshops mapped issues with fish feeds, identifying actors involved in the sector, assessing how FASA can create wider impacts and prioritizing areas for impact assessment.

There were 25 to 30 participants in each workshop. Stakeholders involved included feed millers, nongovernmental organizations (NGOs), the Department of Fisheries (DOF), feed ingredient producers, fish farmers, aggregators, processors, farmer associations, women's groups, youths groups and feed manufacturing certification bodies.

In the workshops, maps were synthesized and digitized and then shared with participants for feedback with a textual narrative. A report of the workshops was published titled, Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa: A systems theory of change. The proposal for the peer-review manuscript was accepted and the manuscript was submitted to the Special issue Innovation Inclusivity in Agricultural Systems, for publication

Study 1

This study was conducted 24 local government areas within six states in Nigeria. It involved engaging a substantial cohort of 600 fish farmers and 180 ingredient processors. To collect data, specialized survey tools have been meticulously designed. Additionally, ethical approval for the study has been successfully obtained, and a team of enumerators has been selected and trained for the upcoming survey scheduled to take place from November to December 2023.

Study 2

This study covers 11 districts in six provinces in Zambia. A comparable engagement with 600 fish farmers and 120 ingredient processors is anticipated. The questionnaire design and programming have been implemented using Kobo Toolbox software an online data collection platform. Although the ethical approval process is currently underway, the survey for this study was slated to begin in January 2024.

Recommendations

The study made the following four recommendations:

1. Focus the impact assessment on both the intended and unintended consequences of the intervention.
2. Profile and identify who the project's activities will likely impact, either directly or indirectly.
3. Ensure that different activities, such as training sessions, workshops, information sessions and demonstrations by different partners, are synchronized to ensure effective follow-up evaluations.
4. Provide timely information to ensure that evaluation assessments are done on time.

3.1.12. Perspective of Aller Aqua Zambia Limited

Virtual presentation by Dr. Alexander M. Greiling, Aller Aqua Limited Zambia

Overview

Monthly feed production increased approximately 1000 t over the previous year. Purchases of raw materials, about 80% of which were sourced within Zambia, increased significantly. This increased local value addition for farming, transportation and logistics, job creation and aquaculture.

Implementation

Market trends

More fish feed factories and competitors are entering the East African market and can service Zambia and surrounding countries. This is good for aquaculture production, as competition

will likely reduce prices. Primary production of agricultural crops, such as grains and soy, are stable, including common products and processed crops and by-products. However, there are still insufficient quantities of animal by-products in the country, and quality remains low. East Africa has access to ports and could import these by-products at better rates.

Raw material Scoping study

The scoping study on raw materials provided great geographical coverage and good insight into primary production. It revealed that there are no animal by-products available, only primary animal-derived resources such as fish, crayfish and caterpillars, most of which are in great part directly consumed. As such, there is much room for development in the local industry.

FASA should evaluate untapped and available resources. Abattoirs can evaluate the processing potential of animal by-products, particularly from beef and poultry, while the project itself can explore emerging resources like pea proteins and investigate other innovative processing technologies. FASA should also evaluate the commercial market for raw materials. This would involve taking into consideration farmer cooperatives and assessing small-scale processing and value addition methods, with a focus on maintaining quality control, for commodities such as maize.

3.1.13. Perspective of the Natural Resources Development College

Presentation by Mr. Melon Mulamfu, NRDC

Overview

The NRDC was established in 1964 by the first Republican president Dr. Kenneth David Kaunda. It is among Zambia's seven agricultural colleges operating under the Ministry of Agriculture. The primary focus of the NRDC is to train middle-level human resources for the agriculture and related sectors. The college offers diploma-level training in 10 disciplines and is committed to nurturing skilled professionals in various aspects of agriculture.

The NRDC's wet laboratory was established in 2019 to conduct research projects using a flow-through aquaculture system that was designed and built, by WorldFish. In 2023, FASA upgraded the system to Recirculating Aquaculture System (RAS). To avoid previous challenges, specifically theft, the NRDC also upgraded its security systems for the flab and the entire college.

Two research projects have been implemented in the facility since 2020: (1) Replacing fishmeal with a single cell protein feedstuff in the diet of Nile tilapia (*O. niloticus*) and (2) the performance of Nile tilapia and three-spotted tilapia in controlled laboratory conditions in Zambia.

Expectations and achievements

The NRDC supplied technical support to upgrade the system in the laboratory. Mrs. Majory Chma, a training officer from the Department of Fisheries Science and Aquaculture, was listed the contact person, and the college provided security by installing a lighting system, a security gate at the main entrance, burglar-bars on all the windows of the laboratory as well as hiring a security company. The purpose was to host the feed experiments in the lab.

Benefits

The college upgraded its Fisheries Science curriculum and built the Aquaculture Skills Training Centre. It implemented effective and efficient practical student activities and hosted short, demand-driven courses to boost small-scale fish farming. In addition to installing the RAS, the NRDC also built up the capacity of staff and students involved in research activities and exposed students to research findings through seminars and scientific talks.

3.1.14. Technical and Financial Reporting

Presentation by Mr. Tan Ban Swee and Mr. Tan Chao Yan, WorldFish Headquarters

Finance

FASA uses the Norwegian Kroner (NOK) as its currency, with a grant of NOK 80 million from the Norwegian Agency for Development Cooperation (Norad). However, the project's fund will be received in USD. Any equipment, intellectual property and consumables, like feed or supplies, generated or used during the project are owned either by WorldFish or collaborating partners. FASA must keep accounting records for at least 5 years from the time of Norad's approval of project's final report. There is a zero-tolerance policy against

corruption. Any financial irregularities will be applied to WorldFish and its partners.

The WorldFish's procurement provisisons are:
- Contract must be awarded to the most economically advantageous tender
- Procurement of award with value of less than NOK 500,000 may be awarded following any procurement procedure established by the Grant Recipient.
- Procurement of award with value exceeding NOK 500,000 shall be awarded based on one of the following procurement procedures open tender procedure, restricted procedure or competitive procedure with negotiation

If the grant recipient does not launch an open tender procedure, it shall justify and document in writing the choice of tenderers that are invited to submit an offer.

The spending status of the FASA project is as follows:
- Year 1 (July 1, 2022–June 30, 2023): NOK 6,881,809
- Year 2 (July 1, 2023– September 30, 2024): NOK 1,523,817
- Total cumulative expenditure: NOK 8,405,626

Reporting and auditing schedules
FASA's technical and financial reporting schedule is as follows:
- July 1–December 31, 2022 (submission deadline: April 15, 2023)
- January 1–December 31, 2023 (submission deadline: April 15, 2024)
- January 1– December 31, 2024 (submission deadline: April 15, 2025)
- January 1–December 31, 2025 (submission deadline: April 15, 2026)
- January 1–December 31, 2026 (submission deadline: April 15, 2027).

After the conclusion of the project, the submission deadline for the final reports are October 31, 2027.

FASA's auditing schedule is as follows:
- July 1–December 31, 2022 (submission deadline: June 1, 2023)
- January 1–December 31, 2023 (submission deadline: June 1, 2024)
- January 1–December 31, 2024 (submission deadline: June 1, 2025)
- January 1–December 31, 2025 (submission deadline: June 1, 2026)
- January 1–December 31, 2026 (submission deadline: June 1, 2027).

After the conclusion of the project, the submission deadline for the final report is October 31, 2027.

The SLU and IITA will follow the submission schedule and reporting requirements as stated in the original subgrant agreement (no changes). Both CORAF and the ICIPE will follow the submission schedule and reporting requirements as stated in a new addendum to the subgrant agreement.

CORAF and ICIPE will submit technical reports annually and financial reports quarterly. Deliverables required for submission include technical reports, financial reports, invoices, quarterly forecast workplans and quarterly forecast budgets.

The technical reporting schedule for both CORAF and ICIPE is as follows:
- 2023: January 31, 2024 (remaining submission deadline for the year)
- 2024: January 31, 2025
- 2025: January 31, 2026
- 2026: January 31, 2027.

The financial reporting schedule for both CORAF and ICIPE is as follows:
- 2023: December 31, 2023 (remaining submission deadline for the year)
- 2024: April 30, July 31, October 31, December 31
- 2025: April 30, July 31, October 31, December 31
- 2026: April 30, July 31, October 31, December 31

After the conclusion of the project, the submission deadlines for final technical and financial eports are April 30 and May 15, 2027 respectively.

3.1.15. Q&A

Q: Dr. Nieyidouba asked how the summary of the findings from the workshop would be communicated to all participants and target communities to ensure the information is conveyed to everyone accurately.

A: Dr. Yossa explained that people will not

send different messages to all the stakeholders. WorldFish will package all the information through a communication specialist based in Nigeria. The information will not be communicated separately to ensure that all partners are on the same page.

Q: Dr. Yossa asked Dr. Sartas who are the focal points or contact persons for scaling who are working on the ground there with the partners in Kenya, Zambia and Nigeria.

A: Dr. Sartas explained that the focal points have not been determined yet, as he is currently in the midst of recruiting people for those positions.

Q: Dr. Jere raised a concern regarding the practicality of using *kapenta* and maize, as they are also used for direct human consumption. As such, there will be competition in the availability of ingredients.

A: Dr. Greiling agreed and explained that all ingredients, except for a few by-products, are subject to the food versus feed dilemma. It is possible that raw materials will be limited in the area that kapenta is predominantly fished. In contrast, planting maize exclusively for feed production is most likely more beneficial than using kapenta, which has higher nutritional and monetary value to the local communities.

3.2. Day 2: Planning sessions for 2024 (and tentatively 2025)

The project leader gave a comprehensive overview of the current implementation plan. The country partners presented in-depth workplans for 2024 and tentatively 2025 with tentative budgets (Plate 4). During the presentations, each team presented its workplan and specific outputs/deliverables to achieve. Copies of the PowerPoint presentations for Day 2 are in Appendix 4.

Plate 4. Participants at the workshop in Abuja, Nigeria.

3.2.1. Detailed plan of work: Kenya

Presentation by Dr. Chrysantus Mbi Tanga, ICIPE

The following activities are planned for 2024:
- Recruit 10 MSc students (ongoing).
- Conduct literature reviews.
- Design research protocols.
- Secure animal ethics approval.
- Conduct 12 tilapia experiments.
- Analyze data and samples.
- Organize an online stakeholder workshop in the country.
- Prepare and disseminate reports.
- Discuss the results with internal and external partners, and select 15 ingredients.

The following activities are tentatively planned for 2025:
- Conduct literature reviews (ongoing).
- Design research protocols (ongoing).
- Conduct 12 tilapia experiments (ongoing).
- Analyze data and samples (ongoing).
- Organize two stakeholder workshops in the country.
- Prepare and disseminate reports.
- Develop innovation platforms to bring key scaling stakeholders together.
- Identify and set up demonstration sites and model farms.
- Host farmer field days at demonstration sites and model farms.
- Build partnerships with cooperatives to test and use novel feeds
- Support the establishment of new feed services and business by young people, farmers, etc.
- Help small-scale feed millers develop new products.
- Build partnerships with NGOs, the private sector and extension service providers.

3.2.2. Detailed plan of work: Nigeria

Presentation by Dr. Charity Obetta, Dr. Ibiyo and Dr. Caroline, CORAF

Eight experiments are planned to determine the nutrient requirements (methionine, lysine, vitamin C, calcium and phosphorus) of improved strains of tilapia and African catfish using locally available ingredients in Nigeria.

The activities planned for 2024 are as follows:
- Conduct the feeding experiment to determine the methionine requirement.
- Analyze samples and data.
- Prepare a report for submission and publication.
- Conduct the feeding experiment to determine the lysine requirement.
- Analyze samples and data.
- Prepare a report for submission and publication.
- Hold an annual workshop in Zambia.
- Host a local workshop to share results with farmers and feed millers.

The tentative timeline planned for 2025 is as follows:
- Conduct the feeding experiment to determine the vitamin C requirement.
- The PhD student begins research with associated activities.
- Analyze samples and data.
- Prepare a report for submission and publication.
- Conduct the feeding experiment the determine the calcium and phosphorus requirements.
- Analyze samples and data.
- Organize a local workshop.
- Hold an annual workshop in Kenya.

3.2.3. Detailed plan of work: Zambia

Presentation by Dr. Arthertone Jere and Mr. Gregory Kasanga, WorldFish Zambia

Experiments are planned to determine the nutrient requirements. FASA will hold a stakeholder engagement workshop in the country. It will set up partnership meetings and support its partners and will also host the annual workshop 2024.

The following are the steps involved to conduct the experiments:
- Design the research protocol.
- Secure animal ethics approval.
- Conduct experiments to determine the nutrient requirements for tilapia.
- Analyze data and samples.
- Prepare a research report for publication.

The following is the timeline for the experiments:
- Experiment 1: January–March 2024
- Experiment 2: April–June 2024
- Experiment 3: July–September 2024
- Experiment 4: October–December 2024.

FASA will provide new knowledge on the type, price and seasonality of local ingredients used in fish feeds produced in Zambia and make it available within and outside the focal countries through published reports and results.

3.2.4. Detailed plan of work: Malaysia

Presentation by Ms. Nurulhuda Ahmad Fatan and Dr. Aaqillah Amr, WorldFish Headquarters

The following research activities were planned for 2024

- Three tilapia experiments will be conducted to assess the digestibility of the ingredients obtained from Zambia, Kenya and Nigeria
- Development of fish ingredient database
- Develop publication (technical and research report) from the experiments finding

All findings on the ingredients will be synthesized to enable prioritization, and the results will be discussed with internal and external partners to select 15 ingredients.

In addition to research activities, the project continuously receives support from the project management team which includes the grants and contracts, monitoring evaluation and learning (MEL), data management, impact assessment, communication, procurement, finance, to ensure that the project implementation is on track.

Digestibility experiments

Three experiments will be conducted using the GIFT to assess the digestibility of the ingredients samples collected from Zambia, Nigeria and Kenya. The experiments timeline was planned as following:

- Digestibility experiment with ingredient from Zambia (November – December 2023)
- Digestibility experiment with ingredient from Nigeria (Feb – March 2024)
- Digestibility experiment with ingredient from Kenya (May – July 2024)
- Digestibility experiment with ingredient from Zambia (Sep – Oct 2024)

Other research works in Malaysia

Solid-state fermentation: A tool for improving the nutritional value of novel feed ingredient

Other research works in Malaysia will be conducted to investigate and improve nutritional value of feed ingredient using solid state fermentation (SSF) application. Experiments will be conducted to optimize SSF process for effective fermentation, such as identification of microbes, moisture content, temperature, pH and inoculum concentration. This will be done by Q2. A further experiment by Q3 is to produce nutritious and functional products. Finally the fermented product will be tested as feed ingredient in a feeding trial on tilapia by Q4.

Enhancing reproductive performance using high-quality oil in the broodstock of the GIFT strain of tilapia (Oreochromis niloticus) diet

Another research to be conducted is to enhance reproductive performance using high quality oil in the diet for GIFT broodstock. The objective is to evaluate growth performance and gonad maturation at the early stage of development of juvenile tilapia and to assess fecundity and sperm quality during the breeding stage. GIFT tilapia weighing approximately 20 g will be used in the experiment. Different type of oil, fish oil and squid oil from Malaysia, insect oil produced from BSFL raised on potato waste from Kenya, sunflower oil from Zambia, and groundnut oil and palm oil from Nigeria will be tested and used as ingredient. There will be two feeding trials: one on gonadal maturation and the other on reproductive performance.

3.2.5. Detailed plan of work: Sweden

Presentation by Dr. Kartik Baruah, SLU

Two PhD students will conduct research and development on sustainable feeds for farmed fish. The student from Zambia will work on tilapia and the one from Nigeria on African catfish. The objective is to find a novel (functional) feed that will improve fish growth performance, health and robustness as well as cost effective and has a low ecological footprint.

In addition, a comparative study will be conducted to investigate the functional responses of both wild and genetically improved strains of tilapia in response to feeding them novel feed.

The following additional activities are planned for 2024 and 2025:

- Conduct experiments to prioritize key ingredients by analyzing the biochemical parameters of ingredients.
- Develop and use processing techniques to improve the quality of key ingredients.
- Check the quality of improved ingredients, formulation and production on fish feeds for lab trials in Sweden.
- Conduct a validation study on farms in Nigeria and Zambia.

3.2.6. Training on proper financial reporting

Presentation by Mr. Tan Ban Swee and Mr. Tan Chao Yan, WorldFish Headquarters

With the exception of the first advance fund transfer to the partner, subsequent advances are subject to the following conditions:

- WorldFish must receive and accept technical and financial reports that are due in accordance with the submission schedule as stated in the subgrant agreement.
- Submit a quarterly forecast workplan and budget that are consistent with the implementation plan.
- Submit WorldFish-approved invoices for the relevant quarter.
- Provide sufficient supporting evidence to support spending.
- Upon request from WorldFish, the partner must support and revert the corresponding year-end balance confirmation.
- Final payment to partners will be cost-reimbursement and will be released only upon acceptance and approval of all deliverables and final technical and financial reports from partners.

With the exception of the first advance fund transfer to the partner, subsequent cost reimbursements are subject to following conditions:

- WorldFish must receive and accept technical and financial reports that are due in accordance with the submission schedule as stated in the subgrant agreement.
- Prior to receiving payment, partners must complete contractual deliverables and incurred expenses that exceed the first advance payment, subject to WorldFish approval.
- Submit WorldFish-approved invoices for payment.
- Provide sufficient supporting evidence to support spending.
- Upon request from WorldFish, the partner must support and revert the corresponding year-end balance confirmation.

Partners must ensure the following areas of improvement:

- Budgets must comply with subgrant agreement categories.
- The reporting period stated in the financial report must be accurate.
- Expenditures must be consistent with those reported in previous periods.
- Expenditures stated in the financial report must align with the fund status report and transaction listing.
- Complete the fund status report.
- Complete and ensure the accuracy of information reported in the transaction listing.

3.2.7. Q&A

Q: Dr. Baruah suggested acquiring species in earlier stages of experiment to prevent delays for required broodstock.

A: Kasanga agreed, as it is a challenge to acquire broodstock.

Q: Dr. Ndebele-Murisa asked is there any duplication on the digestibility experiment between the SLU with WorldFish.

A: Dr. Baruah explained that WorldFish Headquarters is primarily conducting the experiment, but it is happy to assist from Sweden.

A: Dr. Yossa added that the SLU may conduct digestibility experiments on ingredients that the organization will process and improve itself.

4. Field visits in Nigeria

4.1. TIDDO Fish Farms Limited

On November 6, 2023, the workshop participants visited feed producers at TIDDO Fish Farms in Abuja (Plate 5). This local feed mill produces feed for catfish at different life stages, both for farms and for sale. About 85% of the raw ingredients used to formulate and manufacture the feed are sourced locally (Plate 6). The feed mill is well equipped with all required equipment to produce complete feeds, including a hammer mill, grinder, mixer, extruder, oil sprayer, feed dryers and packaging machine, most of which were purchased from China. The finished products, which include various pellet sizes (2, 3, 4, 6 and 8 mm), are packaged onsite. The farm also has a laboratory, which it uses to analyze the proximate composition of feed. Challenges that the company faces include a shortage of replacement parts, inconsistent feed prices because of seasonal variation and an increase in feed costs.

Plate 5. Field visit to TIDDO Fish Farms.

Plate 6. Fish feed equipment at TIDDO Fish Farms.

Plate 7. Fish feed produced at TIDDO Fish Farms

4.2. Flourishing Centre Fish and Agro Farms

On November 6, 2023, participants also visited the Flourishing Centre Fish and Agro Farms in Abuja. This farm has 30 concrete ponds and is owned by Mr. Onoja Sunday Musa, president of the Catfish Farmers Association of Nigeria (CAFAN). The farm produces its own fish feed and sells excess feed. It has five extruders onsite that can produce approximately 1000kg of fish feed daily. Mr. Sunday also recommended using fresh azolla and duckweed as supplementary feed in addition to manufactured feed. The farm produces over 300,000 fingerlings of catfish per year. It also has other species, including pangasius, African arowana, tilapia and common carp. In addition, the farm offers training opportunities in fish farming to youths. One of the challenges that the farm faces is the high cost of repairing machinery.

Plate 8. Owner and CEO of Flourishing Centre Fish and Agro Farms, Mr. Sunday, briefs visitors

Plate 9. Fish feed extruder at Flourishing Centre Fish and Agro Farms.

Plate 10. Azolla used as fish feed at Flourishing Centre Fish and Agro Farms

4.3. Nigerian Institute for Oceanography and Marine Research

On November 9, 2023, the workshop participants visited the NIOMR in Lagos. Professor Abiodun Sule, executive director, welcomed the participants and introduced the company's mandate and the range of research and innovation activities taking place. The NIOMR provides research in fisheries and aquaculture across the value chain. It has several departments and provides training to people who are involved in oceanographic research and product development. Some of the notable sections under the institute include aquaculture, fish technology, extension services, marine geography, fishing technology and safety, marine culture, biotechnology, analytical laboratory, and fisheries resources assessment. The NIOMR is also equipped with a wet lab in its fish technology building, which can be used to run nutrient requirement experiments.

Plate 11. The NIOMR's main office in Lagos

Plate 12. The NIOMR's central analytical laboratory

Plate 13. The company's RAS used for fish nutrition experiments

Plate 14. The NIOMR's fish technology section and products

Plate 15. Fishing gear and machinery developed by the NIOMR

5. Outcomes

The main outcome of the workshop was the revised implementation plan for the year 2024 and tentatively for 2025. The timeframe and specific outputs for each activity were specified. The revised plan was agreed upon and the project's partners will implement it. The amended plan will be used to carry out the project on the ground in 2024 and 2025

6. Next steps and conclusions

Each partner will implement the 2024 and, tentatively, 2025 project activities in Kenya, Nigeria, Zambia, Sweden and Malaysia, as per the revised implementation plan and the approved annual workplan. Partners have agreed to hold the project's next annual workshop in Zambia in 2024 .

Appendix 1. List of workshop participants

Partner/Consultant/Stakeholder			
No	**Organization**	**Participant**	**Attendance**
1	ARCN, CORAF	Charity Obetta	Yes
2	NIFFR, CORAF	Lenient Mercy Onivie Ibiyo	Yes
3	NIOMR, CORAF	Caroline Iretioluwa Ayo-Olalusi	Yes
4	CORAF	Lamien Niéyidouba	Yes
5	NRDC	Melon Mulamfu	Yes
6	SLU	Sri Kartik Baruah	Yes
7	ICIPE	Chrysantus Mbi Tanga	Yes
8	Includovate	Sujata Ganguly	Yes
9	NAGI Enterprise	Mzime Regina Murisa	No (Late arrival)
10	DOF, ARCN	Femi John Akinniyi	Yes
11	WorldFish, SLU	Arnold Ebuka Irabor	No (Late arrival)
12	WorldFish	Rodrigue Yossa	Yes
13	WorldFish	Arthertone Jere	Yes
14	WorldFish	Gregory Mulenga Kasanga	Yes
15	WorldFish	Aaqillah Amr Binti Mohd Amran	Yes
16	WorldFish Laboratory	Ning Shahira Binti Sharbini	Yes
17	WorldFish	Nurulhuda Ahmad Fatan	Yes
18	WorldFish	Tan Ban Swee	Yes
19	WorldFish	Tan Chao Yan	Yes
20	WorldFish	Sunil Siriwardena	No
21	WorldFish	Yogeswary Chellappan	Yes
22	WorldFish	Timothy Manyise	No (Late arrival)

Table 1. List of participants on Day 1 (November 6, 2023).

Partner/Consultant/Stakeholder			
No	**Organization**	**Participant**	**Attendance**
1	ARCN, CORAF	Charity Obetta	Yes
2	NIFFR, CORAF	Lenient Mercy Onivie Ibiyo	Yes
3	NIOMR, CORAF	Caroline Iretioluwa Ayo-Olalusi	Yes
4	CORAF	Lamien Niéyidouba	Yes
5	NRDC	Melon Mulamfu	Yes
6	SLU	Sri Kartik Baruah	Yes
7	ICIPE	Chrysantus Mbi Tanga	Yes
8	Includovate	Sujata Ganguly	Yes
9	NAGI Enterprise	Mzime Regina Murisa	Yes
10	NAGI Enterprise	Angela Samundengo	Virtual
11	IITA	Murat Sartas	Virtual
12	Aller Aqua Zambia Limited	Alexander Michael Greiling	Virtual
13	ARCN	Garba Hamidu Sharubutu	Absent with reason
14	NIOMR	Sule Abiodu	Absent with reason
15	DOF, ARCN	Zakari Adamu Isah	Yes
16	DOF, ARCN	Femi John Akinniyi	Yes
17	Embassy of Norway	Svein Baera	Yes
18	Embassy of Norway	Eivind Fjeldstad	Yes
19	DOF, ARCN	Musa Musa	Yes
20	WorldFish, SLU	Arnold Ebuka Irabor	Yes
21	WorldFish	Rodrigue Yossa	Yes
22	WorldFish	Arthertone Jere	Yes
23	WorldFish	Gregory Mulenga Kasanga	Yes
24	WorldFish	Aaqillah Amr Binti Mohd Amran	Yes
25	WorldFish Laboratory	Ning Shahira Binti Sharbini	Yes
26	WorldFish	Nurulhuda Ahmad Fatan	Yes
27	WorldFish	Tan Ban Swee	Yes
28	WorldFish	Tan Chao Yan	Yes
29	WorldFish	Sunil Siriwardena	Yes
30	WorldFish	Yogeswary Chellappan	Yes
31	WorldFish	Timothy Manyise	Yes
32	WorldFish	Victor Siamudaala	No

Table 2. List of participants on Day 2 (November 7, 2023).

Partner/Consultant/Stakeholder			
No	**Organization**	**Participant**	**Attendance**
1	ARCN, CORAF	Charity Obetta	Yes
2	NIFFR, CORAF	Lenient Mercy Onivie Ibiyo	Yes
3	NIOMR, CORAF	Caroline Iretioluwa Ayo-Olalusi	Yes
4	CORAF	Lamien Niéyidouba	Yes
5	NRDC	Melon Mulamfu	Yes
6	SLU	Sri Kartik Baruah	Yes
7	ICIPE	Chrysantus Mbi Tanga	Yes
8	Includovate	Sujata Ganguly	Yes
9	NAGI Enterprise	Mzime Regina Murisa	Yes
10	NAGI Enterprise	Angela Samundengo	Virtual
11	IITA	Murat Sartas	Virtual
12	Aller Aqua Zambia Limited	Alexander Michael Greiling	Virtual
13	ARCN	Garba Hamidu Sharubutu	Absent with reason
14	NIOMR	Sule Abiodu	Absent with reason
15	DOF, ARCN	Zakari Adamu Isah	Yes
16	DOF, ARCN	Femi John Akinniyi	Yes
17	DOF, ARCN	Musa Musa	Yes
18	WorldFish, SLU	Arnold Ebuka Irabor	Yes
19	WorldFish	Rodrigue Yossa	Yes
20	WorldFish	Arthertone Jere	Yes
21	WorldFish	Gregory Mulenga Kasanga	Yes
22	WorldFish	Aaqillah Amr Binti Mohd Amran	Yes
23	WorldFish Laboratory	Ning Shahira Binti Sharbini	Yes
24	WorldFish	Nurulhuda Ahmad Fatan	Yes
25	WorldFish	Tan Ban Swee	Yes
26	WorldFish	Tan Chao Yan	Yes
27	WorldFish	Sunil Siriwardena	Yes
28	WorldFish	Yogeswary Chellappan	Yes
29	WorldFish	Timothy Manyise	Yes
30	WorldFish	Victor Siamudaala	No

Table 3. List of participants on Day 3 (November 8, 2023).

Partner/Consultant/Stakeholder			
No	**Organization**	**Participant**	**Attendance**
1	ARCN, CORAF	Charity Obetta	Yes
2	NIFFR, CORAF	Lenient Mercy Onivie Ibiyo	Yes
3	NIOMR, CORAF	Caroline Iretioluwa Ayo-Olalusi	Yes (Host)
4	CORAF	Lamien Niéyidouba	Yes
5	NRDC	Melon Mulamfu	Yes
6	SLU	Sri Kartik Baruah	Yes
7	ICIPE	Chrysantus Mbi Tanga	Yes
8	Includovate	Sujata Ganguly	Yes
9	NAGI Enterprise	Mzime Regina Murisa	Yes
10	WorldFish, SLU	Arnold Ebuka Irabor	Yes
11	NIOMR	Sule Abiodu	Yes (Host)
12	WorldFish	Rodrigue Yossa	Yes
13	WorldFish	Arthertone Jere	Yes
14	WorldFish	Gregory Mulenga Kasanga	Yes
15	WorldFish	Aaqillah Amr Binti Mohd Amran	Yes
16	WorldFish Laboratory	Ning Shahira Binti Sharbini	Yes
17	WorldFish	Nurulhuda Ahmad Fatan	Yes
18	WorldFish	Tan Ban Swee	Yes
19	WorldFish	Tan Chao Yan	Yes
20	WorldFish	Sunil Siriwardena	Absent with reason
21	WorldFish	Yogeswary Chellappan	Yes
22	WorldFish	Timothy Manyise	Yes

Table 4. List of participants on Day 4 (November 9, 2023).

Appendix 2. Workshop agendas

08:30–08:45	Registration, meet & greet	
Opening		
09:00–09:05	Welcome speech	Sule Abiodu, executive director, NIOMR
09:05–09:15	Welcome speech (virtual)	Essam Mohammed, director general, WorldFish
09:15–09:20	Welcome speech	Lamien Nieyidouba, CORAF
09:20–09:25	Welcome speech	Sunil Siriwardena, WorldFish Nigeria
09:25–09:35	Opening speech	H.E. Svein Baera, Norwegian Ambassador to Nigeria, Embassy of Norway
09:35–09:40	Introduction and scope of the meeting	Rodrigue Yossa
Session 1		
09:45–10:15	Year 1 implementation update for Nigeria	Charity Obetta, CORAF
10:15–10:45	Year 1 implementation update for Kenya	Chrysantus Mbi Tanga, ICIPE
10:45–11:00	Coffee break	
11:00–11:30	Year 1 implementation update for Zambia	Arthertone Jere, WorldFish Zambia
11:30–12:00	Year 1 implementation update for Malaysia	Rodrigue Yossa, Aaqillah Amr and Nurulhuda A. Fatan, WorldFish
12:00–12:30	Discussion, Q&A	All participants
12:30–13:30	Lunch	
Session 2		
13:30–14:00	Year 1 implementation update for the climate change section	Mzime Regina Murisa, NAGI Enterprise
14:00–14:30	Year 1 implementation update for the gender and social inclusion study section	Sujata Ganguly, Includovate
14:30–14:45	Introduction on organization and team, experience in market assessments and scaling, workplan (virtual)	Murat Sartas, IITA
14:45–15:00	Year 1 implementation update for Sweden	Sri Kartik Baruah, SLU
15:00–15:30	Discussion, Q&A	All participants
15:30–15:45	Coffee break	
Session 3		
15:45–16:15	Update on country TOC and annual outcome monitoring studies	Timothy Manyise, WorldFish Headquarters
16:15–16:30	Perspectives of Aller Aqua Zambia Limited on Year 1 implementation (Virtual)	Alexander Michael Greiling, Aller Aqua Zambia Limited
16:30–16:45	Perspectives of the NRDC on Year 1 implementation	Melon Mulamfu, NRDC
16:45–17:00	Update on project finances	Tan Chao Yan and Tan Ban Swee, WorldFish
17:00–17:15	Technical and financial reporting	Rodrigue Yossa and Tan Chao Yan, WorrldFish
17:15–17:45	Discussion, Q&A	All participants
End of open session		

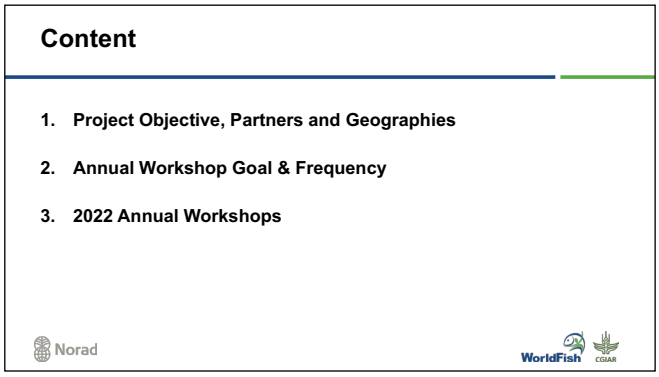
Table 5. Day 2 agenda (November 7, 2023).

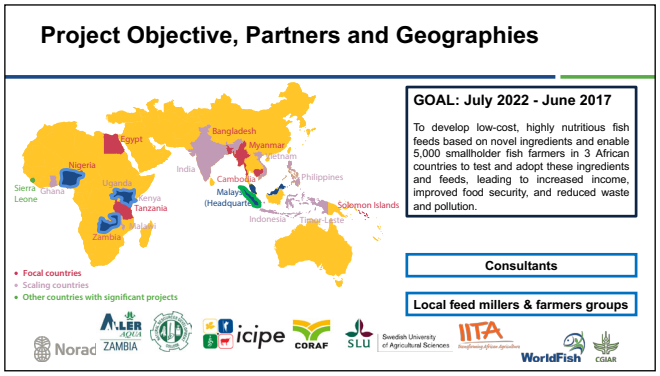
08:30–08:45	Meet and greet	
09:00–09:05	Introduction and scope of the meeting	Rodrigue Yossa, project leader, WorldFish
Session 1		
09:05–10:05	Detailed plan of work in Kenya	Chrysantus Mbi Tanga, ICIPE
10:05–11:05	Detailed plan of work in Nigeria	Charity Obetta, CORAF
11:05–11:30	Coffee break	
11:30–12:30	Detailed plan of work in Zambia	Arthertone Jere, WorldFish Zambia
12:30–13:30	Lunch	
Session 2		
13:30–14:15	Detailed plan of work in Malaysia	Rodrigue Yossa, Aaqillah Amr Mohd Amran and Nurulhuda A. Fatan, WorldFish
14:00–14:30	Detailed planning of work in Sweden	Sri Kartik Baruah, SLU
14:30–15:00	Discussion, Q&A	All participants
15:00–15:15	Coffee break	
Session 3		
15:15–15:45	Training on proper financial reporting	Tan Chao Yan and Tan Ban Swee
15:45–16:15	Updated implementation plan	Rodrigue Yossa, WorldFish
16:15–16:45	Discussion, Q&A	All participants
16:45–16:55	Closing remarks	Rodrigue Yossa, WorldFish
End of open session		

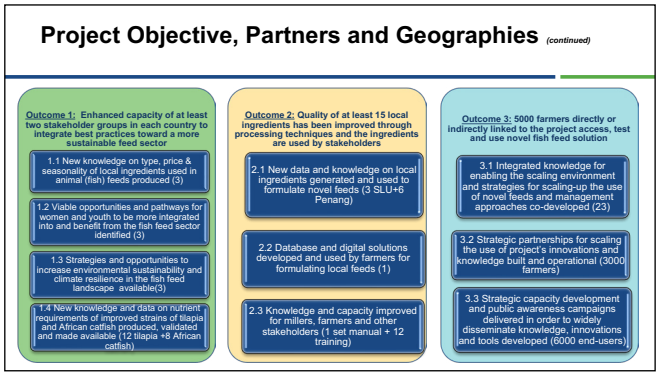
Table 6. Day 3 agenda (November 8, 2023).

Appendix 3. Slides presentations for Day 1

Introduction and scope of the meeting WorldFish (Dr. Rodrigue Yossa)







Introduction of the team members and update on the implementation of year 1 of the FASA project in Nigeria CORAF (Dr. Charity Obetta)

Introduction

- Nigeria is the largest aquaculture producer in SSA but with a big challenge of supplying quality and affordable nurtrent to farmed fish.
- The expansion of smallholder aquaculture production is limited due to the scarcity, unsustainability, and high environmental and economic costs of fish feeds.
- Through the FASA project, we hope to have an inclusive, equitable and sustainable aquatic food system in Nigeria.

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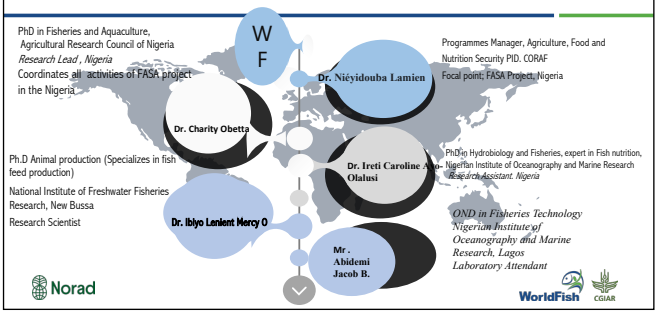
Introduction of CORAF Team Members



Project key facts

Scoping studies on the type, price and seasonality of local ingredients used in fish feeds in Nigeria.

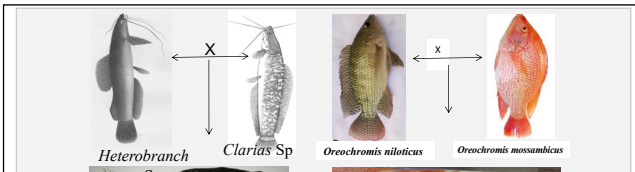


Plate 1: Hybrid Catfish strain (Cross of *Heterobranchus* sp & *Clarias* Sp)

Plate 2: Hybrid Tilapia strain (Cross of Nile Tilapia and Red Tilapia)

Nutrients requirement of improved strain of African catfish (Hybrid of *Heterobranchus Spp. X Clarias gariepinus) and* Hybrid Tilapia *(Oreochromis niloticus X Oreochromis mossambicus) with both* compared with their locals in Nigeria

Project goals

- Scoping studies:
  - to conduct an in-depth literature review on available fish feed ingredients in Nigeria
  - to assess, document and publish information on local ingredients that could be used sustainably in fish feeds in order to fill up data gap on available local ingredients for fish feed in Nigeria.

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Project componets

- Literature review
- Meetings with stakeholders
- Study design
- Approval of research protocol
- Human ethics approval
- Selection and training of enurmerators
- Data collection
- Ingredient collection
- Packaging of samples and sending to WF and SLU
- Data analyses, report writing and publication

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Study Area

- 46 locations
- 20 respondents
- Five (5) respondents
- Total 920

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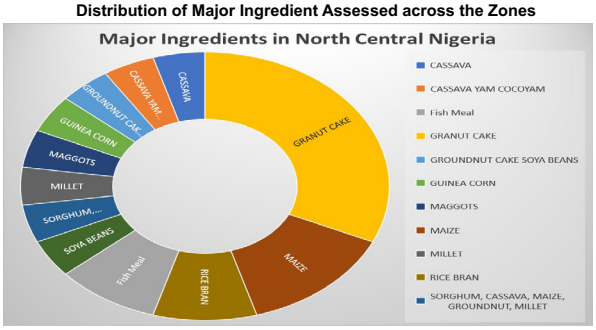
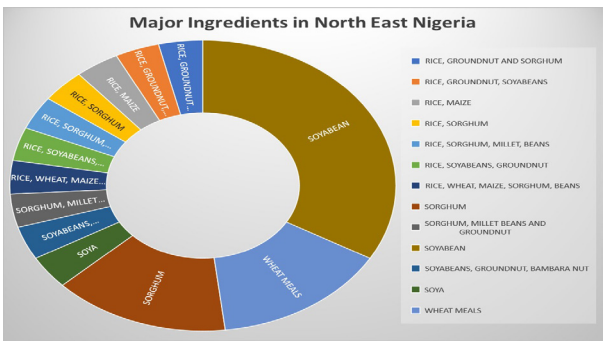
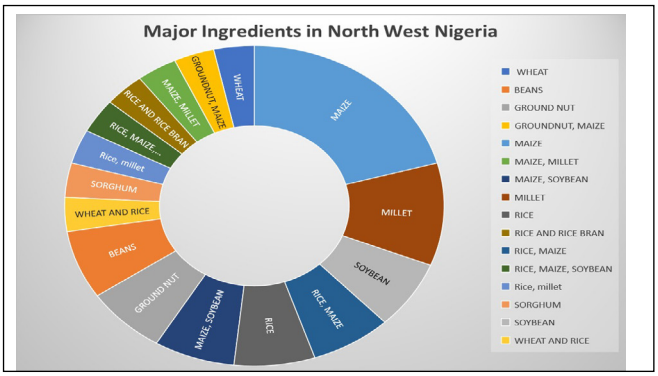
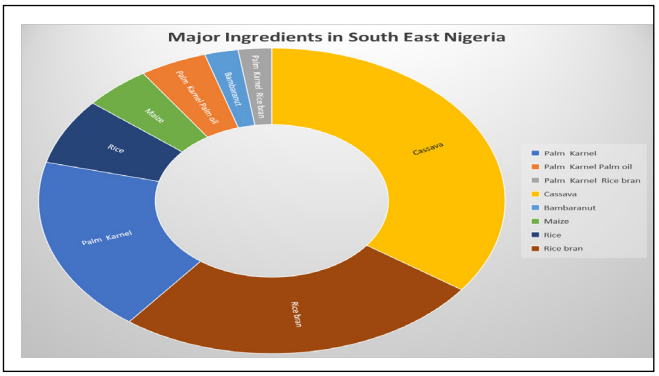
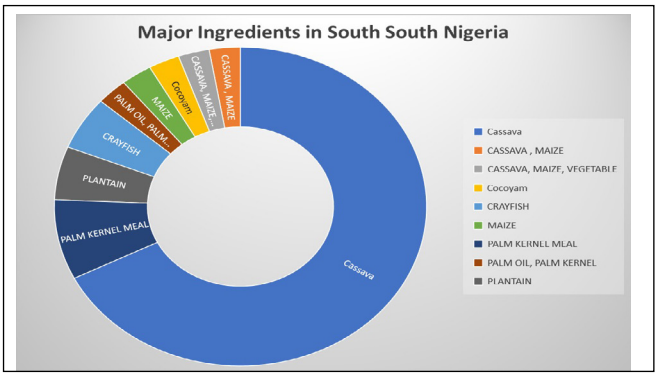
Distribution of Major Ingredient Assessed across the Zones

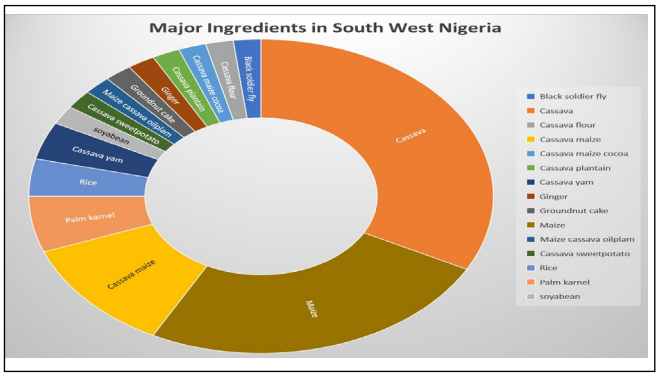


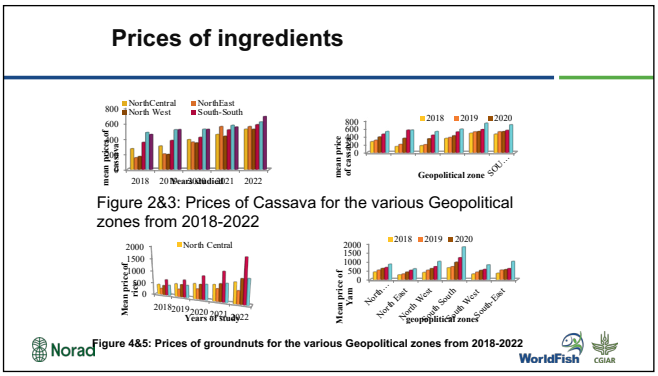


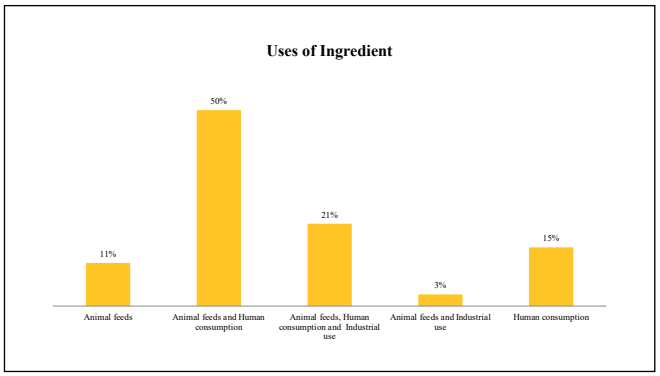

Major Ingredients in North West Nigeria
MAIZE
MILLET
SOYBEAN
RICE, MAIZE
RICE
MAIZE, SOYBEAN
GROUND NUT
BEANS
WHEAT AND RICE
SORGHUM
Rice, millet
RICE, MAIZE...
RICE AND RICE BRAN
MAIZE, MILLET
GROUNDNUT, MAIZE
WHEAT
WHEAT
BEANS
GROUND NUT
GROUNDNUT, MAIZE
MAIZE
MAIZE, MILLET
MAIZE, SOYBEAN
MILLET
RICE
RICE AND RICE BRAN
RICE, MAIZE
RICE, MAIZE, SOYBEAN
Rice, millet
SORGHUM
SOYBEAN
WHEAT AND RICE

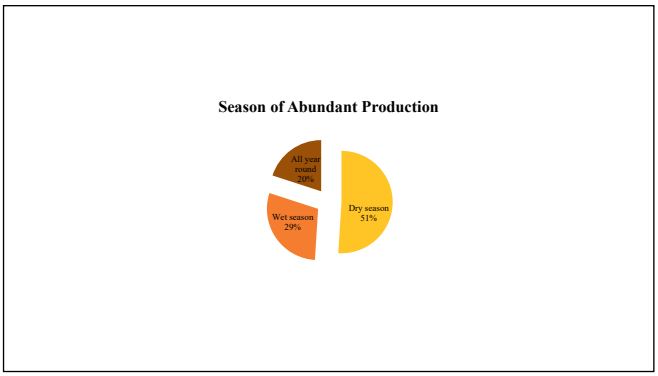

Major Ingredients in South East Nigeria
Cassava
Rice bran
Palm Karnel
Rice
Maize
Palm Karnel Palm oil
Bambaranut
Palm Karnel Rice bran
Palm Karnel
Palm Karnel Palm oil
Palm Karnel Rice bran
Cassava
Bambaranut
Maize
Rice
Rice bran

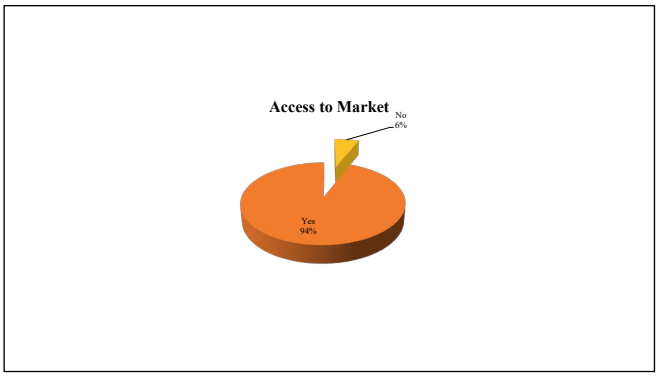

Major Ingredients in South South Nigeria
Cassava
PALM KERNEL MEAL
PLANTAIN
CRAYFISH
PALM OIL, PALM...
MAIZE
Cocoyam
CASSAVA, MAIZE...
CASSAVA, MAIZE
Cassava
CASSAVA , MAIZE
CASSAVA, MAIZE, VEGETABLE
Cocoyam
CRAYFISH
MAIZE
PALM KERNEL MEAL
PALM OIL, PALM KERNEL
PLANTAIN

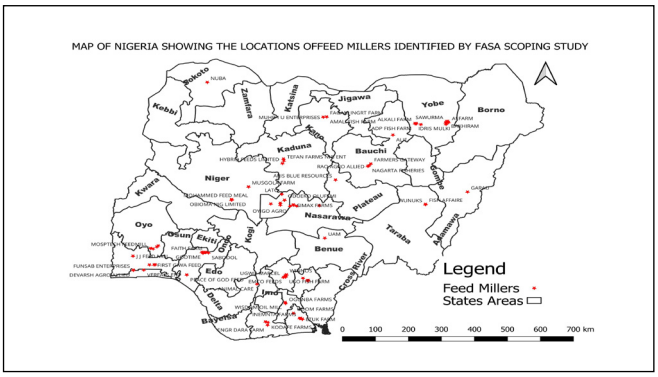

Major Ingredients in South West Nigeria
Cassava
Maize
Cassava maize
Palm karnel
Cassava yam
Rice
soyabean
Cassava sweetpotato
Maize cassava oilplam
Groundnut cake
Ginger
Cassava plantain
Cassava maize cocoa
Cassava flour
Cassava malze
Black soldier fly
Black soldier fly
Cassava flour
Cassava malze
Cassava maize cocoa
Cassava plantain
Cassava yam
Ginger
Groundnut cake
Maize
Maize cassava oilplam
Cassava sweetpotato
Rice
Palm karnel
soyabean

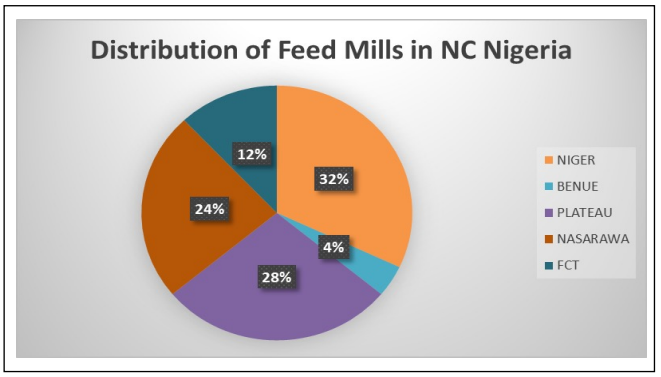

Prices of ingredients
NorthCentral
NorthEast
North West
South-South
mean price of cassava
2018
2019
2020
Geopolitical zone
Figure 2&3: Prices of Cassava for the various Geopolitical zones from 2018-2022
North Central
Mean price of Yam
Years of Study
Figure 4&5: Prices of groundnuts for the various Geopolitical zones from 2018-2022
Norad
WorldFish
CGIAR

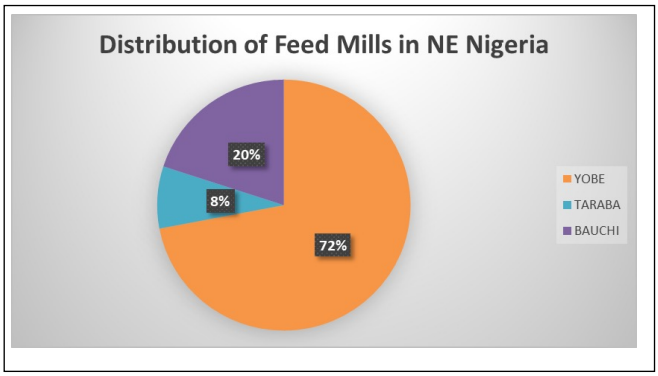

Uses of Ingredient
11%
50%
21%
3%
15%
Animal feeds
Animal feeds and Human consumption
Animal feeds, Human consumption and Industrial use
Animal feeds and Industrial use
Human consumption

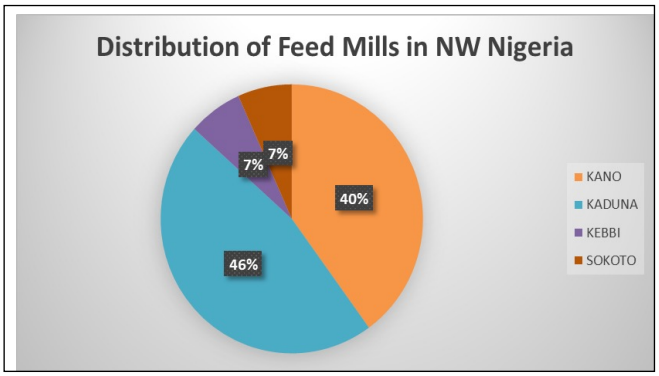

Season of Abundant Production
All year round 20%
Dry season 51%
Wet season 29%

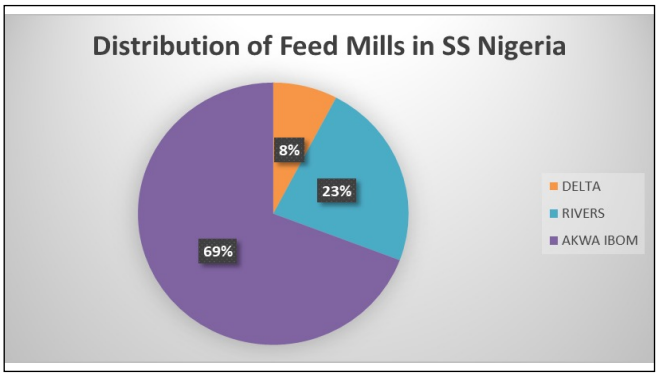

Access to Market
No 6%
Yes 94%

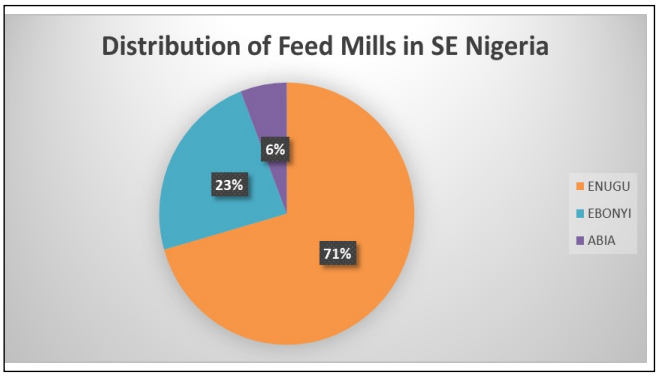

MAP OF NIGERIA SHOWING THE LOCATIONS OFFEED MILLERS IDENTIFIED BY FASA SCOPING STUDY
Legend
Feed Millers
States Areas
0 100 200 300 400 500 600 700 km

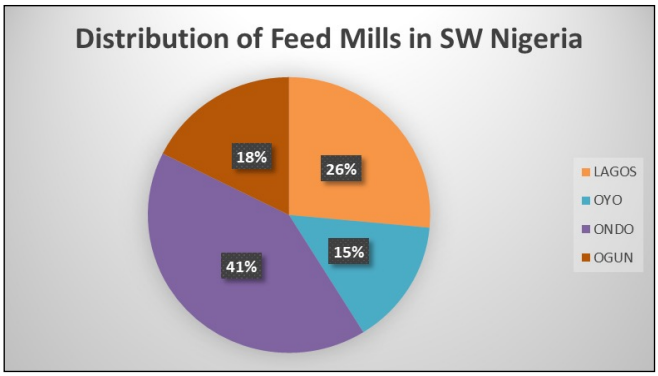

Distribution of Feed Mills in NC Nigeria
12%
32%
24%
4%
28%
NIGER
BENUE
PLATEAU
NASARAWA
FCT











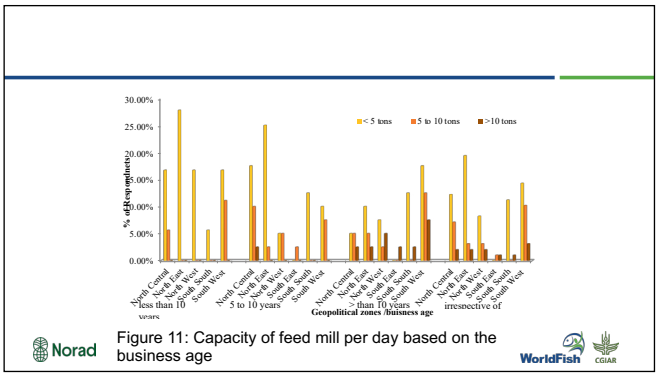
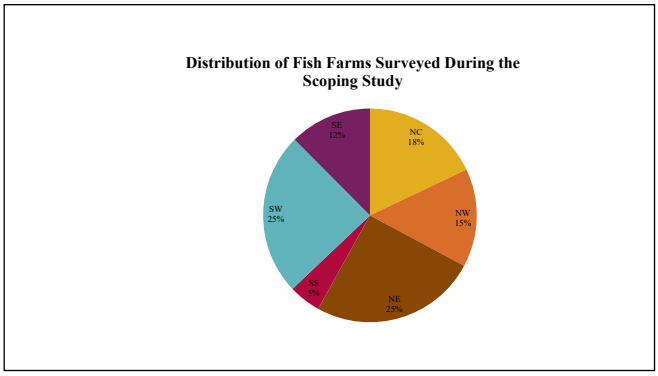
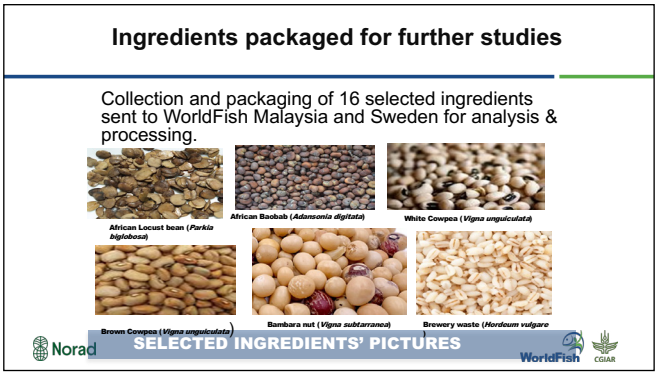
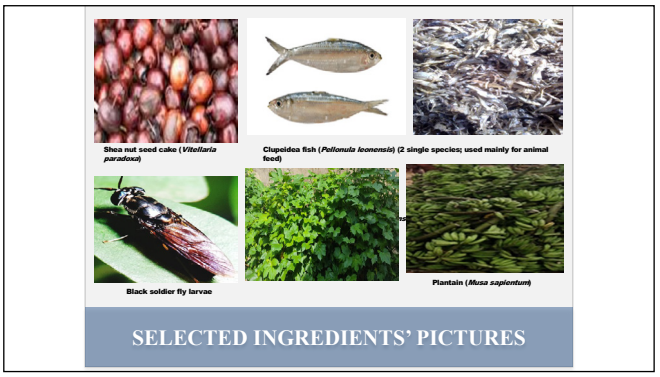


Figure 11: Capacity of feed mill per day based on the business age







Nutritional studies

Nutrients requirements of improved strains of Tilapia and African Catfish using locally available ingredients in Nigeria.

- ❖ Methionine requirement
- ❖ Lysine Requirement
- ❖ Vitamin C Requirement and
- ❖ Mineral (Calcium and Phosphorus) requirement. Eight experiments in all.

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Nutritional studies

- ❖ Progress made
  - o Research protocol approved by the project coordinator.
  - o Human ethics approval obtained
  - o Rehabilitation of experimental system (WRS) done
  - o Procurement of experimental fish done
  - o Acclamation of experimental fish species on-goingPlanning for Feed formulation, Sampling and Chemical analysis of this experimentation.

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Partners

- ❖ Federal Ministry of agriculture
- ❖ Agricultural Development Programme
- ❖ Ingredient producers
- ❖ Ingredient farmers
- ❖ Fish farmers
- ❖ Feed millers
- ❖ Research Scientist and Technologist
- ❖ Local cooperatives/groups
- ❖ Women and youth groups;
- ❖ Local NGOs;
- ❖ private sector; extension service providers; policy and finance organizations; government; regional bodies (AfDB, SADC, ECOWAS, EAC, and environmental agencies)

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Thank You

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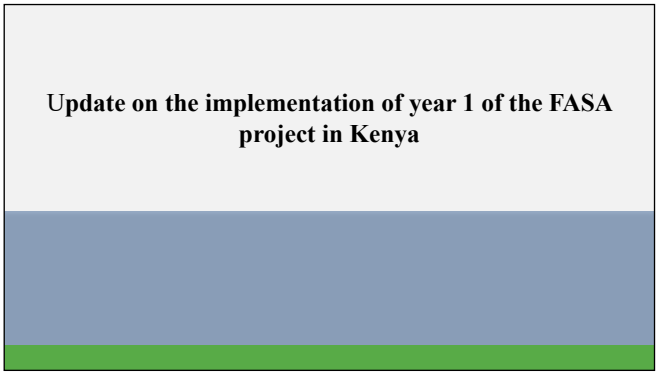
In partnership with

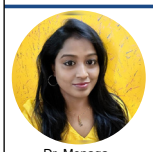
icipe CORAF SLU Swedish University of Agricultural Sciences ZAMBIA IITA Transforming African Agriculture

Introduction of the team members and update on the implementation of year 1 of the FASA project in Kenya
ICIPE (Dr. Chrysantus Mbi Tanga)

Team Members



Recruit New Staff



Dr. Menaga Meenakshisundaram

- Assistant Professor at Tamil Nadu University
- Five years of experience in the Aquaculture sector
- Specialized in different culture systems, such as raceways, recirculating aquaculture systems, aquaponics, and intensive ponds.
- Trained aquapreneurs seeking to enhance their production.

Mr. Isaiah Rachami

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Recruit of MSc & PhD Students

Mr John Muia

Master of science in Aquaculture and Fisheries Management

Ms Judy Kaguthi

Mrs Evalyne Wambui Ndotono

Insect-based diet in fish: implications for gut microbiota

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Conduct project start-up workshops

- Attended the online FASA partners' kick-off meeting (05th August 2022) with 18 participants.
- Attended the in-person Kick-off workshop: 28 - 30th Nov. 2022 at WorldFish HQ, Penang, Malaysia, followed by a site visit to Fisheries Research Institute Malaysia, Pulau Sayak and Jitra Aquaculture Extension Centre in Kedah
- Over 30 participants present at the WorldFish Headquarter Penang.
- On 18th January 2023, online Kenyan stakeholder kick-off meeting was organized with over 25 participants.

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Conduct project start-up workshops

- First Kenyan stakeholders' meeting: 16 - 25th February 2023.
- **Fish farms:** Kamuthanga farm (Machakos), Kenya Marine and Fisheries Research Institute (KMFRI) (Sagana), Bukani Aquapark, Hydro Victoria Fish Hatchery and Farm Ltd, and Bunyala Agro Industrial Park (Busia), Victory Fish Farms & Jabali Fish Farm
- **Feed millers:** Great Lake Feeds and Hatchery Ltd (Siaya), Captain Feeds and KMFRI Sangoro centre in Kisumu County, and and Kinyasaga group in Homa Bay county.

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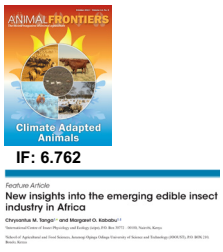
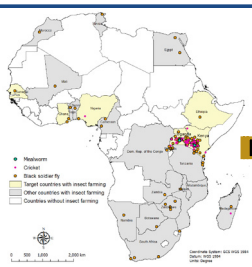
Conduct literature review of insect farming industry in Africa





Over 20,000 MT/Year

394,640,000 tonnes of feed at 50% inclusion of BSF meal

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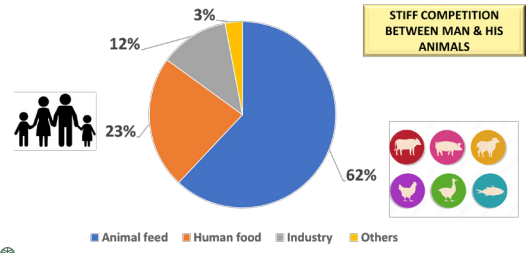
Where Do Our Grains Go?



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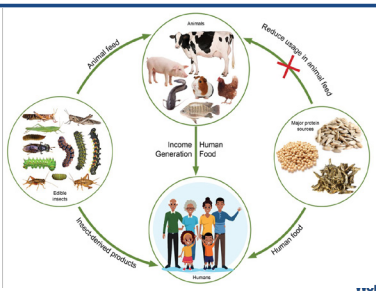
How to Reduce Competition

Reduce competition between man and his animals



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Conduct scoping review on role multilateral development organization, public & private investments in aquaculture subsector in Kenya

Role of multilateral development organizations, public and private investments in aquaculture subsector in Kenya

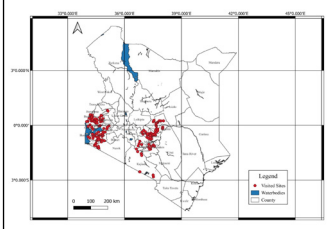
- More collaborative research
- Devoted to the design and construction of climate smart culture systems
- Developing new species to guarantee supply of high-quality products
- Developing and scaling low-cost and highly nutritious fish feeds based on novel ingredients

IF: 5.005

Conduct scoping review on role multilateral development organization, public & private investments in aquaculture subsector in Kenya

- Enhancing resilient livelihoods through innovative aquaculture practices and market linkages to create employment opportunities for youth and women.
- Governments should create an enabling policy environment through tax incentives and regulatory reforms to combat climate change, protect nature and biodiversity, sustain livelihoods, and mainstream food and nutrition initiatives into the design and implementation of future aquaculture projects.

Scoping assessments in fish production zones

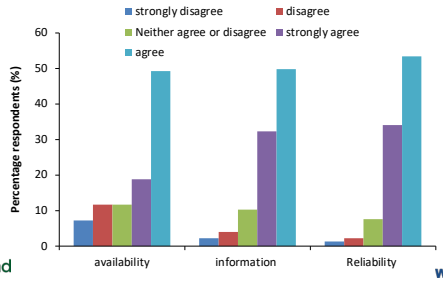


- Out of 220 respondents interviewed, 93.2% kept tilapia (93.2%) followed by catfish (6.2%).
- Most farmers (70.7%) harvested their fish once yearly.
- Majority of fish farmers obtain their feed supply from other farmers (15.2%), private companies (10.8%) and only 5.8% produce their own fish feeds.
- 66% of farmers use compounded feeds to feed their fish, only 25.8% have reportedly use insect meal.

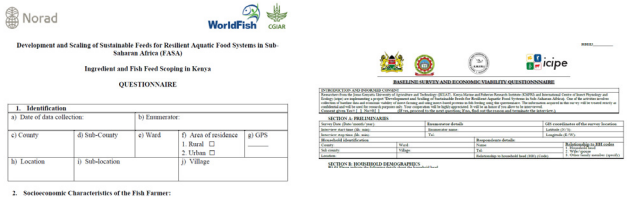
Scoping assessments in fish production zones

- Government is the highest supplier of fingerlings (25.6%) to the farmers followed closely by the private companies (22.9%) and other farmers (22.4%).
- Most farmers used complete compounded feeds (65.5%) and dry supplements (63.2%) and only 10.3% used wet supplements to feed their fish.
- Farmers strongly agreed (20.6%) and agreed (47.5%) that the use of insect meals in fish production might help lower the feed price and overall production cost in fish farming.
- The most used protein sources included: freshwater shrimp (commonly referred to as "Ochonga") at 45.3%, fishmeal (17.9%), dry poultry waste (9.4%), Sardines (Omena) (6.7%), insects/earthworms (5.8%), legume residues (5.4%), sunflower cake (4.4%), blood meal (5.4%), soybean meal (3.1%), cotton seed cake (2.7%) and sesame seed meal (1.3%).
- Common home-made feeds for the fish are either single ingredients used on feed formulation such as maize bran or household food left-overs.

Factors influencing the utilization of insect-based feeds



Design scoping studies for Kenya



Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Ingredient and Fish Feed Scoping in Kenya

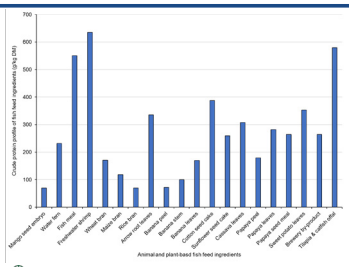
QUESTIONNAIRE

1. Identification

2. Socioeconomic Characteristics of the Fish Farmer:

BASELINE SURVEY AND ECONOMIC VIABILITY QUESTIONNAIRE

Data collection (ingredients): Top 20 protein sources



Commonly used feed ingredients of plant and animal origin for aquaculture production in Kenya.

Data collection (ingredients): Proximate Composition

Defatted and full-defatted black soldier fly (*Hermetia illucens*) larvae meal

Parameter (%)	Full fatted BSFL	Defatted BSFL
Dry matter	93.65 ± 0.035	92.41 ± 0.198
Protein	**48.17 ± 0.427**	**57.00 ± 0.219**
Ash	10.43 ± 0.145	14.43 ± 0.033
Fat	**21.48 ± 0.223**	**9.47 ± 0.067**
Fibre	7.12 ± 0.113	9.11 ± 0.162

Data collection (ingredients): Amino acids

Amino acid (mg/g)	Full fat BSFL	Defatted BSFL
Histidine	0.18 ± 0.003	0.19 ± 0.004
Isoleucine	0.76 ± 0.025	1.23 ± 0.124
Leucine	1.59 ± 0.067	2.36 ± 0.083
Lysine	**0.31 ± 0.009**	**0.46 ± 0.011**
Methionine	**0.30 ± 0.005**	**1.03 ± 0.034**
Phenylalanine	1.69 ± 0.050	2.65 ± 0.293
Threonine	0.14 ± 0.002	0.17 ± 0.004
Valine	1.13 ± 0.017	1.77 ± 0.033
Arginine	0.41 ± 0.005	0.47 ± 0.013
Cystine	0.01 ± 0.005	0.02 ± 0.002
Glutamic acid	0.31 ± 0.008	0.45 ± 0.004
Proline	0.82 ± 0.009	1.13 ± 0.30
Tyrosine	0.86 ± 0.013	2.91 ± 0.191
Glycine	0.25 ± 0.004	0.26 ± 0.006
Alanine	0.13 ± 0.003	0.15 ± 0.004

Amino acid profile of partially defatted and full-defatted black soldier fly (*Hermetia illucens*) larvae meal

Data collection (ingredients): Minerals

Mineral	Full fat BSFL	Defatted BSFL
Calcium (g/100g)	**0.03 ± 0.008**	**0.91 ± 0.528**
Phosphorous (g/100g)	0.15 ± 0.028	0.63 ± 0.424
Potassium (g/100g)	0.21 ± 0.060	1.14 ± 0.527
Sodium (mg/100g)	245.33 ± 60.416	155.93 ± 71.071
Magnesium (g/100g)	0.03 ± 0.008	0.20 ± 0.090
Sulphur (g/100g)	0.11 ± 0.018	0.20 ± 0.056
Iron (mg/100g)	**12.33 ± 0.841**	**32.67 ± 20.228**
Manganese (mg/100g)	0.90 ± 0.223	4.82 ± 2.497
Copper (mg/100g)	0.27 ± 0.067	0.83 ± 0.411
Zinc (mg/100g)	**4.72 ± 1.185**	**4.80 ± 1.886**

Mineral profile of partially defatted and full-defatted BSF

Data collection (ingredients): BSF Oil

- 40% Lauric acid
- Highly rich in antimicrobial agent

Investigate nutrient requirements in improved strains of tilapia

Design Research Protocol

Utilization of black soldier fly (*Hermetia illucens*) larvae as a potential substitute for fish meal in the production of Nile tilapia (*Oreochromis niloticus* L.)

IMPROVED NILE TILAPIA, KMFRI-SAGANA STRAIN (F-8)

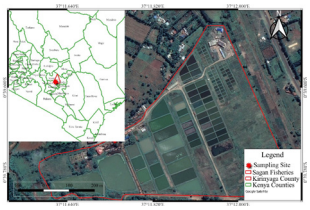
Secure Animal Ethics Approval

Institutional Animal Care and Use Committee (IACUC) of Kenya Agricultural and Livestock Research Organization (KALRO)-Veterinary Science Research Institute (VSRI); Muguga North, in compliance with all applicable regulations and guidelines, under the reference code KALRO-VSRI/IACUC028/16032022

ETHICS Universities

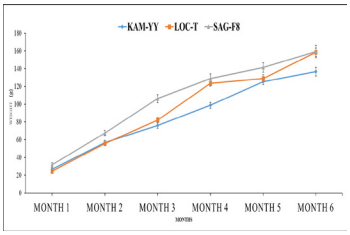
National Commission for Science, Technology and Innovation

Results: Study site



National Aquaculture Research Development and Training Center, Sagana

Results: Comparative growth performance



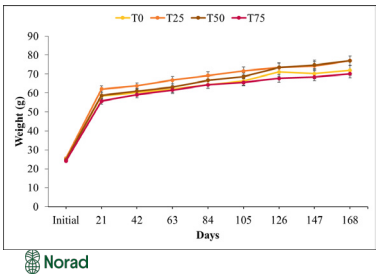
Benefits of selective breeding

- Increased farm production
- Fish with better fillet yield
- Fish with improved growth rates
- Fish resistant to diseases
- Resilience to climate changes

Results: Ingredients and nutritional composition of experimental diets

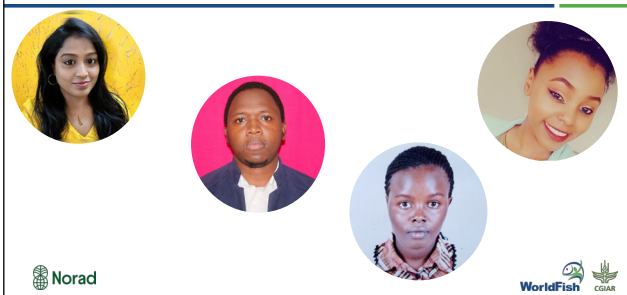
Ingredient	T0	T25	T50	T75
Wheat pollard	7.00	7.00	7.00	7.00
Rice polishing	20.00	19.25	19.00	18.75
Maize germ	22.00	22.00	21.50	21.00
Fish meal	7.00	5.25	3.50	1.75
BSFLM	-	2.50	5.00	7.50
Soybean meal	35.00	35.00	35.00	35.00
Sunflower cake	5.00	5.00	5.00	5.00
Lysine	1.00	1.00	1.00	1.00
Methionine	1.00	1.00	1.00	1.00
Fish premix	2.00	2.00	2.00	2.00
Total	100.00	100.00	100.00	100.00
Nutrient Level				
CP (%)	30.60	30.52	30.42	30.32
Energy (MJ/kg)	3,037.21	3,049.11	3,049.95	3,050.80

Results: Growth curves (weight) for *O. niloticus*



- 25% and 50% replacement of fishmeal protein with BSFLM provides best growth performance of Nile tilapia, as measured by final mean body weight gain (BWG), specific growth rate (SGR), feed conversion ratio (FCR) and condition factor (K).

Conduct 7 tilapia and 7 catfish experiment (Ongoing)



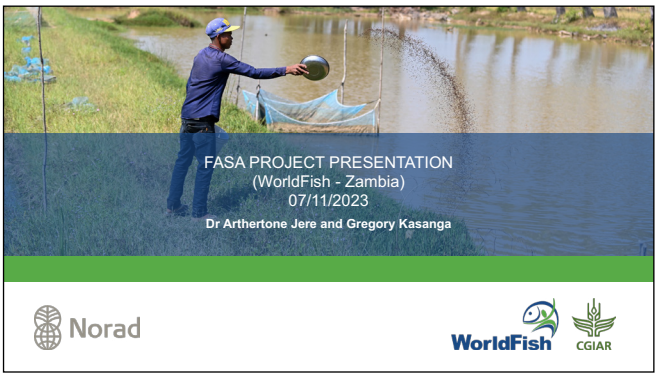
Capacity Building

- Trained over 357 farmers (70% women)
- 100 women from 31 Counties supported by the office of the first Lady (Mama Rachel Ruto)
- 75 Government extension officers

Partnerships

1. Kenya Marine and Fisheries Research Institute (KMFRI)
2. Kamuthanga Fish Farm, Machakos, Kenya
3. Victory Farms Ltd, Kenya (Private sector)
4. National Universities
5. JABALI FISH FARM (JABALI FISHERIES TRADERS)
6. Beach Management Units (BMU), County Government
7. Kenya Bureau of Standards (KEBS)

Update on the implementation of year 1 of the FASA project in Zambia
WorldFish Zambia (Dr. Arthertone Jere and Gregory Kasanga)



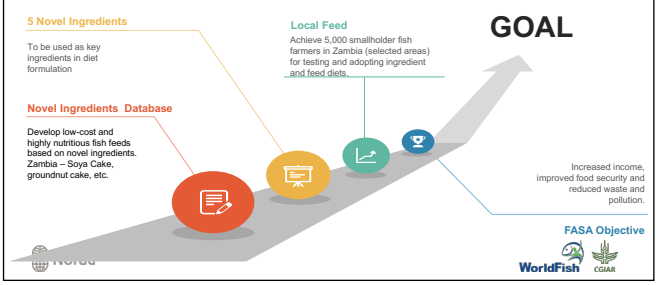
INTRODUCTION

The Development and Scaling of Sustainable feed for Resilient Aquatic food Systems in Sub-Saharan Africa (**FASA**) project aims to develop low-cost, highly nutritious fish feeds based on novel ingredients.

The development of these feeds will lead to:

- ✓ Increased income,
- ✓ Improved food security,
- ✓ Reduced waste and pollution.

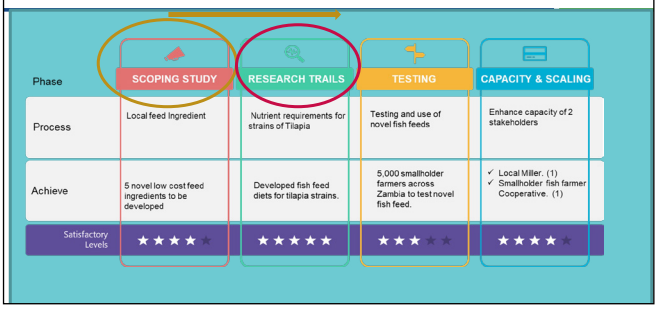
PROJECT GOALS



PROJECT GOALS

Launched the FASA project in Zambia on 20th December, 2022

IMPLEMENTATION PATH



IMPLEMENTATION

1. Ingredient and fish feed scoping study.
Conduct a ingredient and feeds scoping study of novel feed ingredients.
- ✓ Study completed: samples sent for proximate analysis and digestibility studies.

2. Upgrade of NRDC Laboratory.
Fisheries wet laboratory from a flow through system to a recirculation aquaculture system.
- ✓ Completed and operational.

3. Nutrient requirement experiment.
- ✓ 1st Study on strains of tilapia and completed.

1. IMPLEMENTATION: Scoping study

Ingredient and fish feed Scoping Study Report

Arthertone Jere (Principal Investigator)

Co-Authors
Gregory Kasanga, Alexander M. Greiling & Rodrigue Yossa.

1. IMPLEMENTATION: Scoping study of fish ingredients and feed

INTRODUCTION

- ✓ Fish feed **cost is a major constraint** to fish farming in Sub-Saharan Africa.
- ✓ In Zambia, fish feed is a determinant factor in the aquaculture value chain and accounts for 60 -70% of the fish production cost.

1. IMPLEMENTATION: Scoping study of fish ingredients and feed

OBJECTIVE

To provide information on the **type, price, availability & seasonality** of the ingredients in Zambia.

Furthermore, to provide insights on the **fish feed value chain & its influences** on the aquaculture industry in Zambia.

1. Scoping study of fish ingredients and feed

METHODOLOGY

	Province	Number of Districts	Number of Camps/Wards
	Eastern	5 districts visited	15 camps/wards visited
	Northwestern	5 districts visited	15 camps/wards visited
	Southern	5 districts visited	15 camps/wards visited
	Luapula	5 districts visited	15 camps/wards visited
	Northern	5 districts visited	15 camps/wards visited
	Lusaka	5 districts visited	15 camps/wards visited
Total	6	30	90

1. Scoping study of fish ingredients and feed

Results (Summary) Ingredient Identified across

Table: Type of ingredients mapped during the March-May 2023 scoping study.

S/N	Type of feed ingredient	Nutrient content	Ingredient category	Other
1	Maize	Carbohydrate	Plant	Unprocessed
2	Rice	Carbohydrate	Plant	Unprocessed
3	Sorghum	Carbohydrate	Plant	Unprocessed
4	Finger millet	Carbohydrate	Plant	Unprocessed
5	Cassava	Carbohydrate	Plant	Unprocessed
6	Chikanda	Unknown	Plant	Unprocessed
7	Soy beans	Protein	Plant	Unprocessed
8	Sunflower	Protein	Plant	Unprocessed
9	Cow peas	Protein	Plant	Unprocessed
10	Velvet beans	Protein	Plant	Unprocessed
11	Pumpkin leaves	Vitamins	Plant	Unprocessed
12	Palm tree seed oil	Lipids	Plant	Processed
13	Sunflower cake	Protein	Plant	Processed
14	Tea waste (red dust)	Protein/Vitamins	Plant	Processed
15	Sunflower extra residue	Lipids	Plant	Processed
16	Maize bran	Carbohydrate	Plant	Processed
17	Rice bran	Carbohydrate	Plant	Processed
18	Brewery waste	Protein	Processing	Processed
19	Cotton seed waste	Protein	Plant	Processed
20	Kakeya	Protein	Animal	Unprocessed
21	Chisense	Protein	Animal	Unprocessed
22	Cray fish	Protein	Animal	Unprocessed
23	Caterpillar 1	Protein	Animal	Unprocessed
24	Caterpillar 2	Protein	Animal	Unprocessed
25	Blood meal	Protein	Animal	Unprocessed
26	Local salt	Mineral	Animal	Unprocessed
27	Dry yeast	Protein	Animal	Processed

1. Scoping study of fish ingredients and feed

Results (Summary) Ingredient Identified across

3 main categories of ingredient sources were found, namely:

Plant (70.4% of found ingredients),

Animal (22.2%) and

Other ingredient sources (7.4%).

1. Scoping study of fish ingredients and feed

Results (Summary) Plant ingredient sources

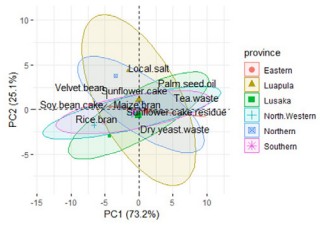


Figure 2. PCA clustering of animal ingredients based on their type, availability.

1. Scoping study of fish ingredients and feed

Results (Summary) Animal ingredient sources

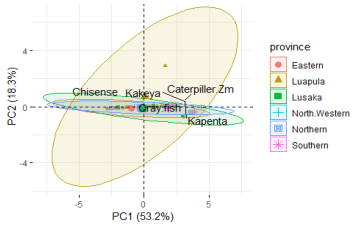


Figure 3. PCA clustering of animal ingredients based on their type, availability.

CONCLUSION

Study overall revealed a diversity of local ingredients available in Zambia with **huge potential for use as aqua feed**.

Plant ingredient sources produced by the agriculture farmers was high 56% compared to the processor (23%) who produce by-products such as maize bran, rice bran, sunflower cake, soy bean cake and brewery waste.

About 85.2% of the agriculture farmers did not process their ingredients to produce the ingredients for feed production & was similar across the sampled provinces.

CONCLUSION

Similarly, the animal ingredient sources production by fishers, processors, forest gatherers used for human consumption is higher standing at only 78.6% on average than other uses like fish feeds.

In Lusaka & Southern Provinces, use & demand of commercial fish feeds was high **compared to** North – Western, Northern, Luapula & Eastern Provinces due to **accessibility & proximity** to fish feed factories.

Use of ingredients for **human consumption was 87.8%** & higher than livestock user at 12.2%

RECOMMENDATION

1. Proximate analysis & digestibility studies are required on the selected ingredient to understand their nutritional composition & potential use as local fish feed ingredients.

2. Need to encourage the private sector participation in deliberate **production, supply & distribution** of key local ingredient to support aquaculture feed industry

SAMPLE OF INGREDIENTS COLLECTED FOR LABORATORY ANALYSIS

	COUNTRY	CITY	DATE	INGREDIENT SOURCE	NAME OF INGREDIENT	SCIENTIFIC NAMES	FORM OF THE INGREDIENT	WEIGHT(KG)
1	ZAMBIA	SIAVONGA	Sunday, 19 March 2023	ANIMAL	SIAVONGA KAPENTA	Limnothrissa miodon	DRY	6
2	ZAMBIA	MONZE	Tuesday, 21 March 2023	ANIMAL	CRAYFISH	Cherax quadricarinatus	DRY	6
3	ZAMBIA	ZAMBEZI	Tuesday, 28 March 2023	ANIMAL	KAKEYA	Assorted fish	DRY	6
4	ZAMBIA	ZAMBEZI	Tuesday, 28 March 2023	ANIMAL	CATERPILLAR1	Gonimbrasia zambesina	DRY	6
5	ZAMBIA	KASAMA	Wednesday, 19 April 2023	ANIMAL	CATERPILLAR2	Gonimbrasia belina	DRY	6
6	ZAMBIA	CHENGE	Monday, 24 April 2023	ANIMAL	CHISENSE	Potamotherica acutirostris	DRY	6
7	ZAMBIA	ZAMBEZI	Tuesday, 28 March 2023	PLANT	SUNFLOWER CAKE MEAL	Helianthus annuus	DRY	6
8	ZAMBIA	MBALA	Thursday, 13 April 2023	PLANT	VELVET BEANS MEAL	Mucuna pruriens	DRY	6
9	ZAMBIA	MBALA	Thursday, 13 April 2023	PLANT	VELVET BEANS SEED	Mucuna pruriens	DRY	6
10	ZAMBIA	KAWAMBWA	Saturday, 22 April 2023	PLANT	TEA WASTE (Red dust)	Camellia sinensis	DRY	6
11	ZAMBIA	MANSA	Thursday, 27 April 2023	PLANT	CHIKANDA	Dioscoreaota N.E.Br.	DRY	6
12	ZAMBIA	KAPUE	Friday, 19 May 2023	PLANT	YEAST WASTE	Saccharomyces cerevisiae	DRY	6

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Gregory M. Kasanga, Dr. Arthertone Jere, Majory Chama, Khuairal Abu Bakar and Dr. Rodrigue Yossa

UPGRADE OF NRDC WET LABORATORY

UPGRADE OF NRDC FISH WET LABORATORY

1. Introduction
2. Recirculation Aquaculture System Set-up
3. Complete set-up of Recirculation Aquaculture System Set-up
4. Operation of Recirculation Aquaculture System

INTRODUCTION

FLOW-THROUGHT SYSTEM (2019)


Design by Dr. Rodrigue Yossa
Fabrication and operationalized by: Dr. Rodrigue Yossa and NRDC staff

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INTRODUCTION

Wet- Laboratory Status at Beginning of Upgrade - 2023

CHALLENGES

Theft
After experiments, and Covid19 interruptions, vital components were stolen as a result staff and students halted using the flow through system.

Finance
Challenges to bring Laboratory to life. Hence, it was not in operation.

OPPORTUNITY
FASA project - upgrade of the Wet Laboratory from a Flow Through System to Recirculation Aquaculture System.

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Recirculation Aquaculture System Set-up

Recirculation Aquaculture System required installation of the following components

1. Mechanical Filter
2. Biological Filter
3. Sand Filter
4. Sump
5. Aeration
6. Aquarium tanks
7. Reservoir tanks
8. Water pumps
9. UV light
10. Heaters

Mr. Isaac, Mr. Gregory, Mrs Majory, Mr. Chanda, Mr. Simon, Mr. Mumbi, Mr. Khairul and Mr. Anthony (from left to right)

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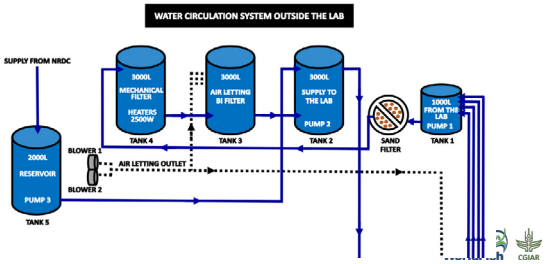
Recirculation Aquaculture System Set-up

Components used to set up system were divided two parts outdoor and indoor



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Recirculation Aquaculture System Set-up

Outdoor components

Pipe work and installation of sand filter and tanks for mechanical and biological filtration

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Recirculation Aquaculture System Set-up

Fencing of tank area to secure outdoor unit components

BEFORE AFTER

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Recirculation Aquaculture System Set-up

Outdoor components

Securing area and installation of air blowers to supply oxygen to fish tanks and biological filter

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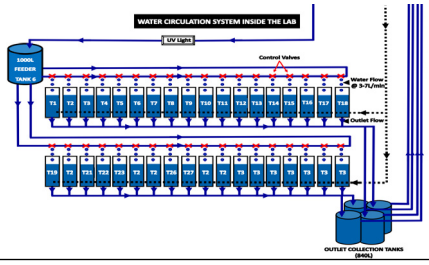
Recirculation Aquaculture System Set-up

Components used to set up system indoor



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Recirculation Aquaculture System Set-up

Indoor Components

Electrical switch board installation (control of water heaters, air blowers, water pumps)

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Recirculation Aquaculture System Set-up

Indoor Components

Pipe works to ensure indoor water supply to aquarium tanks

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Recirculation Aquaculture System Set-up

Indoor Components



Testing of water flow system and works on linkages

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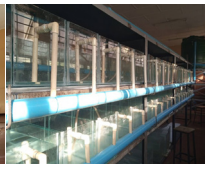
Recirculation Aquaculture System Set-up

Indoor Components





Replacement of broken Aquarium tanks, and installation and connection of water outlet system

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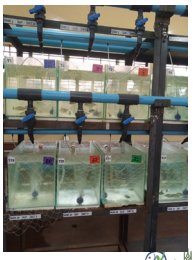
COMPLETE SET-UP OF RECIRCULATION AQUACULTURE SYSTEM

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OPERATIONAL RECIRCULATION AQUACULTURE SYSTEM

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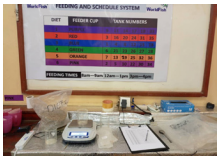
OPERATIONAL RECIRCULATION AQUACULTURE SYSTEM



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3. IMPLEMENTATION: 1st Nutrient Requirement Experiment

Comparative estimation of the lysine requirements for the strains of *Orenchromis andersonii* at Juvenile stage.

Arthertone Jere (Principal Investigator)

Co-Authors

Gregory Kasanga, Alexander M. Greiling, Majory Chama & Rodrigue Yossa.

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3. IMPLEMENTATION: Nutrient Requirement Experiment

Comparative estimation of the lysine requirements for the strains of *Orenchromis andersonii* at Juvenile stage.

Introduction

- ✓ Among the essential amino acids, lysine is necessary for many bodily functions such as growth.
- ✓ Despite its importance, lysine is among most limiting amino acids in plant based ingredient (Gatlin III et al., 2007)

Image source: FeedNavigator, Google images

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3. IMPLEMENTATION: Nutrient Requirement Experiment

Comparative estimation of the lysine requirements for the strains of *Orenchromis andersonii* at Juvenile stage.

Introduction

- ✓ Lysine requirement levels were estimated at 1.4% of the diet & 5.4% of crude protein for Nile tilapia (Santiago & Lovell, 1988).
- ✓ This lysine level requirement is still recommended today for other strains of tilapia species (Wing-Keong Ng & Romano, 2013).
- ✓ However, no studies conducted to estimate the lysine requirement for *O. andersonii* .

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3. IMPLEMENTATION: Nutrient Requirement Experiment

Comparative estimation of the lysine requirements for the strains of *Orenchromis andersonii* at Juvenile stage.

The overall objective:

- ✓ To estimate the lysine requirement of SUZ and GIP strains of *O. andersonii* species.

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3. IMPLEMENTATION: Nutrient Requirement Experiment

Comparative estimation of the lysine requirements for the strains of *Orenchromis andersonii* at Juvenile stage.

Hypothesis:

- ✓ Lysine requirement level of SUZ strain is the same as GIP strain of *O. andersonii*.

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3. IMPLEMENTATION: Nutrient Requirement Experiment

Comparative estimation of the lysine requirements for the strains of *Orenchromis andersonii* at Juvenile stage.

MATERIALS AND METHODS

1. Experimental design:

- ✓ Completely randomized 2*6 factorial design
- ✓ Experiment period was 10 weeks from August 2023
- ✓ 36 tanks (75liters/tank)
- ✓ 20 fish per tank = 720 fish stock at average 10grams (360 fish/strain).
- ✓ Lysine level in feed (1.13%, 1.30%%, 1.48%, 1.64%, 1.89% and 2.14%).

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3. IMPLEMENTATION: Nutrient Requirement Experiment

MATERIALS AND METHODS

2. Experimental feed:

Table 1: Composition of the experimental diets (as fed)

INGREDIENT	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Rice bran	15.1	15.1	15.1	15.1	15.1	15.1
Soybean meal (48 solv)	28.6	28.6	28.6	28.6	28.6	28.6
Gluten (corn)	18.9	18.9	18.9	18.9	18.9	18.9
Corn (7.5% CP)	19	19	19	19	19	19
Wheat bran	10.8	10.8	10.8	10.8	10.8	10.8
Canola oil	1.5	1.5	1.5	1.5	1.5	1.5
Fish oil	1.25	1.25	1.25	1.25	1.25	1.25
Dicalcium Phosphate	2	2	2	2	2	2
Trace mineral premix	1	1	1	1	1	1
Vitamin C	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.3	0.3	0.3	0.3	0.3	0.3
DL-Methionine	0.2	0.2	0.2	0.2	0.2	0.2
L glutamic acid	1.2	1	0.8	0.6	0.9	0
L-Lysine	0	0.2	0.4	0.6	0.3	1.2
TOTAL	100	100	100	100	100	100

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3. IMPLEMENTATION: Nutrient Requirement Experiment

✓ **Experimental feed making:**

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3. IMPLEMENTATION: Nutrient Requirement Experiment

MATERIALS AND METHODS

3. Data collection & Sampling:

- ✓ **Initial stocking,**
- ✓ **week 3 sampling,**
- ✓ **Week 6 sampling,**
- ✓ **week 9 sampling,**
- ✓ **Final Sampling**

→

- ✓ Weight of fish (Body +Bulk)
- ✓ Length of fish
- ✓ Lever weight
- ✓ Visceral weight
- ✓ Collection of fish samples

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3. IMPLEMENTATION: Nutrient Requirement Experiment

4. Data collection:

✓ **Proximate composition Determination**:

➢ Samples have been collect for analysis;
Dried fish samples (**654** specimen)

➢ Dry matter, Ash content, Crude fat, Crude Protein, Crude Fibre, Gross Energy, Amino Acid profile

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3. IMPLEMENTATION: Nutrient Requirement Experiment

4. Data collection:

✓ **Growth performance and feed utilization computation**:

- Average final weight $= \frac{\text{sum of individual weights in the sample}}{\text{total number of observation}}$
- Weight gain (WG, g) = final weight (g) – initial weight (g)
- Specific growth rate $= \frac{(\ln \text{final mean weight} - \ln \text{initial mean weight})}{\text{initial mean weight}} \times 100$
- Survival rate (%) $= \frac{(\text{initial number of fish} - \text{number of dead fish})}{\text{initial number of fish}} \times 100$
- Feed intake(% BW/day) $= \frac{\text{Feed consumption (g) x 100}}{\text{Average biomass (g) x days.}}$
- AFCR $= \frac{\text{Weight of food consumed}}{\text{Weight gain}}$
- HSI $= \frac{\text{Weight of the liver}}{\text{Body weight of fish}} \times 100$
- **VSI** (%)$= \frac{\text{Gut Weight}}{\text{Fish Weight}} \text{X } 100$

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3. IMPLEMENTATION: Nutrient Requirement Experiment

5. Data analysis

- ➢ ANOVA was used to determine the significant difference ($p<0.05$) between the treatments and strains of tilapia. Tukey test was applied to separate treatment means. Polynomial contrast were further used to determine linear, quadratic & cubic effects
- ➢ Data analyses were carried out using R software version 4.3.2
- ➢ The following statistical model was used:

$\mathbf{Yij = \mu + \tau_i + \varepsilon_{ij}}$

Where: **Yij** = j^{th} observation or response on i^{th} level of treatment.

μ = Overall mean.

τ_i= Effect of the i^{th} level of factor.

ε_{ij}= Random and independent errors.

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3. IMPLEMENTATION: Nutrient Requirement Experiment

RESULTS

TABLE 4. EFFECT OF DIETARY LYSINE LEVELS ON THE GROWTH PERFORMANCE AND FEED UTILISATION ON STRAINS OF *O. ANDERSONII* (MEAN±SE).

Growth parameters & indices	Treatments						Contrast		
	Diet 1 (1.13%)	Diet 2 (1.30%)	Diet 3 (1.48%)	Diet 4 (1.64%)	Diet 5 (1.89%)	Diet 6 (2.14%)	Linear	Quadratic	Cubic
Initial Weight (g)	15.19±0.24	15.06±0.34	15.03±0.12	15.01±0.55	14.87±0.34	14.95±0.23	ns	ns	ns
Final Weight (g)	51.47±1.97^a	49.63±1.68^a	50.35±1.95^a	48.62±1.95^a	66.47±0.32^b	51.86±0.45^a	ns	ns	*
Weight Gain (g)	36.28±2.20	34.57±1.87	32.34±1.54	33.60±2.47	37.53±0.19	37.86±0.29	ns	ns	ns
SGR (%-day)	3.18±0.05	3.13±0.05	3.21±0.09	3.11±0.06	3.09±0.12	3.22±0.01	ns	ns	ns
Survival rate (%)	70.56±8.22	71.33±7.26	68.33±1.74	72.33±1.67	74.73±6.73	73.67±7.64	ns	ns	ns
Hepatosomatic index (%)	0.42±0.02^{ab}	0.37±0.01^{bc}	0.24±0.04^c	0.45±0.03^a	0.42± 0.12^a	0.43± 0.01^a	*	*	ns
Visceral somatic index (%)	2.62±0.157	2.58±0.14	2.16±0.35	2.12±0.22	2.44±0.14	2.34±0.113	ns	ns	ns
Feed intake (g)	3.62±0.158	3.23±0.25	3.19±0.32	3.38±0.476	3.41±0.23	3.18±0.21	ns	ns	ns
AFCR (%)	2.93±0.30	2.89±0.28	2.71±0.02	2.67±0.09	2.62±0.22	2.62±0.22	ns	ns	ns

NB: Values are means ± standard error, within the row, treatments with the same letter are not significantly different ns=non-significant, *= significant ; AFCR= Feed conversion ratio; SGR = Specific growth rate.

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3. IMPLEMENTATION: Nutrient Requirement Experiment

CONCLUSION

- ➢ Different replacement levels of Lysine at 1.13%, 1.30%, 1.48%,1.64% and 2.14% on the strains of *O. andersonii* diet does not have any effect on the growth parameters, **except for 1.89%.**
- ➢ Replacement of Lysine level in diet at **1.13% and 1.64 up to 2.14%** did not affect the Hepatosomatic index, except for 1.30% on strains of *O. andersonii.*

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3. IMPLEMENTATION: Nutrient Requirement Experiment

RECOMMENDATION

- ✓ Similar study should be carried out with similar Lysine replacement level on native fish species such as *O. machrochir, O. tanganicae & C. rendalli.*

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PARTNERS

PARTNERSHIPS

NAGI CONSULTANCY

SLU Swedish University of Agricultural Sciences

ALLER AQUA ZAMBIA

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IITA Transforming African Agriculture

Update on the implementation of year 1 of the FASA project in Malaysia
WorldFish Malaysia (Rodrigue Yossa, Aaqillah Amr and Nurulhuda A. Fatan)

FASA Project work in Malaysia

By Rodrigue Yossa, Nurulhuda A. Fatan, Aaqillah Amr Mohd Amran, Muhammad Rahimi Ramli & Ning Shahira
&
PMU, MEL, Communication, Procurement, Accounting, Finance & Consultant Teams

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Content

1. Scope of Project Work in Malaysia
2. Aquaculture Research in Malaysia
3. Aquaculture Extension from Malaysia
4. Other project works in Malaysia

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Scope of Project Work in Malaysia

Non- Aquaculture work:

- Project Management
- MEL & Data Management
- Communication
- Procurement
- Finance
- Accounting

Aquaculture work+:

- Aquaculture Research
- Aquaculture Extension
- Impact Assessment
- Consultants

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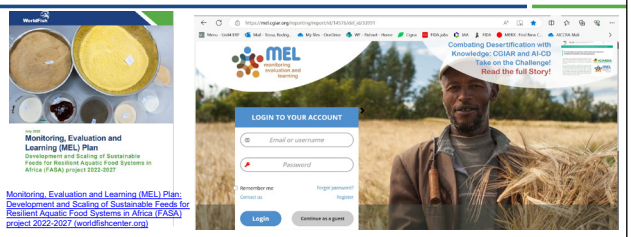
FASA project MEL plan



Monitoring, Evaluation and Learning (MEL) Plan: Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Africa (FASA) project 2022-2027 (worldfishcenter.org)

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FASA project communication: Comm Plan

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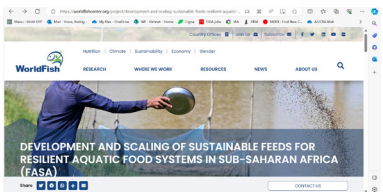
FASA project communication: website

Project webpage

Development And Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA) | WorldFish (worldfishcenter.org)



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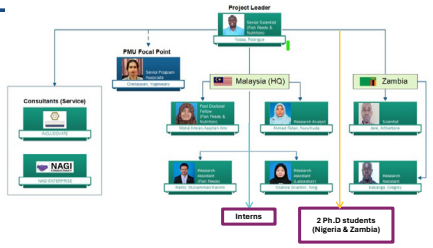
FASA project staffing plan



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Aquaculture Research in Malaysia

Work Plan

Output 2.1: New data and knowledge on local ingredients generated, used in the formulation of novel fish feeds, and made widely available			
Activity 2.1.1: Conduct experiments to prioritise 15 ingredients			
			Quarters (3 months each)
Subactivity 2.1.1.2: Conduct digestibility experiments of ingredients samples collected for output 1.1	Posdoc Fellow	Nurulhuda Fatan; research assistant; laboratory technician (all in Penang)	
Subactivity 2.1.1.3: Database development and research report preparation and publication	Posdoc Fellow	Nurulhuda Fatan; Saadiah Ghazali; research assistant; laboratory technician (all in Penang)	

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Aquaculture Extension from Malaysia

Activity 2.1.2: Stakeholder consultations (1 online workshop per country) to discuss results of activity 2.1.1 and potential benefits, risks, challenges, and hazards to the use of local ingredients

Subactivity 2.1.3.1: Synthesize all findings on ingredients generated so far to enable prioritization

Subactivity 2.1.3.2: Discuss all results with internal and external partners (including 1 online workshop per project country) and select 15 ingredients

Activity 2.3.1: Develop printed booklets/manuals for ingredients and fish feeds and make available to the public

Output 3.3: Strategic capacity development and public awareness campaigns delivered in order to widely disseminate knowledge, innovations, and tools developed by the project

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Objectives

1. To study the **nutritional composition, apparent digestibility coefficients, and anti-nutritional factors** of various sustainable local ingredients obtained from Sub-Saharan African
2. To examine the **growth performance and the biochemical composition** of GIFT, *Oreochromis niloticus* fed with sustainable local feed ingredients
3. To assess fish **health status** through the analysis of histopathology and cortisol levels when fed with sustainable local feed ingredients

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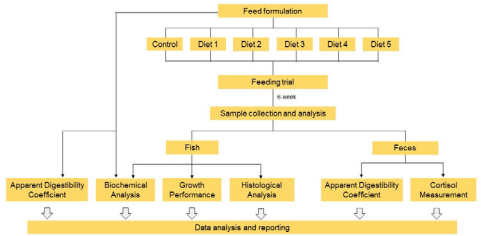
Experimental Design



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Ingredients received from Zambia

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Ingredients received from Zambia

1) Caterpillar (Vinkubala)
2) Caterpillar (Tukanja)
3) Siavonga kapenta
4) Kakeya
5) Chisense
6) Crayfish
7) Velvet bean meal
8) Velvet bean seed
9) Tea waste
10) Sunflower cake meal
11) Chikanda

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Ingredients received from Zambia

1) Caterpillar (Vinkubala)
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3) Siavonga kapenta
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5) Chisense
6) Crayfish

Animal-based

7) Velvet bean meal
8) Velvet bean seed
9) Tea waste
10) Sunflower cake meal
11) Chikanda

Plant-based

Digestibility 1

Proximate analysis

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Feed Production

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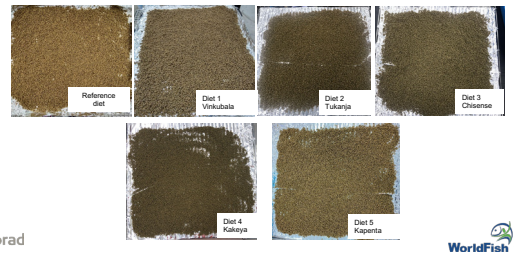
Feed Production



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Digestibility 1

Activity	2023											2024	
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Protocol and formulations													
Preparation and approval of animal ethics													
Ingredients arrive from Zambia													
Feed manufacture													
Animal sourcing and acclimating													
Start of experiment													
Final sampling													
Sample Preparation													
Biochemical Analysis													
Data analysis													
Reporting													

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Effects of Insect Meals on Fish Digestibility, Health, and Economic Performance: A Meta-Analysis

Aaqillah-Amr, M.A., Hidir, A., Ikhwanuddin, M., Fatan, N.A., Muhammad-Rahimi, R., Ning-Shahira, S., Siankhe, R.G.N., Vandenberg, G.W., Tanga, C.M., Yossa, R.

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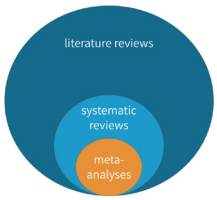
Meta-analysis

Various meta-analyses on several parameters in various fish species in response to substitution of FM by IM

- Fish nutritional profile[1]
- Growth performance[2-5]
- Feed efficiency[5]
- Consumer acceptance[6]

However, the study did not include the fish welfare and economic performance



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Objectives

- Recent progress in developing fish feeds from various insect proteins and the impact on
  - ❑ Apparent digestibility coefficient (ADC)
  - ❑ Fish health (blood parameters)
  - ❑ Economic analysis
- Such data are essential, especially to the public and policymakers, to fully understand the benefits gained from IM when used as FM replacement

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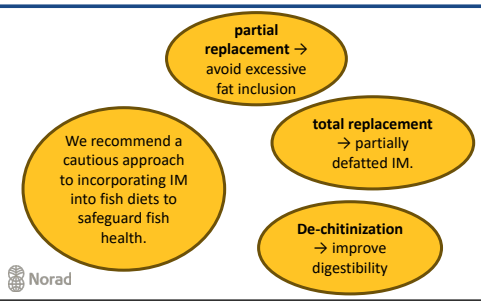
Parameter	df	Mixed model (fixed or random effect) based on heterogeneity				Effect summary	CI95%
		τ^2	Q	p	I^2		
Apparent digestibility coefficient							
(i) Dry matter	19	3.88	62.61	0.00	69.65	-0.92	-1.97 to 0.14
(ii) Crude protein	27	5.25	77.46	0.00	65.14	0.12	-0.82 to 1.07
(iii) Crude lipid	21	2.72	37.85	0.01	44.51	-0.51	-1.33 to 0.31
Fish health (blood parameters)							
(i) Non-specific immune							
- Lysozyme activity	15	12.05	126.35	0.00	88.13	2.38	0.40 to 4.37
(ii) Blood metabolite							
- Glucose	21	1.99	4.80	1.00	-337.60	0.31	-0.38 to 1.00
- Total protein	15	4.846	8.94	0.88	726.13	-1.36	-2.52 to -0.20
- Triglycerides	17	5.16	76.61	0.00	77.81	0.84	-0.34 to 2.02
- Cholesterol	23	4.04	92.68	0.00	75.18	-0.46	-1.38 to 0.45
(iii) Hematological							
- Hemotocrit	7	10.36	0.81	1.00	-762.11	0.31	-1.99 to 2.60
- Monocytes	7	0.48	13.17	0.07	46.84	-0.02	-0.72 to 0.69
Economic analysis							
(i) Fish feed cost	9	0.00	6.93	0.64	-29.86	-0.07*	-0.31 to 0.15
(ii) Economic profit index	5	0.00	4.39	0.50	-14.02	0.00	-0.47 to 0.49

*The negative effect summary for feed cost indicates a positive outcome associated with lower costs

Conclusion and Recommendation



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Unveiling the effect of nutrition on freshwater-farmed fish during different life cycles: A systematic review

Aaqillah-Amr MA, Hidir A, Fatan NA, Ikhwanuddin M, Ley TM, Rossita S, Mat Noordin Noordiyana, Khairul-Adha AR, Siankhe RGN, Yossa R

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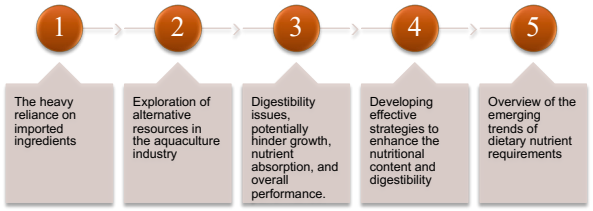

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Objectives

To compile the present research focus, nutritional strategies, and management practices to address critical industry challenges.

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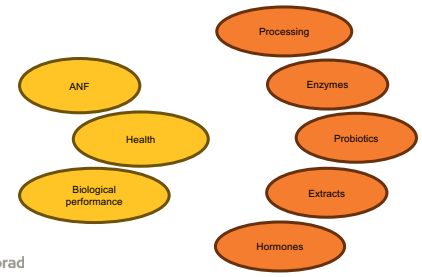
Nutritional enhancement



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Conclusion and Recommendation

By prioritizing alternative energy sources and improving their nutritional value, the industry can move towards a more efficient, eco-friendly, and nutritionally balanced approach to freshwater aquaculture.

Exploring broodstock nutrition is crucial for maintaining optimal breeding conditions and ensuring the production of healthy offspring.

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Establishment of Fish Feed and Nutrition Lab

Lab inauguration

On May 25, 2023, WorldFish board member Dr. Baba Yusuf Abubakar has officially inaugurated the lab.

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Fish Feed and Nutrition lab

Person in charge:
Ms Ning Shahirah Mohd Sharbini with the supervision of Dr Rodrigue Yossa
Interns

The lab will serve WorldFish scientists and partners in Penang and across Asia, Africa, and the Pacific to conduct experiments on proximate analysis and more!

Analysis that can be conducted:

- Main analysis
  - Dry matter
  - Ash
  - Acid insoluble ash
  - Crude protein
  - Crude fat
  - Crude fiber
  - Gross energy
- Upcoming analysis
  - Calcium
  - Phosphorus
  - etc




Result of the raw ingredients from Zambia

Proximate Analysis (dm)	Vinkubala	Tukanja	Siavonga kapenta	Kakeya	Chisense	Crayfish
Dry Matter (%)	86.5	89.6	89.8	86.5	88.3	88.7
Ash (%)	8.7	11.9	34.4	13.7	21.8	25.5
Crude Protein (%)	62.5	54.4	48.3	55.3	58.1	45.8
Crude Fibre (%)	10.5	10.8	0.14	1.28	0.05	11.0
Crude Lipid (%)	7.83	13.8	7.90	23.4	8.9	4.62
Gross Calorific Value (J/g)	19,700	22,800	13,400	21,900	18,400	14,700

Solid-state fermentation: a tool for improving the nutritional value of novel feed ingredient

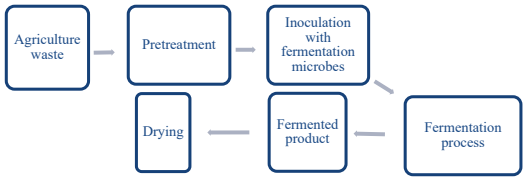
Objective of the study

- The overall objective of this study will be to investigate the effect of solid-state fermentation (SSF) on the changes in the nutrients profile particularly protein and fiber and reduction of anti-nutritional factors in agriculture waste
- Optimization of solid-state fermentation parameters for the production of functional product by the microorganism on selected agriculture waste

Significant of the research

- Urgent need to identify and develop new sources of aquaculture feed, particularly those rich in nutritious and palatable protein.
- Therefore, repurposing or transforming agriculture waste into functional forms to be used in animal feed as a sustainable alternative

Methodologies



- Nutritional value evaluation of fermented product
- Application effect of fermented product on Tilapia
- Optimization of solid-state fermentation parameters for the production of functional products by the microorganisms

SSF activities conducted at WorldFish Penang

- Collaboration with expert from the Bioprocess Technology, chool of Technology Industry, USM Penang
- Literature review
- Develop a research protocol on SSF in an application using bacteria, yeast, and fungi
- Conducted a preliminary SSF experiment on tea waste using Lactic acid bacteria

SSF activities conducted at WorldFish Penang- Cont'd

- A preliminary SSF experiment on tea waste using Lactic acid bacteria
- 10g of tea waste
- Microorganisms
  - *Lactobacillus acidophilus*
  - *Pediococcus acidilacties*
- Morphology
- Inoculum preparation
  - MRS broth (37 °C, 24hrs)
- SSF
  - 10% w/w microbes
  - Substrate: water – 1:2
  - Incubate at 37 °C, 3 days
- Sample drying – proximate analysis



Expected Outputs

There will be changes and improvement in the nutrient composition of fermented tea waste and reduced anti-nutritional factors.

Climate Change and Environmental Assessment:

An update on the implementation of year 1 of the FASA project

By Dr. Mzime Ndebele-Murisa
on behalf of
NAGI CONSULTANCY

Presentation outline

1. Introduction
2. Year 1 activities
3. Implementation challenges and successes
4. Outputs
5. Recommendations for Year 2
6. Year 2 activities

Introduction

Identify opportunities for the project to benefit the environment within the novel feeds landscape in the 3 project countries using life cycle assessment (LCA) methods

1. Highlight situational analysis of the climate and the environment
2. Analyze LCA feasibility; focus:
   - weaknesses in the currently available data
   - contribute towards improved and broadened understanding of aquaculture fish feed carbon footprint along value chains- where and how GHGs emissions arise
   - identify potential opportunities including mitigation pathways within the novel fish feed landscape

Year 1 activities

Implementation challenges and successes

Successes

- Representative sample achieved despite challenges met in data collection
- Good sense of industry and VC processes; farmers and millers willing to engage and potentially work with project
- Research reports and articles successfully compiled and reviewed

Challenges

- Quantitative data inaccessible as solicitation was considered to be intrusive
- Mobilisation quite challenging for some sites
- Delayed kick off of activities and consequent delays in meeting some of the deadlines
- Daily targets during field work difficult to meet due to sparsely located farmers in one of the sites/identification of these farmers cumbersome due to unavailability of updated list of registered farmers/inaccessibilty of some communities

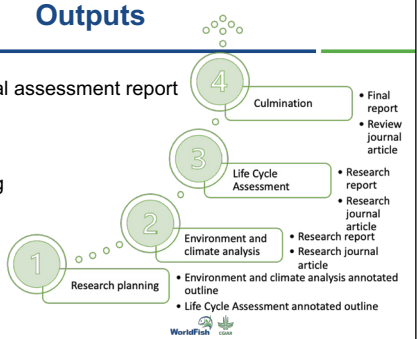
Outputs

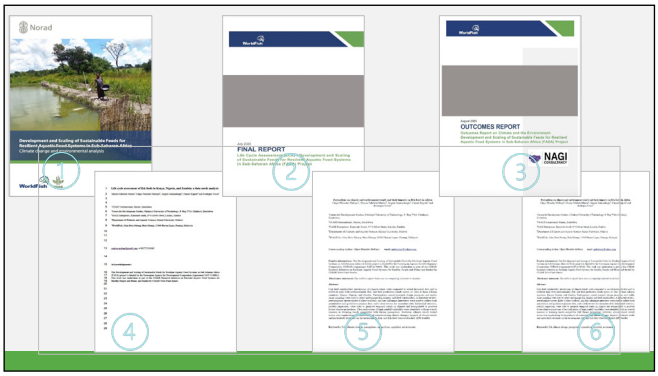
Climate and environmental assessment report

LCA report

Outcomes report including

3 journal articles





Recommendations for Year 2

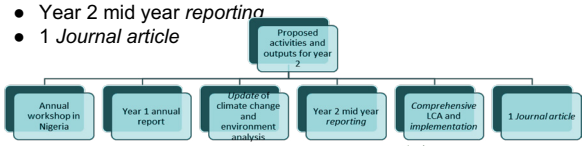
Update of climate and environmental analysis

Comprehensive LCA based on modeling

Capacity building

Year 2 activities

- Annual workshop in Nigeria
- Year 1 annual *report*
- *Update* on climate change and environment analysis
- *Comprehensive* LCA and *implementation*
- Year 2 mid year *reporting*
- 1 *Journal article*



Update on the implementation of year 1 of the FASA project in Gender and Social Inclusion Study Section
Gender and Social Inclusion (Includovate/Sujata Ganguly)

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Dr. Sujata Ganguly, Principal Researcher (GESI), Includovate

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Year 1 progress

- **Gender and social assessments (Gender Equality and Social Inclusion (GESI)) analysis for each country - Report**
- **Gender and Inclusive Development Action Plan (GIDAP) and Outcome report**
- **One Journal article**

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Introduction – GESI report

Research objectives
The primary purpose is to lead the gender and social inclusion work in the FASA project. The specific objectives are to:
1.Conduct gender and social assessments for the development and scaling of sustainable feeds;
2.Identify opportunities for the project to advance gender and social inclusion goals of Norad, WorldFish, and other key stakeholders within the novel feed landscape.

Research questions
1.What are the gendered and socially differentiated ***needs*** associated with the use of novel ingredients?
2.What are the gendered and socially differentiated ***risks*** associated with the use of novel ingredients?
3.What are the gendered and socially differentiated ***opportunities*** associated with the use of novel ingredients?

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Methodology used

- To conduct this Gender and Social Inclusion (GESI) assessment, the project utilised the ADS 205 domains, focusing on identifying key gender and social inclusion-related issues and constraints.
- The assessment involved a meticulous desk-based policy review of the legal frameworks governing the fisheries sector in Kenya, Nigeria, and Zambia, analysing existing laws, policies, and regulations related to fisheries resource management, including aquaculture, from a gender perspective.
- This review was followed by primary data collection, employing a mixed research approach involving 28 key informant interviews and 420 survey responses across the three countries.

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ADS 205 framework

INTERSECTIONALITY

Laws, Policies, Institutional Practices	Cultural Norms, Beliefs	Gender Roles, Responsibilities & Time Use	Access to, and Control Over Resources	Power & Decision-Making
The extent to which laws, policies, regulations, and institutional practices contain explicit gender biases	Locally accepted rules that influence how females and males behave in different domains	The division of labour between productive (market) economic activity and reproductive (non-market) activity that characterises gender-based roles and activity	How genders behave in different domains related to productive assets and resources and information access	The ability of men and women to decide, influence, & exercise control over material, human, intellectual and financial resource

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Gendered policy review of fisheries laws

Nigeria: The policies governing Nigeria's fisheries sector predominantly focus on technical aspects, overlooking broader social dynamics and gender differences within fishing communities. While some regulations benefit small-scale communities, *there's a lack of consideration for distinct experiences, needs, and contributions of men and women.* Nigeria's policies reinforce informal customary rules rooted in traditional norms, limiting women's access rights and decision-making power.

Despite this, there are opportunities for the FASA project to integrate gender-sensitive approaches, aligning with the National Gender Policy and the SDGs. On average, Nigeria's policies are gender unequal.

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Gendered policy review of fisheries laws

Zambia: Zambia's Fisheries Act (2011) and regulations exhibit gender inequality, but the National Water Policy stands out as gender-responsive, considering specific challenges faced by women in water management. The Water Management Act promotes gender balance in representation and management, encouraging women's meaningful participation. *Despite the gender-aware policies, access and tenure rights for women remain inadequately protected.*

The FASA project can address this imbalance by ensuring gender balance in aquaculture-related bodies and sharing gender studies with policymakers.

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Gendered policy review of fisheries laws

Kenya: Kenya's policies vary in their gender responsiveness. While the Fisheries Management and Development Act (2016) showcases gender responsiveness with provisions for women's representation and gender parity, other regulations demonstrate varying degrees of gender awareness. *Policy incongruence is significant in Kenya, creating challenges for effective gender integration.*

The FASA project can enhance institutional capacity by including women, youth, and marginalised groups in fish feed production, advocating for compliance, and adopting a gender-transformative approach aligned with the National Gender Policy.

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Fishfeed ingredients and usage

In Nigeria, the study revealed that respondents, regardless of gender, utilise *maize powder, genetically modified plants (GMP), and rice bran* for fish farming, although women's usage is slightly lower than men's.

- Maize powder is predominantly chosen due to its availability, a factor highlighted primarily by women. Men also mentioned its affordability and nutritional value as reasons for use.
- Genetically modified plants are favoured for their availability and nutritional benefits, with both men and women recognising these qualities.
- Rice bran is utilised mainly due to its availability, a factor mentioned by both men and women respondents.

These essential ingredients are typically acquired through purchases, primarily made by women, from local stores or suppliers in larger towns. Additionally, some individuals, mainly women, process maize powder at home.

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Fishfeed ingredients and usage

In Zambia, the study uncovered that respondents utilise *chicken manure and feathers, along with genetically modified plants*, for their aquaculture practices. Notably, women tend to use chicken manure and feathers more than men.

- Chicken manure and feathers are sourced and utilised, especially by women, due to their availability. Chicken manure is typically processed at home, reflecting a common practice among respondents, particularly women.
- GMP is utilised, with higher usage reported by women. Respondents, especially women, emphasised the affordability and availability of GMP, which are key factors influencing their choice. GMP is primarily purchased from local markets, making it accessible to aquaculturists, particularly women engaged in fish farming.

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Fishfeed ingredients and usage

In Kenya, the study revealed that respondents employ *plant leaves and rice bran* in their aquaculture practices, reflecting the diverse and resourceful approaches of aquaculturists in the region. Plant leaves are a common choice, with a higher percentage of men using them.

- These leaves are predominantly utilised due to their availability, making them accessible resources for aquaculturists. Respondents, particularly men, emphasised that plant leaves are processed at home, showcasing a sustainable and localised approach to aquaculture inputs.
- Rice bran is another significant input, with a higher percentage of women using it. The choice of rice bran is primarily based on its nutritious value, indicating a focus on the health and well-being of the aquatic organisms.

Unlike plant leaves, rice bran is purchased from the market, indicating a market-driven approach to acquiring this input.

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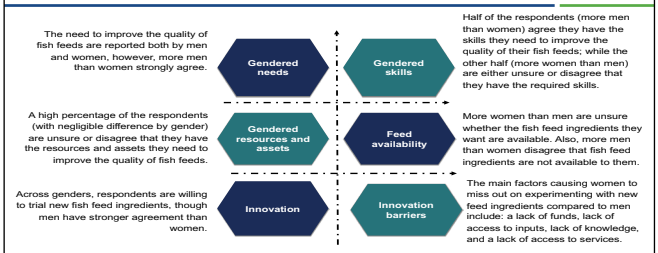
Gendered and socially differentiated needs and risks



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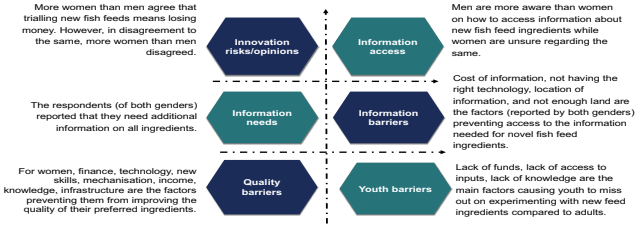
Gendered and socially differentiated needs and risks



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ADS 205 framework

Laws, policies, regulations, and institutional practices
The study highlights a significant gap in the participants' knowledge regarding the formal laws and regulations governing fisheries in all three nations. The household survey identifies grassroots organisations working to address barriers faced by women and youth, bringing attention to the lack of awareness surrounding these organisations.

While Kenya exhibits a higher level of awareness and a greater number of organisations in comparison to Nigeria and Zambia, the overall pattern emphasises the need for improved efforts to inform communities about the existence and initiatives of these organisations.

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ADS 205 framework

Pond construction /digging
Is men's work across countries, involving adult men in Nigeria and Kenya and also some young men in Zambia.

Collecting water from the pond
Adult women and men do this task a lot in Nigeria with 20% more men and even some young men involved. It is not often done in Zambia, but if it is adult men are responsible. A third of men do this in Kenya with some adult women and young men involved.

Pond cleaning
Half as many women as men clean ponds in Nigeria, Zambia and Kenya with some young men involved.

Feeding
Men and women are responsible for feeding fish across countries. Young men compared to adults doing the task with negligible difference across age among women in Zambia and Kenya. In Nigeria where adult women are responsible for doing the same.

Day to day management
Men and women are equally responsible for day to day management of the household in Nigeria, while it is majorly men's work in Zambia and Kenya.

Unpaid domestic duties: adult women do the bulk of the unpaid work across all countries, with some girls children helping and some boy children in Nigeria.

Paid work: men do more of the paid work across all countries, than women. All spouses tend to under report the amount of paid work done by their spouse.

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ADS 205 framework

Fishing/harvesting
Is mainly done by male household members, although women are involved to a lesser extent. Neither spouse is accurately aware of how much fish harvesting their spouse does. However, Nigeria has the largest number of women (62%) out of all the countries reporting their involvement in harvesting.

Selling the fish product
This is majorly done by women across countries, with no stark difference by age. In Nigeria and Zambia, a large percentage of men also sell fish. Neither spouse is accurately aware of how much fish selling their spouse does.

Processing
In Nigeria and Zambia, half to most of the sample do not process fish. If they do, it tends to be a role for women with no stark difference by age, except that in Kenya the task is mainly done by adult women.

Selling surplus produce at markets
In Nigeria there are a number of subsistence farmers in our sample but if there is a surplus then men and women equally sell it with no clear demarcation by age. In Zambia and Kenya, more younger women than men sell the surplus.

Food shopping at markets
Women do the most of the food shopping in all countries. Men self report their involvement although women do not see this contribution in their answers.

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ADS 205 framework

Timeuse
Respondents across the board express a high level of satisfaction, being either satisfied or very satisfied, with their available leisure time. Generally, individuals within these communities feel they have a sufficient amount of time for personal activities and relaxation.

Consequently, both male and female respondents of all age groups should have ample time to participate in training sessions and events for the NORAD-funded project. However, in Kenya, a significant majority of respondents from both genders indicate having only one hour of leisure time.

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ADS 205 framework

Access to and control over resources and information
Cultural norms impact interactions with extension officers, often necessitating spousal approval for training attendance. Key channels include farmers' cooperatives, digital platforms like SMS and WhatsApp, local leaders, and television.

In Nigeria, women primarily rely on friends and group meetings, while Zambian women highly value information from local leaders. Across various countries, young individuals tend to use the internet more than adults. In Kenya, 50% of young women prefer local leaders as their information source, compared to 35% of adult women. Conversely, 36% of young men and 62% of adult men rely on local leaders. Similar age-related differences were not significant in other countries.

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ADS 205 framework

Norms and beliefs
In rural fishing communities of Nigeria, Zambia, and Kenya, deeply rooted cultural norms sustain gender disparities, especially regarding women's access to technology and opportunities within the fishing industry.

The study highlighted prevalent norms, such as women predominantly handling unpaid domestic work, limiting their involvement in paid and physically demanding tasks. While some communities expressed approval for shared tasks, significant portions believed their societies would disapprove.

Particularly in Kenya, young women exhibited strong disapproval, emphasising deeply ingrained societal norms. Despite theoretical acceptance of task sharing, these beliefs often didn't translate into household practices.

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ADS 205 framework

Patterns of power and decision-making
The survey reveals a preference for shared decision-making in household and community matters, highlighting the importance of collaboration.

Gender disparities exist, particularly in Nigeria, but are less prominent in Zambia and Kenya. There's a notable desire among young individuals for increased involvement in decision-making, underlining the necessity for youth engagement initiatives.

In Nigeria and Kenya, women express a need for greater participation in decisions concerning earnings, emphasising the significance of women's economic empowerment. Public speaking comfort varies across countries, with evident gender differences, indicating a requirement for communication and confidence-building programmes. Zambia stands out for its higher overall comfort levels in public speaking. Additionally, the majority of respondents emphasise the importance of consulting spouses in decision-making processes.

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Eight consolidated GESI recommendations shaping the GIDAP

- Propose amendments in policies, laws and regulations to explicitly address gender disparities, ensuring equal opportunities and rights for all participants in the fisheries sector
- Improve the quality of what women feed their fish by engaging with women's groups to raise awareness about the importance of feed ingredient diversity and by providing them with the necessary skills to improve their fish feeds
- Encourage equal access to resources for women and marginalised communities, including economic assets, vital services, financial support, education, information, technology, capacity-building, and market opportunities
- Increase visibility of women and other disadvantaged groups through participation and decision-making.

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Eight consolidated GESI recommendations shaping the GIDAP

- Strengthen extension services to provide tailored support to women and youth in overcoming barriers to fish feed innovation
- Introduce timesaving technologies and mechanisation for producing fishfeeds and work with men to promote positive masculinity and unpaid domestic workload contribution
- Help male run businesses and financial inclusion businesses to reach more women and youth
- Implement a monitoring and evaluation system to assess the progress and effectiveness of the action plan.

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Journal article

Journal article - Kenya

Title: Beyond Tradition: Bridging Gender Disparities in Fish Farming Communities of Kenya

Authors: [Sujata, Wanja, Kristie, Rodrigue]

Abstract: The Gender and Social Inclusion (GESI) assessment undertaken in the context of the ADS 205 domains delved into the intricacies of gender dynamics within the fisheries sector in Kenya. This comprehensive study utilized a two-fold methodology, encompassing a detailed review of existing legal frameworks and primary data collection through interviews and surveys across six counties in Kenya. The research illuminated nuanced gender roles and responsibilities within fish farming households. While women were primarily engaged in unpaid domestic duties, men often undertook fish farming, feeding, and paid work. The study underscored the disparity between theoretical acceptance and practical implementation of shared responsibilities due to fear of societal disapproval, particularly among men. Despite these challenges, a preference for collaborative, shared decision-making was evident, emphasizing the need for targeted programs enhancing communication skills and economic empowerment, especially for women. The study also highlighted the pivotal role of information access and control. Cultural norms influenced interactions with extension officers, necessitating spousal approval for training attendance. Key communication channels included farmers' cooperatives, digital platforms like SMS and WhatsApp, local leaders, and television. Notably, microfinance groups in Kenya predominantly empowered women economically, while men engaged in diverse income-generating activities. Crucially, the research emphasized the need for policy coherence and gender-responsive legislation. While some policies demonstrated gender awareness, incongruences persisted, posing challenges for effective integration. The findings underscored the necessity of informed policy-making and tailored initiatives to address disparities, empower women economically, engage youth, and enhance communication skills within these communities. In summary, the GESI assessment provided deep insights into the multifaceted challenges within the fisheries sector. By addressing these challenges through focused interventions, there is a substantial opportunity to transform gender dynamics, enhance economic prospects, and foster better communication and collaboration within these communities. These findings serve as a foundation for targeted policy-making, enabling the development of inclusive initiatives that can usher in lasting change and promote gender equality in Kenya's fisheries sector.

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In partnership with

icipe CORAF SLU Swedish University of Agricultural Sciences ANLER AGRA ZAMBIA IITA Transforming African Agriculture

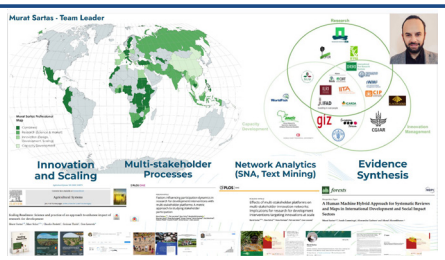
Introduction on organization and team, experience in market assessments and scaling, workplan to implement the FASA project : IITA (Murat Sartas)

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Scaling Team, Analyzing and Accelerating Use of Sustainable Feed at Scale

Norad IITA WorldFish CGIAR

Presenter: Dr. Murat Sartas



- Innovation, Scaling and Impact Management Experience
- Supported WorldFish thinking on scaling and establishing hubs
- Based in Rwanda in Norrsken, Africa's largest innovation hub with offices
  - Katapult
  - Kivu Choice

Analyzing and Accelerating Use of Sustainable Feed at Scale

1. Results and Approach
2. Team
3. Status and The Way Forward

Results
Overview

A. Lead
1. **Market Studies**
2. **Scaling Strategies**
3. **Workshops**

A. Support
1. **Provide intelligence and facilitate** innovation platforms
2. **Design and disseminate** communication products

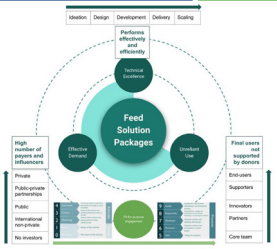
A. But also whenever and wherever possible
1. Build capacity of FASA team and partners on scaling
2. Build infrastructure to support co-design, co-development of solutions
3. Integrate FASA into business ecosystem

Results
Build capacity of FASA team and partners on scaling

Scaling is

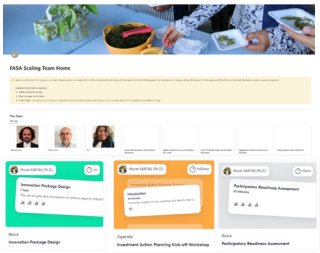
"Increasing the use of a solution at large"
- in users (adoption)
- in times (up)
- in types (up)
- in geographies (out)
- in objectives (cross?)
- in behaviour (deep)

Fundamental	Delivery	Scaling	Impact
the researchers and innovators,	do, can lead	influence, but cannot lead	trigger, cannot lead or plan
done with	partners	communities	societies
implemented by	a project	a program	with programs and policies
focus on	the solution, innovation	complementary solution packages	sectors, ecosystems
aim at	performance	use	benefit
build capacity of	technicians	users and supporters	organizations, networks, systems



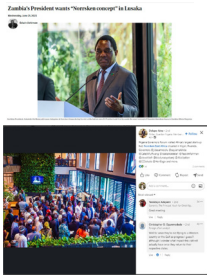
Results
Build infrastructure to support co-design, co-development of solutions

Specific Scaling Support Demand of the case managers of some USD 45 Million Initiative

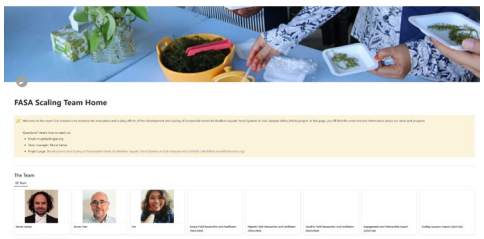


Results
Integrate FASA into business ecosystem

Katapult



Scaling Team



- Murat Sartas
  - Team Lead
  - Strategy and Enabler
- Bruno Tran
  - Measuring readiness of innovative solutions
  - Co-deploying them
- Pat Udomkun
  - Research rigour
  - Field experience
- Field Researcher and Facilitators
  - High quality data
  - Continuous engagements
- Support Experts
  - Facilitation
  - Communication

Status and the Way Forward

- *Finalizing the ontract (Aug)*
- *Designing the team (Sep)*
- *Developing the approach (Sep)*
- *Drafting the workplan (Oct)*
- Updating and finalizing the workplan (Nov)
- Completing the recruitments (Dec)
- Market Research (Apr 24)
- Scaling Strategies (June 24)

Thank You

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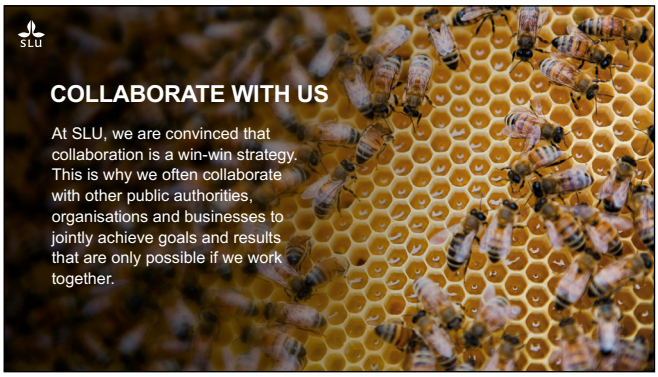
Update on the implementation of year 1 of the FASA project in Sweden
SLU (Sri Kartik Baruah)

Overview of Presentation

1. Overview of SLU-Sweden
2. Brief of the Research Group
3. Role of SLU in the FASA Project
4. Implementation of Year 1 of the FASA project in Sweden



Overview of SLU

Overview of SLU

Departments and faculties
SLU has 33 departments and units, here presented in alphabetical order. They are organised in four faculties.

- Faculty of Veterinary Medicine and Animal Sciences
- Faculty of Forest Sciences
- Faculty of Natural Resources and Agricultural Sciences
- Faculty of Architecture, Horticulture and Crop Production Sciences

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Overview of SLU

Faculty of Veterinary Medicine and Animal Sciences

QS Ranking: 3rd Best University (Agriculture & Forestry)

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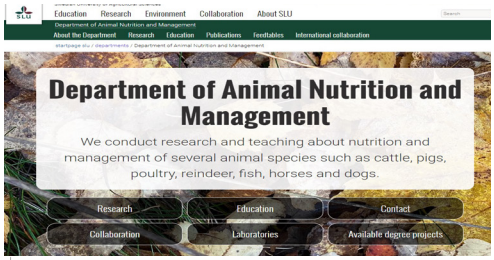
Swedish University of Agricultural Sciences



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Aquaculture Nutraceuticals Research Group: ANARG

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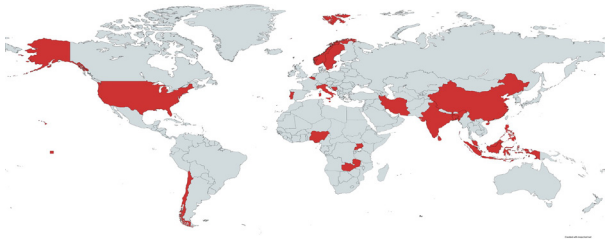
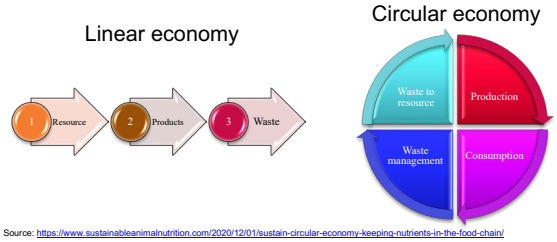
ANARG – International Cooperation

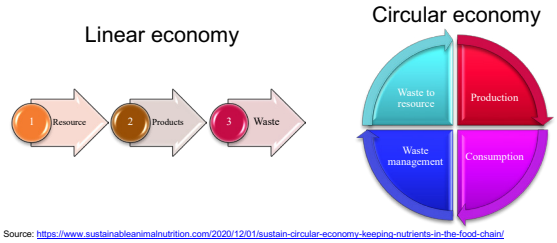


Research Lines: Novel & Circular Feed



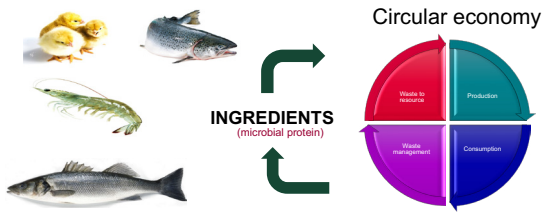
Source: https://www.sustainableanimalnutrition.com/2020/12/01/sustain-circular-economy-keeping-nutrients-in-the-food-chain/

Research Lines: Novel & Circular Feed



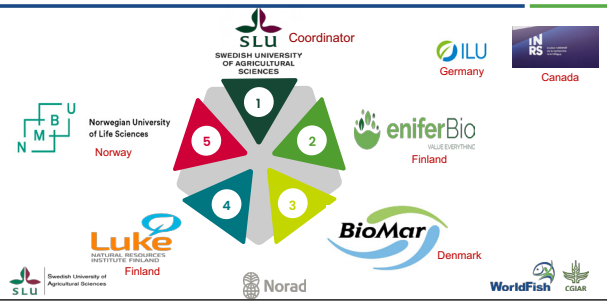
Source: https://www.sustainableanimalnutrition.com/2020/12/01/sustain-circular-economy-keeping-nutrients-in-the-food-chain/

Sustainable Animal Farming: Waste2Feed Approach



Source: https://www.sustainableanimalnutrition.com/2020/12/01/sustain-circular-economy-keeping-nutrients-in-the-food-chain/

Transnational Projects on Circular Feed



Workshop on Microbial Feed Ingredients

Participants: > 74; both from academia & industry (Hybrid)

NordicFeed ForestFeed

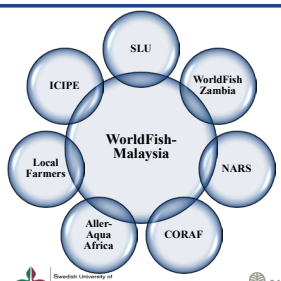
NordForsk

The Research Council of Norway

FOODS of NORWAY

Ås, Norway: 26th September, 2023

Role of SLU in FASA Project: Academic Partner

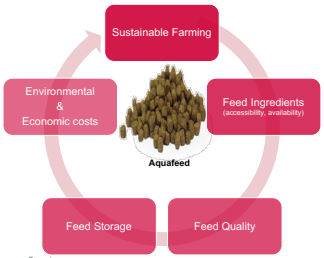


- **International Centre of Insect Physiology & Ecology, Kenya**
- **West & Central African Council for Agricultural Research (CORAF), Nigeria**
- **Aller Aqua Africa (Zambia)**
- **Local Feed Millers & Fish Farmers Groups**
- **National Agricultural Research Services (NARS) agencies of project countries**

Role of SLU in FASA Project

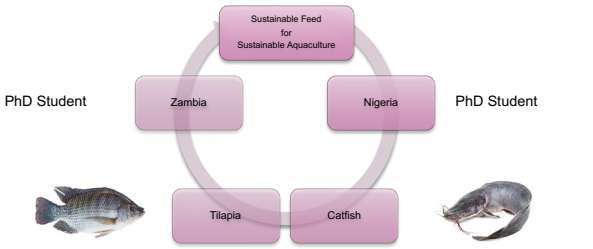
- Capacity Building
- Conduct Research & Development Activities on Sustainable Feed: 2 PhD Research Projects (Nigeria & Zambia)
- Contribute to other relevant activities of the project

Aquaculture Africa: Constraining Factors



Aquaculture Africa: Constraining Factors

Update on Implementation (year 1) : 2 PhDs Selected



PhD Advisory Members


Assoc. Prof. Kartik Baruah


Prof. Torbjörn Lundh


Prof. Mette SØRENSEN (Norway)

WorldFish Center


Dr. Rodrigue Yossa


Assoc. Prof. Christos Palaiokostas

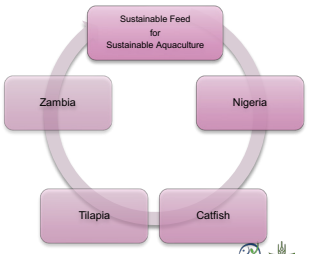

Dr. Aleksandar Vidakovic


Dr. Parisa Norouzitallab

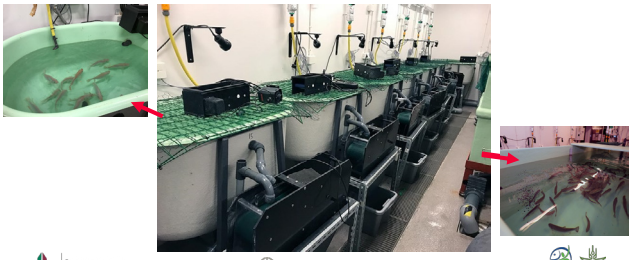
Partner Country members

Import of feed ingredients: Zambia to Sweden

#	NAME OF INGREDIENT
1	FISH MEAL (SIAVONGA KAPENTA)
2	GRINDED CRAFYFISH MEAL
3	KAKEYA (FISH MEAL)
4	CATERPILLAR (TUKANJA)
5	CATERPILLAR (VINKUBALA)
6	FISHMEAL(CHISENSE)
7	SUNFLOWER CAKE MEAL
8	VELVET BEANS MEAL
9	VELVET BEANS SEED
10	TEA WASTE
11	CHIKANDA POWDER

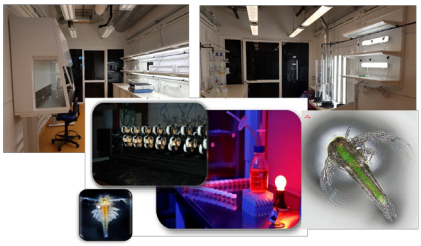


Fish wet lab facilities at SLU



Feed Technology Lab Facility at SLU

Artemia as model in Feed Ingredients Screening



https://www.slu.se/en/departments/animal-nutrition-management/research/our-laboratories-at-huv/artemia-lab/

FASA Project Activities in Sweden

Swedish Launch of FASA Project

7 Mar via Zoom

Swedish Launch of the WorldFish Project: "Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa"

SLU is the academic partner in a 5-year WorldFish project funded by the Norwegian Agency for Development Cooperation (NORAD). Most welcome to our Swedish launch of this aquaculture project focusing on development and scaling of sustainable feeds for resilient aquatic food systems in Sub-Saharan Africa.

- Over 50 participants
- 09 countries (Asia, Europe & Africa)
- SLU Global, SIDA & Stockholm Resilience Center
- ACKNOWLEDGEMENT: SLU Aquaculture Platform & SLU Global

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Update on country ToC and Annual outcome monitoring studies
WorldFish HQ (Timothy Manyise)

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Theory of Change and Annual Monitoring Studies

Timothy Manyise (PhD) – WF HQ

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Outline

- Introduction
- Contextualising the theory of change
- Ongoing baseline characterization studies
- Key messages and recommendations
- Q&A

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Introduction

- We operate in dynamic environments with interrelated components.
- The FASA Project is not an isolated entity but is embedded in larger systems.
- A systems approach allows us to uncover and comprehend the ripple effects of intervention activities.
- Avoiding underestimating impact of intervention activities.
- Anticipation and management of potential negative repercussions.

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Workshops to contextualizing the theory of change to inform monitoring

To explore the potential socio-ecological and economic impact of developing and scaling fish feed using novel ingredients in Zambia, Kenya and Nigeria.

The workshop aim to;

i) Map the problems or issues around fish feeds that need to be addressed

ii) Map the network of actors surrounding fish feeds

iii) Map the potential systemic impact of the FASA project

iv) Prioritize points of impact assessment.

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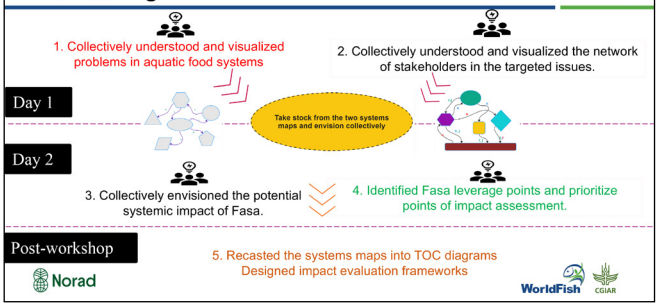
Contextualizing theory of change to inform monitoring



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Contextualizing theory of change to inform monitoring

Stakeholders: Feed millers, NGOs, DoF, feed ingredient producers, fish farmers, aggregators, processors, farmer association, women and youth groups, feed manufacturing certification bodies (25 -30 participants * 3 workshops – Nigeria, Kenya and Zambia

Stakeholders mapping the interconnectedness of access, affordability and availability of fish feed during the systems ToC workshop in Kenya

Stakeholder presenting value chain actors and resource flow in the Kenya fish feed sector during the systems ToC workshop in Kenya in March 2023

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Contextualizing theory of change: Participatory systems mapping

Stakeholder envisioning and mapping the potential socio-ecological impact of the FASA project during the systems ToC workshop in Zambia

Stakeholder mapping innovation partnerships for the FASA project in the Zambian fish feed sector during the systems ToC workshop in February 2023

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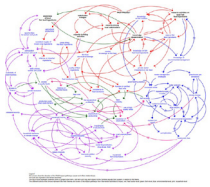
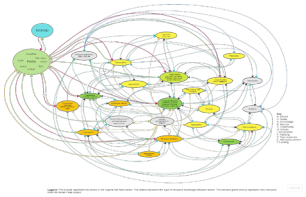
Contextualizing theory of change: Outputs of systems mapping workshops





From the workshop paper versions, maps were synthesised, digitised and shared with participants for feedback with a textual narrative

https://cgspace.cgiar.org/handle/10568/131585

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Contextualizing theory of change: outputs of systems mapping workshops

Participants during the FASA TOC workshops pausing for photos in front of their systems maps in February and March 2023

https://cgspace.cgiar.org/handle/10568/131585

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Contextualizing theory of change: outputs of systems mapping workshops

Stakeholders: Feed millers, NGOs, DoF, feed ingredient producers, fish farmers, aggregators, processors, farmer association, women and youth groups, feed manufacturing certification bodies (25 - 30 participants * 3 workshops – Nigeria, Kenya and Zambia

https://cgspace.cgiar.org/handle/10568/131585

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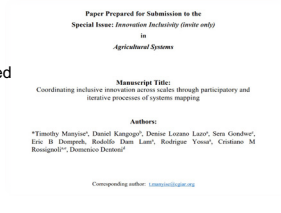
Contextualizing theory of change: outputs of systems mapping workshops

Scientific article
One journal manuscript prepared and submitted for publication.

- Peer-revied manuscript proposal accepted
- Full manuscript under review
- Using examples from the workshops to illustrate how inclusive innovation can be coordinated using participatory systems mapping.


Paper Prepared for Submission to the
Special Issue: *Innovation Inclusivity (invite only)*
in
Agricultural Systems

Manuscript Title:
Coordinating inclusive innovation across scales through participatory and iterative processes of systems mapping

Authors:

Corresponding author:

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Baseline characterization of the practices and utilization of fish feed ingredients

Study 1: Six states in Nigeria, 24 LGAs.
- 600 fish farmers.
- 180 ingredient processors.
- Survey tools designed.
- Ethical approval obtained.
- Enumerators selected.
- Survey (November - December)

Study 2: Six provinces in Zambia, 11 districts
- 600 fish farmers, 120 ingredient processors
- Questionnaire designed and programmed in KoBo.
- Ethical approval (in progress)
- Survey (Jan 2024)

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Four key messages and recommendations

i) Impact assessment should focus on both the intended and unintended consequences of the intervention

ii) It is necessary to profile and identify who the project's activities will likely impact, either directly or indirectly.

iii) Ensure that different project activities such as training sessions, workshops, information sessions, demonstrations by different partners are synchronized to ensure effective follow-up evaluations.

iv) Timely provision of information to ensure that evaluation assessment are conducted on time.

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- Questions
- Suggestions
- Answers

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Perspectives of Aller Aqua Zambia on the implementation of year 1 of the FASA project
Aller Aqua (Alexander Michael Greiling)

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Perspectives of Aller Aqua Zambia on the implementation of year 1 of the FASA project
07.11.2023 – Dr. Alexander M. Greiling (Virtual Presentation)

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Perspectives of Aller Aqua Zambia on the implementation of year 1 of the FASA project

1. Update on Aller Aqua Zambia
2. Market Trends
3. Raw Material Scoping Study
4. Possible Outlook and Perspectives

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Update on Aller Aqua Zambia

- Increased production by approx. 1000t/month compared to last year
- Significantly increased purchase of raw materials
- ~80% sourced locally within Zambia
- Significantly increased local value addition to:
  - Farming
  - Transport/logistics
  - Job creation
  - Aquaculture

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Market Trends

- More fish feed factories/ competitors entering East African Market
  - Can service Zambia and surrounding countries too
  - Good for Aquaculture Production as competition will likely bring prices down
- Primary Production of Agricultural Crops (Grains, Soya, etc.) stable
  - Processed crops and by-products also available
  - Nothing new, just more of common products
- Animal by-products still not locally available in sufficient quantities and quality
  - East Africa has access to ports and can import at better rates

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Raw Material Scoping Study

- Great geographical coverage
- Provides good insight into primary production
- Revealed that there is no animal by-products available
- Only primary animal-derived resources (fish, crayfish, caterpillars)
  - Are these not in great part directly consumed?
- There is great room for development in the local industry!

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Possible Outlook and Perspectives

- Evaluation of untapped and available resources
  - Abattoirs to evaluate potential animal by-product processing potential
  - Beef and Poultry by-products
- Evaluation of untapped yet unavailable resources
  - Pea proteins?
  - Other processing technologies?
- Evaluation of commercial aspect of raw material market
  - Farmers' Cooperatives?
  - Small scale processing and value addition (and Quality Control)? e.g. maize

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In partnership with

icipe CORAF SLU Swedish University of Agricultural Sciences Aller Aqua Zambia IITA Transforming African Agriculture

Perspectives of NRDC on the implementation of year 1 of the FASA project
NRDC (Mr. Melon Mulamfu)

Content

1. Introduction
2. Brief History
3. Project components - Planned
4. Project components – Achieved
5. Benefits

Introduction

The Natural Resources Development College (NRDC) is one of the seven Agricultural colleges in Zambia under the Ministry of Agriculture. The college was established in 1964 through a declaration by the First Republican President Dr. Kenneth David Kaunda.

AIM

Training middle level human resource for the Agriculture and related sectors. In ten (10) disciples at a diploma level

Brief History

The NRDC Wet Laboratory was upgraded in 2019 through the design and building of a flow-through aquaculture system to conduct Research Projects.

WORLDFISH

"Replacing fishmeal with a single cell protein feedstuff in Nile tilapia *Oreochromis niloticus* diets"

PROJECT 1

"Performance of *Oreochromis niloticus* and *Oreochromis andersonii* in controlled laboratory conditions in Zambia."

PROJECT 2

NRDC students and staff then utilized the Fish Wet Laboratory to conduct Basic Research. Unfortunately between 2021 -2022 operations came to a halt due to theft.

RESEARCH

- In 2023 the Laboratory was upgraded by the (NORAD - FASA project) to facilitate hosting of the novel feed experiments.
- To avoid previous challenges, NRDC upgraded its security systems to the Fish Laboratory and entire college

FASA UPGRADE

Project components – Planned NRDC

01 NRDC to provide Fish Wet Laboratory and technical support to the Upgrade of a Recirculating Aquaculture System through WorldFish (NORAD funded project –FASA).

02 NRDC to provide a contact person

03 NRDC to provide Security

04 NRDC shall host the feed experiments in the Fisheries Laboratory

Project components – Achieved

01 Upgrade of the Fish Lab to a Recirculating Aquaculture System through WorldFish support.

Project components - Achieved

Mrs. Majory Chama
Training Officer
Department of Fisheries science and Aquaculture

02 NRDC has provided a contact person to support the project.

Project components - Achieved

- ✓ Lighting System
- ✓ Main entrance Security Gate
- ✓ Hired Security Company
- ✓ Installation of burglar-bars on all windows in the Wet Laboratory.

03 NRDC has provided Security

Project components - Achieved

04 NRDC is hosting the fish feed project experiments in the Wet Laboratory.

Benefits

1. The Fisheries Science curriculum was upgraded.

2. Construction of Aquaculture Skills Training Centre
   - ✓ Effective and efficient Practical student activities
   - ✓ Hosting of short demand driven courses to boost small scale fish farming.

3. Installation of Recirculation Aquaculture System in the Fish Wet Laboratory
   - ✓ NRDC Staff and student capacity building in research activities
   - ✓ Exposure of students to research findings through seminars and scientific talks.

Update on Project Finance and Technical Report
WorldFish (Tan Chao Yan and Tan Ban Swee)

Update on Project Finance

- Project Currency - Norwegian Kroner (NOK)
- Project Grant – NOK 80,000,000
- Project Fund Exchange Rate – Bank Fund Receipt Rate
- Ownership of Equipment, Consumables and IP vested in WorldFish or cooperating partners
- Project's accounting records must be kept for at least 5 years from the time of Norad's approval of Project's final report
- Zero-tolerance policy against corruption and other financial irregularities will be applied to WorldFish and its cooperating partners

Update on Project Finance

Procurement Provisions

- Contract must be awarded to the most economically advantageous tender
- Procurement of award with value of less than NOK 500,000 may be awarded following any procurement procedure established by the Grant Recipient
- Procurement of award with value exceeding NOK 500,000 shall be awarded based on one of the following procurement procedures:
  i. Open tender procedure
  ii. Restricted procedure
  iii. Competitive procedure with negotiation
- Where Grant Recipient does not launch open tender procedure, it shall justify and document in writing the choice of tenderers that are invited to submit an offer

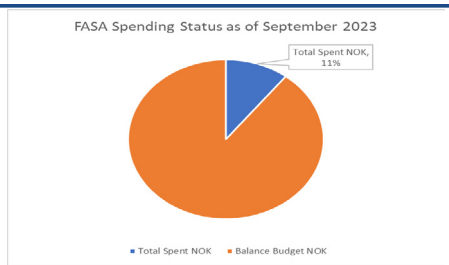
Update on Project Finance

Year 1 (1st July 2022 – 30th June 2023) Spending Status
- NOK 6,881,809

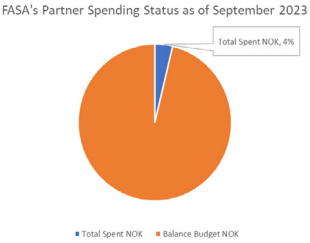
Year 2 (1st July 2023 – 30th September 2023) Spending Status
- NOK 1,523,817

Year 1 & Year 2 Total Cumulative Expenditure
- NOK 8,405,626

Update on Project Finance



Update on Project Finance



Technical / Financial Reporting

FASA Project Implementation Period: 1st July 2022 – 30th June 2027

FASA Project Technical / Financial Reporting Schedule
- 1 July – 31 December 2022 (Submission Deadline - 15 April 2023)
- 1 January – 31 December 2023 (Submission Deadline – 15 April 2024)
- 1 January – 31 December 2024 (Submission Deadline – 15 April 2025)
- 1 January – 31 December 2025 (Submission Deadline – 15 April 2026)
- 1 January – 31 December 2026 (Submission Deadline – 15 April 2027)
- 1 July 2022 – 30 June 2027 (Final Report Submission Deadline – 31 October 2027)

Financial Reporting

FASA Project Annual Audit Schedule

- 1 July – 31 December 2022 (Submission Deadline - 1 June 2023)
- 1 January – 31 December 2023 (Submission Deadline – 1 June 2024)
- 1 January – 31 December 2024 (Submission Deadline – 1 June 2025)
- 1 January – 31 December 2025 (Submission Deadline – 1 June 2026)
- 1 January – 31 December 2026 (Submission Deadline – 1 June 2027)
- 1 July 2022 – 30 June 2027 (Final Report Submission Deadline – 31 October 2027)

Technical / Financial Reporting

WorldFish Partner Technical & Financial Reporting

- SLU & IITA will follow submission schedule and reporting requirements as stated in original sub-grant agreement (no changes)
- CORAF will follow submission schedule and reporting requirements as stated in new addendum to sub-grant agreement (refer to subsequent slide)
- ICIPE will follow submission schedule and reporting requirements as stated in new addendum to sub-grant agreement (refer to subsequent slide)

Technical / Financial Reporting

WorldFish Partner - CORAF & ICIPE

- Reporting frequency : Quarterly
- Deliverables required for submission : Technical Report, Financial Report, Invoice, Quarterly Forecast Work Plan & Quarterly Forecast Budget
- Submission Schedule (Technical & Financial Reporting) :
  i. 2023 (Remaining Submission Deadline) – 31 Dec 2023 (Fin) / 31 Jan 2024 (Tech)
  ii. 2024 – 30 Apr 2024; 31 July 2024; 31 Oct 2024; 31 Dec 2024 (Fin) / 31 Jan 2025 (Tech)
  iii. 2025 – 30 Apr 2025; 31 July 2025; 31 Oct 2025; 31 Dec 2025 (Fin) / 31 Jan 2026 (Tech)
  iv. 2026 – 30 Apr 2026; 31 July 2026; 31 Oct 2026; 31 Dec 2026 (Fin) / 31 Jan 2027 (Tech)
  v. 2027 – 30 Apr 2027; 15 May 2027 (for final report from 2022 – 2027)

Appendix 4. Slides presentations for Day 2

Detailed planning of work in Kenya ICIPE (Dr. Chrysantus Mbi Tanga)

Team Members

Partnerships

1. Kenya Marine and Fisheries Research Institute (KMFRI)
2. Kamuthanga Fish Farm, Machakos, Kenya
3. Victory Farms Ltd, Kenya (Private sector)
4. National Universities (e.g., University of Eldoret etc)
5. JABALI FISH FARM (JABALI FISHERIES TRADERS)
6. Beach Management Units (BMU), County Government
7. Kenya Bureau of Standards (KEBS)

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Detailed Planning of Work in Kenya

Activities	Proposed timeline: 2022 -2026																			
	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Recruit new staff																				
Recruit 10 MSc																				
Workshops in target countries																				
1.1.1.1: Conduct literature review of relevant research documents and protocols																				
1.1.1.2: Design scoping studies in Kenya																				
1.1.1.3: Data collection (including sample ingredients) and analysis																				

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Detailed Planning of Work in Kenya

Activities	Proposed timeline: 2022 -2026																			
	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.1.1.4: Report preparation and publication																				
1.5.1.1: Design research protocols																				
1.5.1.3: Secure animal ethics approval																				
1.5.1.4: Conduct 12 tilapia experiments and 8 catfish experiments in Kenya																				
1.5.1.5: Analyse data and samples																				
2.1.2.1: Organise and facilitate 1 online stakeholder workshop per country																				

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Detailed Planning of Work in Kenya

Activities	Proposed timeline: 2022 -2026																			
	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
2.1.2.2: Reports preparation and dissemination																				
2.1.3.1: Synthesize all findings on ingredients generated so far to enable prioritization																				
2.1.3.2: Discuss all results with internal and external partners (including 1 online workshop per project country) and select 15 ingredients																				

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Detailed Planning of Work in Kenya

Activities	Proposed timeline: 2022 -2026																			
	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
2.3.2.1: Organise and facilitate 4 training workshops per country																				
2.3.2.2: Reports preparation and dissemination																				
3.1.1.1: Organise and facilitate 2 stakeholder workshops per country																				
3.1.1.2: Report preparation and dissemination																				
3.2.1: Develop innovation platforms for bringing key scaling stakeholders together																				
3.2.2: Identify and set up demonstration sites and model farms																				
3.2.3: Host farmer field days on demo sites and model farms																				
3.2.4: Build partnerships with cooperatives to test and use novel feeds																				
3.2.4: Support establishment of new feed services and businesses by young people, farmers, etc																				

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Detailed Planning of Work in Kenya

Activities	Proposed timeline: 2022 -2026																			
	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
3.2.5: Support small-scale millers to develop new product based on project's innovations																				
3.2.6: Build partnerships with NGOs, private sector, and extension service providers to incorporate project's knowledge and innovations to aquaculture farmers																				
3.3.2.1: Develop and publish factsheets (online and printed), BMPs, and project report																				
3.3.2.5: Design and conduct context-specific outreach to target end-users (farmers and millers) to support scale-up																				

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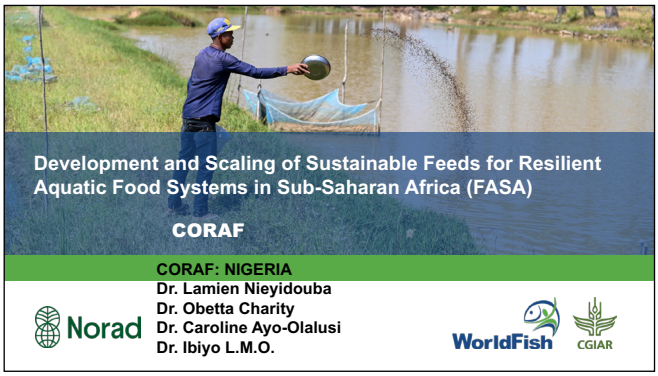
Detailed planning of work in Nigeria : CORAF (Charity Obetta)



Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

CORAF

CORAF: NIGERIA

Dr. Lamien Nieyidouba
Dr. Obetta Charity
Dr. Caroline Ayo-Olalusi
Dr. Ibiyo L.M.O.

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Nutrients requirements of improved strains of Tilapia and African Catfish using locally available ingredients in Nigeria.

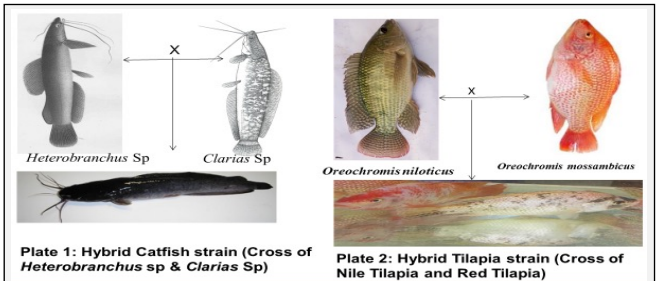

Plate 1: Hybrid Catfish strain (Cross of *Heterobranchus* sp & *Clarias* Sp)

Plate 2: Hybrid Tilapia strain (Cross of Nile Tilapia and Red Tilapia)

Nutrients requirement of improved strain of African catfish (Hybrid of *Heterobranchus Spp. X Clarias gariepinus) and* Hybrid Tilapia (*Oreochromis niloticus X Oreochromis mossambicus) with both* compared with their locals in Nigeria

Project Title: Nutrients requirements of improved strains of Tilapia and African Catfish using locally available ingredients in Nigeria.

1. Introduction
2. Project key facts
3. Project goals
4. Project components
5. Partnerships

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Introduction

- Catfish play a crucial role in sustaining Nigeria's aquaculture industry, making the catfish species particularly vital (Owodeinde and Ndimele, 2011). In recent times interest in tilapia is growing and farmers are now deliberately farming tilapia for harvest.
- Hybridization which is the breeding of individuals from different genetic background has been recognized as a tool in aquaculture industries for stock improvement and management purposes.

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Introd.

- **Tilapia and catfish have been identified to require the same ten essential amino acids as other finfishes.**
- **The most limiting amino acids in plant based ingredients are lysine and methionine so the scope of this project will be focusing on these amino acids.**

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Project key facts

- Provision of data for sustainable fish feeds production in Nigeria.
- Formulation and Production of a balanced affordable and quality fish feeds using locally available ingredients.
- Improved nutritional quality of fish feed to enhance optimum growth of fish which will contribute to increase in fish farmers incomes, improve nutrition and alleviation of poverty.

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Project Goals

To determine the nutrients requirements of hybrid strains of *Oreochromis niloticus* cross with *O. mossambicus* compare with the known level for the O. niloticus strain.

To determine the nutrients requirements of hybrid {*Heterobranchus spp.* cross with *Clarias gariepinus* (*Heteroclarias*)} and local strains of *Clarias gariepinus.*

To compare the requirement of the local pure line with the hybrid

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Project components Contd.

Nutrients requirements of improved strains of Tilapia and African Catfish using locally available ingredients in Nigeria.

1. Methionine requirement
2. Lysine Requirement
3. Vitamin C Requirement and
4. Mineral (Calcium and Phosphorus) requirement.

Eight experiments in all.

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Project components Contd.

- Methionine requirement of improved African catfish (Hybrid of *Heterobranchus Spp X Clarias gariepinus)* compared with local *Clarias gariepinus and* Hybrid Tilapia (*Oreochromis niloticus X Oreochromis mossambicus)* in Nigeria.
- Rehabilitation of experimental system (WRS) just concluded.
- Procurement of experimental fish.
- Acclamation of experimental fish species on-going
- Feed formulation, Sampling and Chemical analysis are strong components of this experimentation. (proximate composition

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Time line for Catfish and Tilapia studies' Activities

S/No	Milestones	Months
1	Procurement of Water quality kits, Laptops, office cabinet, Chairs and tables.	
2	Purchase of ingredients for fish diets	Nov. 2023
3	Preparation of experimental feeds	"
4	End of acclimation and set up of experiments	Nov. 2023
5	Feeding Experiment: twelve weeks monitoring involving water quality management, samplings, Analysis of feeds (twelve samples) and fish (one initial and final samples from all the 2 X 6 groups making a total of twelve with replicates) considering all parameters. For Methionine.	Nov 2023 - Feb 2024
6	Analyses of samples and data	Feb –Mar'24
7	Report preparation for submission and publication	Apr. 2024

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Time line for Catfish and Tilapia studies' Activities

S/No	Milestones	Months
8	Preparation of Research protocols on Lysine studies	April 2024
9	Purchase of ingredients for fish diets	May 2024
10	Preparation of experimental feeds	"
11	Purchase of fingerlings after feed preparation for lysine studies	May, 24
12	Feeding Experiment: Twelve weeks trial, involving water quality management, samplings, Analysis of feeds (twelve samples) and fish (one initial and final samples from all the 2 X 6 groups making a total of twelve with replicates) considering all parameters. For Lysine	June-Aug 24
13	Analyses of samples and data	September
14	Report preparation and publication	Sep - Oct
15	International Workshop/Annual review meeting to be held in Zambia facilitated by WorldFish	November
16	Local Workshop to share results to farmers and millers	Nov., 24

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Time line for Catfish and Tilapia studies' Activities.

S/No	Milestones	Months
17	Preparation of Research protocols on Vitamin C studies	Nov 2024
18	Purchase of ingredients for fish diets	Nov 2024
19	Preparation of experimental feeds for Activity 2.1	"
20	Purchase of fingerlings after feed preparation for Vit C studies	Dec 24
21	Feeding Experiment: Monitoring involving water quality management, samplings, Analysis of feeds, six samples and fish (one initial and final samples from all the 2 X 6 groups making a total of twelve with replicates) considering all parameters outline above . For Vitamin C	Jan - Mar 25
22	Ph. D Student Research need to commence with associated activities	Jan-June
23	Analyses of samples and data	Mar/Apr '25
24	Report preparation	May, 2025
25	Organization of local workshop	June 2025
26	International Workshop/Annual review meeting to be held in Kenya facilitated by WorldFish	November

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Time line for Catfish and Tilapia studies Activities

Activities to be carried out under requirement studies in improved strain of Catfish and Tilapia

(Hybrid) in 2024 and 2025 if activities before its execution are accomplished as stated in annual work plan:

S/No	Milestones	Months
17	Preparation of Research protocols on Mineral studies	July, 2025
18	Purchase of ingredients for fish diets	July 2025
19	Preparation of experimental feeds for Activity 2.1 & Student	"
20	Purchase of fingerlings after feed preparation for Vit C studies	July 2025
21	Feeding Experiment: Monitoring involving water quality management, samplings, Analysis of feeds, six samples and fish (one initial and final samples from all the 2 X 6 groups making a total of twelve with replicates) considering all parameters outline above . For Mineral	Aug-Oct 25
23	Analyses of samples and data	Nov 2025
24	Report preparation	Nov 2025
25		
26	International Workshop/Annual review meeting to be held in Kenya facilitated by WorldFish	November

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Partnerships

Fish Farmers and Millers

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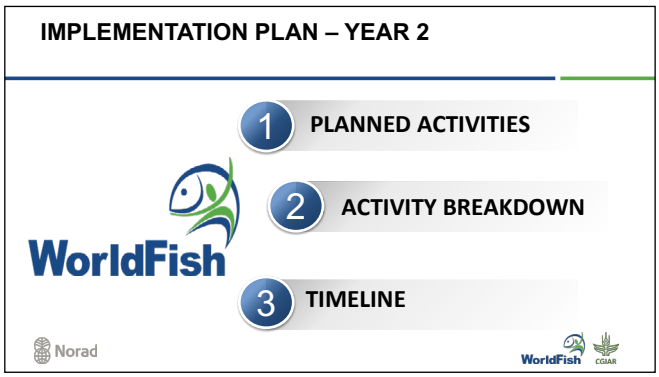
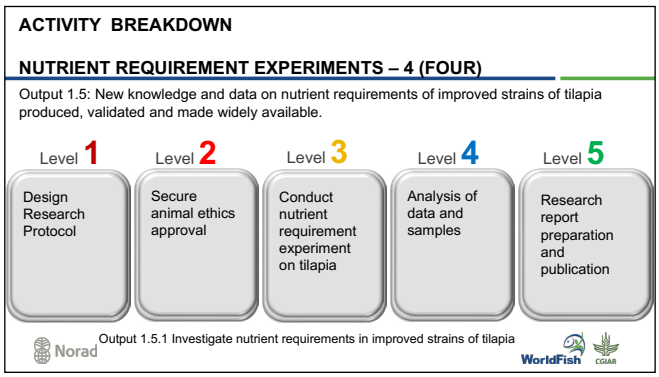
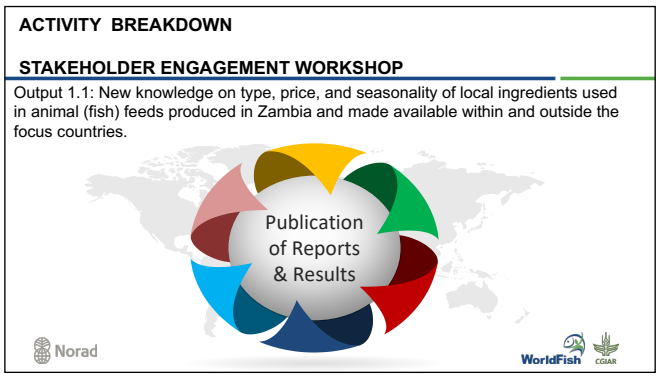
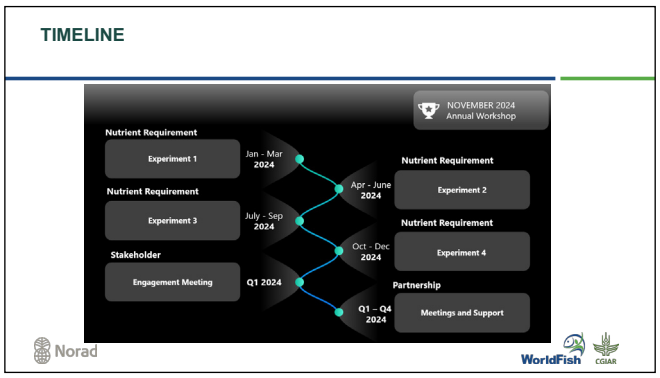
Detailed planning of work in Zambia: WorldFish Zambia (Arthertone Jere and Gregory M Kasanga)









FASA Project work in Malaysia

By Rodrigue Yossa, Nurulhuda A. Fatan, Aaqillah Amr Mohd Amran, Muhammad Rahimi Ramli & Ning Shahira
&

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Content

1. Detailed planning of work in Malaysia
2. Aquaculture Research in Malaysia
3. Other project works in Malaysia

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Detailed planning of work in Malaysia

	Year 2				Year 3			
Outcomes, Outputs, Activities, & Subactivities	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Outcome 2: Quality of at least 15 local ingredients has been improved through various processing techniques and the ingredients are used by stakeholders in the 3 target countries, including local millers and farmers, to produce 9 novel, cost-efficient feed formulations, to improve aquaculture productivity and resilience.								
Output 2.1: New data and knowledge on local ingredients generated, used in the formulation of novel fish feeds, and made widely available								
Activity 2.1.1: Conduct experiments to priorities 15 ingredients								
Subactivity 2.1.1.2: Conduct digestibility experiments of ingredients samples collected for output 1.1								
Subactivity 2.1.1.3: Database development and research report preparation and publication								
Activity 2.1.3: Produce ingredients and co-formulate fish feeds								
Subactivity 2.1.3.1: Synthesize all findings on ingredients generated so far to enable prioritisation								
Subactivity 2.1.3.2: Discuss all results with internal and external partners (including 1 online workshop per project country) and select 15 ingredients								
Project Management (Grants and contracts, MEL, Data Management Impact Assessment, Communication, Procurement, Finance, Accounting Consultants, Reporting internal and to the donor)								

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Apparent digestibility of sustainable ingredients from Sub-Saharan Africa countries in the GIFT strain of tilapia (*Oreochromis niloticus*)

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Digestibility experiment

1. To study the **nutritional composition, apparent digestibility coefficients, and anti-nutritional factors** of various sustainable local ingredients obtained from Sub-Saharan African
2. To examine the **growth performance and the biochemical composition** of GIFT, *Oreochromis niloticus* fed with sustainable local feed ingredients
3. To assess fish **health status** through the analysis of histopathology and cortisol levels when fed with sustainable local feed ingredients

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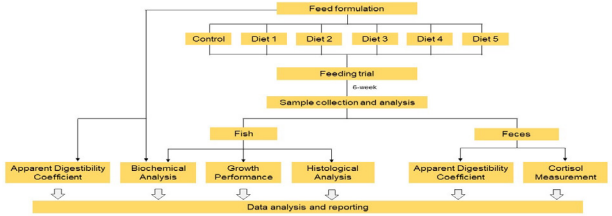
Experimental Design



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Upcoming Digestibility Experiments Year 2

Digestibility 1: Zambia (November – December 2023)
Digestibility 2: Nigeria (Feb – March 2024)
Digestibility 3: Kenya (May – July 2024)
Digestibility 4: Zambia (Sep – Oct 2024)

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Digestibility experiment : Sample Ingredients

- Shipment of sample ingredients from Nigeria and Kenya
- Conduct nutrient analysis
  - Proximate analysis
  - Amino acids
  - Fatty acids
  - Anti Nutritional factors

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Other project works in Malaysia

Solid-state fermentation: a tool for improving the nutritional value of novel feed ingredient

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Objective of the study

- To investigate the effect of solid-state fermentation (SSF) on the changes in the nutrients profile particularly protein and fiber and reduction of anti-nutritional factors in agriculture waste
- Optimization of solid-state fermentation parameters for the production of functional product by the microorganism on selected agriculture waste

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Plan of SSF activities at WorldFish Penang

- Further collaboration with School of Technology Industry, USM Penang
- Finalization research protocol on SSF in an application using bacteria, yeast, and fungi
- Conduct SSF experiment
  - Investigate the effect of SSF on the nutrient profile of agriculture waste meal, including changes in micronutrient composition (protein content, lipid content, carbohydrate, fibre, ash, minerals, fatty acids and amino acid profiles)
  - Optimization of SSF process parameters (eg: moisture content, temperature, pH, and inoculum concentration, for effective fermentation
  - Identification of potential functional product
- Feeding trial on use of SSF product on Tilapia

Plan for SSF activities

Activities	2024
Optimization of SSF process parameters (eg: microbes, moisture content, temperature, pH, and inoculum concentration, for effective fermentation	By Q2
SSF experiment to produce valuable and functional product-	By Q3
Feeding trial on Tilapia	By Q4

Enhancing reproductive performance using high-quality oil in the broodstock of the GIFT strain of tilapia (*Oreochromis niloticus*) diet

Aaqillah Amr M.A., Fatan, N.A., Ramli, M.R., Sharbini, N.S., Ley, T.M., Hui, P.J., Yossa, R.

Introduction

- Lipids play an important role in the reproduction of fish especially during the maturation of gonads
- For fish with high reproductive performance, diets with high lipid content are required.
- Lipids from fish oil are rich in ARA, EPA, and DHA required in broodstock diets to ensure high fecundity, spawning success, and larvae survival.
- The present work will generate data on the gonad maturation, sperm quality, and fecundity of tilapia during the breeding.

Objectives

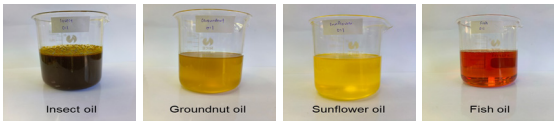
i. Growth performance and gonad maturation at the early stage of development of juvenile tilapia

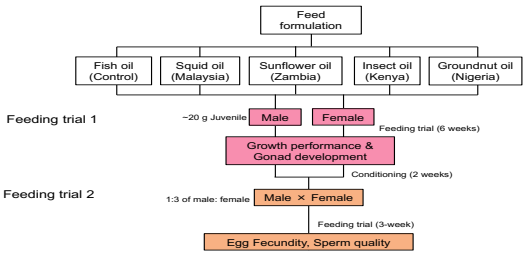
ii. Fecundity and sperm quality of tilapia during the breeding stage

Materials and Methods

Fish collection
- Tilapia ~20 g BW.
- Male fish will be manually separated from the female
- 5 diets × 3 replicates × 2 sexes × 30 individuals per aquarium

Oil collection
- Malaysia: Fish oil (control) and squid oil
- Kenya (ICIPE): Insect oil (BSFL raised on potato waste)
- Zambia (WorldFish Zambia): Sunflower oil
- Nigeria (CORAF): Groundnut oil





Feeding trial 1

Ingredient (%)	Treatments				
	FO	SO	IO	SFO	GNO
Fishmeal (70% - Danish)	20.3	20.3	20.3	20.3	20.3
Soybean meal (48 solv)	18	18	18	18	18
Corn gluten meal, 60% CP	25.8	25.8	25.8	25.8	25.8
Corn meal	12	12	12	12	12
Rice bran	8	8	8	8	8
Wheat bran	12	12	12	12	12
Fish oil (FO)	1.2				
Squid oil (SO)		1.2			
Insect oil (IO)			1.2		
Sunflower oil (SFO)				1.2	
Groundnut oil (GNO)					1.2
Soy lecithin	0.3	0.3	0.3	0.3	0.3
Vitamin premix	0.5	0.5	0.5	0.5	0.5
Vitamin C	0.5	0.5	0.5	0.5	0.5
Vitamin E	0.5	0.5	0.5	0.5	0.5
Choline chloride	0.3	0.3	0.3	0.3	0.3
Dicalcium phosphate	0.1	0.1	0.1	0.1	0.1
Mineral premix	0.5	0.5	0.5	0.5	0.5
	100	**100**	**100**	**100**	**100**

Feeding trial 2

Ingredient (%)	Treatments				
	FO	SO	IO	SFO	GNO
Fishmeal (70% - Danish)	17	17	17	17	17
Soybean meal (48 solv)	19	19	19	19	19
Corn gluten meal, 60% CP	20	20	20	20	20
Corn meal	16.5	16.5	16.5	16.5	16.5
Rice bran	13.5	13.5	13.5	13.5	13.5
Wheat bran	8.8	8.8	8.8	8.8	8.8
Fish oil (FO)	2.5				
Squid oil (SO)		2.5			
Insect oil (IO)			2.5		
Sunflower oil (SFO)				2.5	
Groundnut oil (GNO)					2.5
Soy lecithin	0.3	0.3	0.3	0.3	0.3
Vitamin premix	0.5	0.5	0.5	0.5	0.5
Vitamin C	0.5	0.5	0.5	0.5	0.5
Vitamin E	0.5	0.5	0.5	0.5	0.5
Choline chloride	0.3	0.3	0.3	0.3	0.3
Dicalcium phosphate	0.1	0.1	0.1	0.1	0.1
Mineral premix	0.5	0.5	0.5	0.5	0.5
	100	**100**	**100**	**100**	**100**

ACTIVITY	TIMELINE
Protocol and formulations	by July 2023
Animal Ethics approval	by December 2023
Animal sourcing and acclimating	by November 2023
Feed manufacture	by December 2023
Start of experiment	by December 2023
Final sampling	by February 2024
Data analysis	by April 2024
Reporting	by June 2024

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Expected outputs

- The different oil sources are likely to impact the timing and quality of gonad maturation in the broodstock.
- Certain oils may accelerate or delay the onset of gonad maturation, while others may contribute to better overall gonad health and development.
- Various oil sources may affect the quality of sperm produced by the broodstock.
- The fecundity could vary based on the oil sources used in the diet of the broodstock.

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Upcoming broodstock experiment

Activity	2024
Systematic review on broodstock diets	By Q1
To explore FM-free diets on the reproductive performance of broodstock	By Q2
To estimate the macronutrient and micronutrient requirements for broodstock to establish a database	Q4

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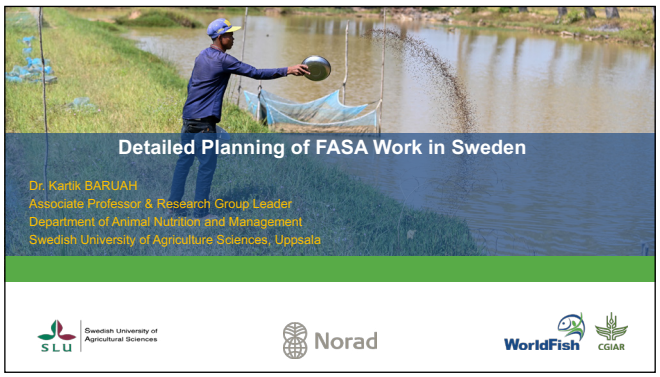
Detailed planning of work in Sweden: SLU (Dr. Kartik Baruah)

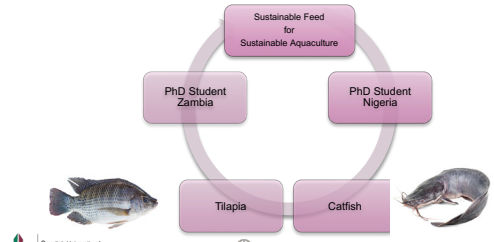


Role of SLU in FASA Project

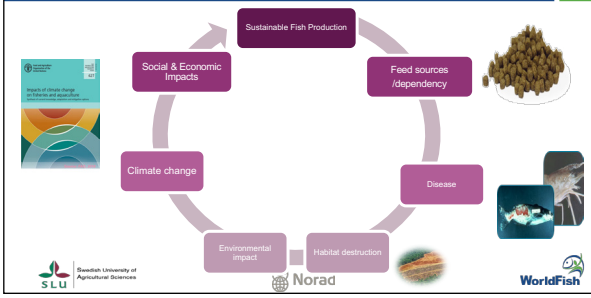
- Capacity Building
- Research & Development Activities:
  - 2 PhD Research Projects (Nigeria & Zambia)
- Contribute to other relevant activities of the project

Role of SLU in FASA project: 2 PhDs Selected

Conduct Research & Development on Sustainable Feeds for Farmed African Catfish & Nile Tilapia



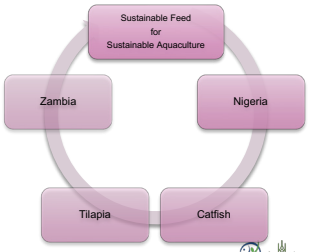
PhD Thesis Projects: Constraining Factors



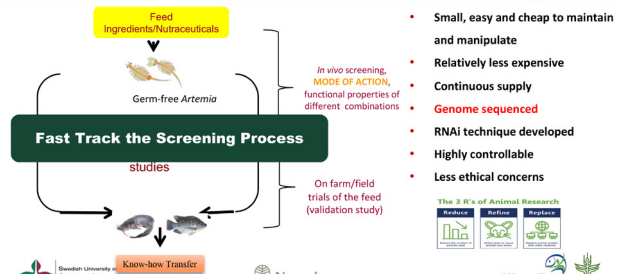
PhD Thesis Projects: Overall Aim

Selected Feed Ingredients (Zambia)

#	NAME OF INGREDIENT
1	FISH MEAL (SIAVONGA KAPENTA)
2	GRINDED CRAFYFISH MEAL
3	KAKEYA (FISH MEAL)
4	CATERPILLAR (TUKANJA)
5	CATERPILLAR (VINKUBALA)
6	FISHMEAL(CHISENSE)
7	SUNFLOWER CAKE MEAL
8	VELVET BEANS MEAL
9	VELVET BEANS SEED
10	TEA WASTE
11	CHIKANDA POWDER

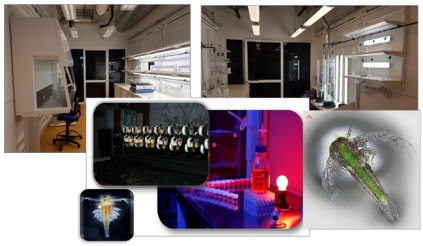


FASA Project: SLU´s Roles



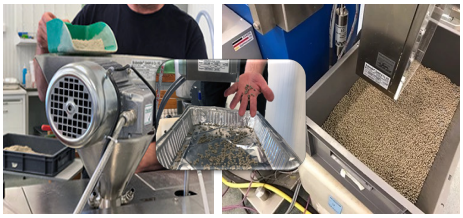
- Small, easy and cheap to maintain and manipulate
- Relatively less expensive
- Continuous supply
- Genome sequenced
- RNAi technique developed
- Highly controllable
- Less ethical concerns

Artemia Lab at SLU



https://www.slu.se/en/departments/animal-nutrition-management/research/our-laboratories-at-huv/artemia-lab/

Feed Development & Quality Analysis



- **Nutritional Quality**
- **Pellet Quality**

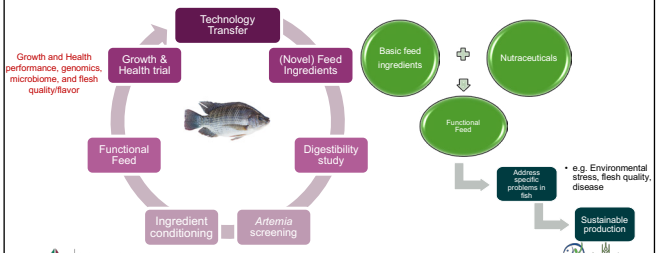
FASA PhD Project in Zambia: Nile Tilapia

- Genetic improvements increase the nutritional requirement of fish (Rotta et al. 2023).
- Methionine requirement level of genetically improved farmed tilapia (GIFT) increased by 60% compared to non-GIFT strains (Yossa et al., under review).
- Comparative study to investigate the functional responses of wild-type and genetically improved tilapia strains in response to feeding novel feed.

Tilapia

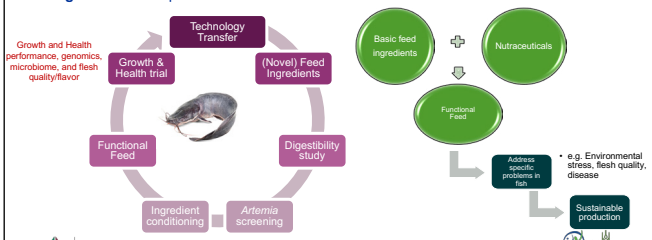
Fish wet lab facilities at SLU

FASA PhD Project in Zambia: Nile Tilapia



FASA PhD Project in Nigeria: African Catfish

Nigeria: PhD in Aquaculture with a focus on New Fish Feed for African Catfish



Current Status & Future Plan

Activities	Timeline	Status
Recruit 2 PhDs (Zambia and Nigeria)	Year 2 (Q1)	Completed before Year2 (Q2)
Conduct experiments to prioritise KEY ingredients: biochemical analysis of ingredients	Year 2 (Q1) – Year 3	In line with timeline (Ingredients from Zambia)
Digestibility study at WorldFish	Year 1 (Q3) – Year 3 (Q4)	
Develop and use processing techniques to improve quality of KEY ingredients	Year2 (Q3) – Year 3 (Q1)	
Quality check the improved ingredients, and formulate and produce fish feed, and lab trial	Year 2 (Q3) – Year (Q4)	
Conduct validation study on farm	Year 3(Q3) – Year 4 (Q4)	
PhD Defense	Year 4(Q2) – Year 5 (Q2)	

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Training on the proper financial reporting: WorldFish Malaysia: Mr. Tan Chao Yan and Mr. Tan Ban Swee

Development and Scaling of Sustainable Feeds for Resilient Aquatic Food Systems in Sub-Saharan Africa (FASA)

Tan Ban Swee & Tan Chao Yan
Research Finance

Norad

WorldFish CGIAR

Training on Proper Financial Reporting

Partner Financial Reporting – Advance Liquidation Type

- With the exception of first advance fund transfer to the partner, subsequent advances to the partner is subject to following conditions:
  - Technical and financial reports that are due in accordance with the submission schedule as stated in the sub-grant agreement must be received and accepted by WorldFish
  - Submission of quarterly forecast Work Plan and Budget that are consistent with the Activity Implementation Plan and submission of invoice for relevant quarter that is approved by WF
  - Sufficient supporting evidence must be provided to support the spending
  - Upon WorldFish request, the partner must support and revert the corresponding year-end balance confirmation to WorldFish
  - Final payment to partner will be cost-reimbursement payment and release only upon acceptance and approval of all deliverables, final Technical & Financial Reports from partner

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Partner Financial Reporting – Cost Reimbursement Type

- With the exception of first advance fund transfer to the partner, subsequent cost reimbursements to the partner is subject to following conditions:
  - Technical and financial reports that are due in accordance with the submission schedule as stated in the sub-grant agreement must be received and accepted by WorldFish
  - Payment will be made after partner has completed the contractual deliverables and incurred expenses that exceed first advance payment, subject to WorldFish approval
  - Partner must submit an invoice for payment request, subject to WorldFish approval
  - Sufficient supporting evidence must be provided to support the spending
  - Upon WorldFish request, the partner must support and revert the corresponding year-end balance confirmation to WorldFish

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Sample partner budget in sub-grant agreement

IV. Budget, Reporting and Payment Schedule

1) BUDGET in NOK

Table 2: BUDGET in NOK

Budget Item/ Year	Year 1 (NOK)	Year 2 (NOK)	Year 3 (NOK)	Year 4 (NOK)	Year 5 (NOK)	Total (NOK)
Personnel Cost	348,543	348,543	348,543	348,543	300,543	1,694,715
Travel	45,113	45,113	76,543	45,113	40,113	251,995
Specific project-related costs	391,678	344,811	381,517	607,661	200,110	1,925,777
Operating Costs	2,182	2,182	2,182	2,182	182	8,910
Purchase of equipment	27,691	-	-	-	-	27,691
Indirect operating costs (5%)	42,260	37,032	40,439	50,175	12,497	182,403
Total (NOK)	857,468	777,681	849,224	1,053,874	553,445	4,091,491

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Sample financial reporting template attached to sub-grant agreement

Microsoft Excel Worksheet

Sample partner year-end balance confirmation template

Microsoft Excel Worksheet

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Partner Financial Reporting – Areas of Improvement

- Ensure the budget allocated are complied with sub-grant agreement categories.
- Ensure the reporting period stated in financial report is accurate
- Ensure consistency of expenditure reported for previous periods
- Ensure the expenditure stated in financial report is aligned with fund status report and transaction listing
- Ensure fund status report is complete
- Ensure the information reported in transaction listing is accurate & complete

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About WorldFish

WorldFish is a leading international research organization working to transform aquatic food systems to reduce hunger, malnutrition, and poverty. It collaborates with international, regional, and national partners to co-develop and deliver scientific innovations, evidence for policy, and knowledge to enable equitable and inclusive impact for millions who depend on fish for their livelihoods. As a member of CGIAR, WorldFish contributes to building a food- and nutrition-secure future and restoring natural resources. Headquartered in Penang, Malaysia, with country offices across Africa, Asia, and the Pacific, WorldFish strives to create resilient and inclusive food systems for shared prosperity.

For more information, please visit www.worldfishcenter.org