Workshop Report, Kisumu, Kenya

By Katrine Soma (WUR), Benson Obwanga (Laikipia University)

Feed future - how to ensure accessibility and affordability of sustainable feed to the small-scale farmers?

Place: Acacia Hotel, Kisumu, Kenya
Time: 07.11.2024 at 9.30-15.00

Background: Currently thousands of small-scale farmers depend on commercial highly processed feed for their fish and livestock. Common protein sources in commercial feed, soybean and fish meal, have shown to not be sustainable with high climate impacts. Recent research conducted with small holder fish farms in Kenya has demonstrated that replacing commercial feed and substituting fish meal in diets with locally available protein sources like Spirulina (*Spirulina platensis*), dried Black Soldier Fly Larvae (BSFL) (*Hermetia illucens*) and dried freshwater shrimp (*Caridina nilotica*) result in equally high growth of Nile Tilapia (*Oreochromis niloticus*) fingerlings as commercial fish meal-based feed. This provides opportunities to replace highly priced commercial feed with high quality local protein sources, and thus enhance sustainability and reduce the climate footprint drastically.

Main aim: The overall aim of the workshop is to explore opportunities for small scale farmers to use alternative high quality protein sources which are locally available, affordable and sustainable, by means of farmer interactions as well as dissemination of outcomes of a project KB35: Food & nutrition security in the global south (KB-35-102-01), financed by the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN) (2023-2024).

PROGRAMME:

9.30-10.00	Arrival and registration/ Coffee	
10.00-10.15	Welcome	Laikipia University, Benson Obwanga
10.15-11.00	Interactive	Laikipia University, Felicia Yieke
11.00-12.40 (EAT) Online meeting		
11.00-11.05	Welcome online	WUR, Katrine Soma
11.05-11.15	Motivation	LVVN, Bart Pauwels
11.15-11.20	Overview	WUR, Siemen van Berkum
11.20-11.30	Introducing the small-scale farmers	Laikipia University (short film)
11.30-11.40	Access, affordability and sustainability	WUR, Katrine Soma
11.40-11.55	Spirulina feed trials	Laikipia University, Benson Obwanga
11.55-12.10	Spirulina farm trials	Nasio Trust, Maurice Onyango
12.10-12.20	Affordable-Recirculation Aquaculture systems (A-RAS)	FOSPA, Charles Mbauni Kanyuguto
12.20-12.30	Black Soldier Fly Larvae (BSFL) – perceptions of farmers	WUR, Asaah Ndambi
12.30-12.40	Questions & Answers	Laikipia University, Felicia Yieke
12.40-13.00 Short coffee break		
13.00-13.30	Group break-out	Participants/ Felicia Yieke
13.30-13.50	Group presentations	Participants/ Felicia Yieke
13.50-14.00	Final remarks	Laikipia University, Benson Obwanga
14.00-15.00 LUNCH/ NETWORKING		

1) Welcome: Benson Obwanga, Laikipia University

Table 1. Overview of participants

Groups of participants	Affiliation/location	Number
Farmers	Kisumu County	13
Farmers	Nasio Trust/ Kakamega	10
Farmers	Busia County	5
Researchers	Laikipia University	3
Researchers	Wageningen University & Research (WUR)	3
Farmers	Siaya County	2
County governors	Fisheries officers/ Kisumu	1
Researchers	Maseno University	1
Others	Film team/ administration	5
TOTAL		43

2) Interactive session

Facilitator: Prof Felicia Yieke, Laikipia University

In this section, the main purpose was to ensure that every participant had the word. This started with a brief introduction round, and continued with a question about the expectations of the workshop, as well as the experiences with alternative protein sources as Black Soldier Fly Larvae (BSFL), Azolla and spirulina.

Table 2. Expectations of the workshop

	Number
Networking	12
Learning	12
Reduce costs of feeds for chicken/fish	6
Opportunities for alternative protein production	6
Market presentation of alternative feed/fish	5
Production requirements	5
Sustainable practices	5
Inclusion of small-scale farmers	5
Circular economy	4
Sustainable fish farming	3
Scaling of good practices	3
Organic farming	3
Nutrient values/requirements	2
Good partnership/integrated farmers	2
Chemical solutions for spirulina	1
Insights in value addition opportunities	1

Insights in value chain opportunities	1
Reduction of feed waste	1
Commercial production of fish	1
How to produce high quality fingerlings	1
Profitable business opportunities	1

Table 3. Experiences with alternative protein sources such as Azolla/BSFL/Spirulina

	Number
Azolla	10
BSFL	9
Spirulina	4
Reduces costs/ increase profits	8
Organic waste management (BSFL)	7
Substitute of commercial feed/ production capacity	6
Sustainable/ climate smart source of feed/ circular economy	6
Affordable to grow/ produce	5
Good production and feed practices	5
Easy to grow/ set up	3
Increase in animal maturity/ growth	3
Provides tasty and protein rich feeds	2
Daily practice learning opportunities	2
Research	2
Farmers reluctant to replace commercial feed with BSFL	2
Challenging to calculate feed requirements	2
Easy calculation of feeding needs	1
Challenges to expand scale of production	1
Challenges of seed supply of BSFL/Azolla	1
Spirulina failed due to chemical fertiliser	1
Contributes to locally available feed	1
Needs of installation/ equipment	1
Lack of information	1
Improved health	1
Needs of both animal and plant sources in feed	1
Solve unemployment among youth	1
Needs for controlled production (avoid spreading)	1

3) Online session

For this session, please see the slides in Appendix 1. In the following we wrap up some short messages from each speaker:

3.1. Motivation by Bart Pauwels, Dutch Ministry of Agriculture, Fisheries, Food security and Nature (LVVN)

I am honored to be here to discuss an issue that is both critical and transformative for smallholder farmers in Kenya; **the alternative sustainable and affordable feed sources for livestock and fish farming.** Feed accounts for a significant portion of the costs faced by thousands of small-scale farmers. Farmers heavily rely on highly processed, commercially produced feed. However, as we look at both the economic and environmental costs, we realize that this dependency is not sustainable in the long term.

Traditionally, commercial feeds are largely based on protein sources like soybean meal and fish meal. Although these offer essential nutrients, they also carry serious drawbacks. Soybean, for example, is associated with deforestation and extensive use of water and land, while fishmeal contributes to overfishing and depletion of ocean resources. These practices not only harm our environment, but also result in escalating costs. But there is also good news. Research has identified promising alternatives, black soldier fly larvae and spirulina, both of which are locally available and sustainable. Studies indicate that substituting commercial feed with these alternatives can lead to equally high growth rates for tilapia fingerlings. This discovery opens up interesting opportunities for Kenyan farmers to produce affordable, high-quality protein for their livestock and fish while reducing environmental impact and costs.

So why are BSFL and spirulina such game changers? First, let's look at the BSFL. These insects are natural waste converters. They can be raised on organic waste from homes, farms and food processing facilities which helps in managing waste efficiently, while generating high protein larvae, making it an excellent replacement for conventional protein sources. Additionally, the black soldier fly thrives in warm climates, making them ideally suited for Kenya's environment. Second, spirulina is a nutrient rich microalga that is high in protein and other valuable nutrients. Spirulina is not only efficient in terms of resource use, but it also thrives in area with plenty of sunlight. Another advantage here in Kenya, the cultivation of spirulina uses relatively little water. With no use of chemical inputs, it offers a sustainable option for small scale farmers. Hence, both BSFL and spirulina are sustainable, and can be locally produced which could reduce dependency on imported feed.

So, we can lower feed costs and ultimately make animal farming more accessible for lower income farmers. How can we ensure that these alternatives reach the farmers who need them most? First, there must be awareness and training at grassroot level. Training and production techniques should create opportunities for small scale farmers to begin producing their own feed components, potentially creating new income streams and employment opportunities. Second, investment in infrastructure is essential. With some initial capital, farmers could acquire small scale processing units to dry and grind BSFL and spirulina, making it easier to incorporate these products into feed. Governmental support, or micro loans from financial institutions, could assist in funding these initial investments.

Collaboration with the government, private sector and research is necessary to standardize production and ensure quality and build a market for these alternative feeds. Moving towards more sustainable feed resource, as a Dutch government, we can lead the way in sustainable agriculture to set examples of resilience and innovation in the face of the global challenges that we have.

Thank you.

3.2. Overview by Siemen van Berkum, Wageningen University and Research (WUR)

Thank you for inviting me to present in this online meeting. The key question that this research investigates is how to ensure accessibility and affordability of the locally produced feed to small scale farmers.

Ultimately, improving livelihoods and enhancing food security for farmers and their households are core objectives of this project and in this region. Feeding a growing population while respecting the planetary boundaries, is one of the greatest challenges for current and future generations.

On the one side, we are aiming at solving the problems of farmers at their farm, for instance, and how to improve, be more productive and produce more. On the other side, we want to understand the function of the entire food system that a farmer is part of.

Thinking along a food system broadens our perspective of finding sustainable solutions for producing enough food, sufficient food, healthy food. Some may think that hunger and malnutrition can be solved by just producing more food, but limited access to food can a core cause to hunger. Access to food is related to how the food chain is organized.

To understand accessibility, it is relevant to understand who determines the conditions of market transactions. Is it the government having big role or is it say big companies or traders that were really having market power? Who has access to technology and knowledge or credits or owns the land? In a food system, a best and most efficient and effective solution will strengthen food security for all, not only for some. To emphasize this point, I think we as researchers can be relevant to policymakers and businesses to reach this end. With knowledge, decisions can be made that are necessary to strengthen food security for all. So, what is needed for this?

Projects like this presented today are of great importance to directly help farmers move forward. In addition, to increase the success of the proposed innovations and challenges, it is necessary to understand how others in the food chain respond and how actors in the food supply chain interact with and respond to socioeconomic drivers that affect the whole food system. Socioeconomic drivers are, for instance, population growth and urbanization, while government policies or climate change can operate as environmental drivers. These drivers bring about changes in the food system, and relate with the behavior of farmers, and other actors in the food system.

Moreover, it is important to link pathways of technical and behavioral change. Technical solutions are often available, but they are not adopted because the investment is considered too risky, so each technical solution must be assessed in socioeconomic context. But does the innovation in production, for instance, lead to more sales? Do the benefits really reach the farmer? Those are important questions to address and to understand, and I can see in your project presented today that many of these aspects have been addressed, so I am very happy with that.

Thank you for your attention.

3.3. Access, affordability and sustainability, by Katrine Soma (WUR)

Thanks a lot for this great opportunity. I want to provide a talk about accessibility, affordability and sustainability, related with our research approach that we are using in Kenya. The research conducted over the last six years has resulted in impacts, which has been the main intention from the very beginning across all the activities. As such, the seven household surveys conducted in the projects have been seen as the beginning of effective operations, and not as end-products.

The small-scale farmers we work with carry out mixed farming, producing multiple products by diary, poultry, aquaculture, and horticulture, among others, but often earn their income from self-employment or employment outside the farm. This type of farming is actually representative to 60% of the population in Sub-Saharan Africa.

Some of the surveys included questions about perceptions about using or producing the BSFL and spirulina as feed. The results were clear, this is of interest if the ingredients, production system and final products are affordable, accessible, of good quality and sustainable. Also, access to finance is critically important, given the low access the farmers have to finance today, as well as capacity building which will be urgently needed.

In research we have already shown that commercial feed can be replaced by alternative locally sources protein sources, such as BSFL, Spirulina and Caradina shrimp (a biproduct in Lake Victoria). The Tilapia fingerlings have shown to grow equally much if replacing commercial feed up to 20-30% with these locally produced protein sources, and possibly more. See: 1) https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2024.1283150/full and 2) https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2024.1298551/full

The effective operations implemented in the projects address core bottlenecks in the food system, including; 1)a new market innovation solution in Kibera (https://edepot.wur.nl/549634), 2) new Affordable Recirculation Aquaculture Systems (A-RAS) for the small-scale farmers in Nyeri (https://link.springer.com/article/10.1007/s10668-024-05574-6), and 3) new innovations making it possible to grow spirulina affordably by means of manure instead of commercial fertilizer on the farms, in Kakamega and Nyeri.

In addition, a lot of studies exist that illustrates the potential gain in sustainability of replacing the use of protein sources like soya and fish meal, see for instance: https://edepot.wur.nl/574099

To ensure inclusion of small-scale farmers in feed production, it is thus important to emphasize accessibility, affordability and sustainability. Note that to reach impact on the small-scale farmers, the communities and the consumers, the strategy of implementation should be based on local ownership, co-creation, communication, operation, and operationalization, linked with the small-scale farmers' business model, minimizing the environmental and climate impacts. We intend to increase inclusion by means of research and implementation hand in hand targeting a large share of the Sustainable Development Goals (SDGs)including SDG1: no poverty and SDG2: zero hunger.

Thank you.

3.4. Spirulina feed trials, by Benson Obwanga Laikipia University

Good morning. Spirulina is a blue-green microalgae, one of the most ancient living organisms on planet Earth. It's very common in alkaline lakes in Kenya. It has been shown that consumption of spirulina boosts immunity and has therefore become an important protein source for human beings. It has high growth rate. Because it requires high pH and high salinity levels in production, other organisms are discouraged in its growth environment, and competition for resources reduced. In this project we investigate Spirulina for animal feed. Spirulina uses minimal space, is able to multiply by making use of organic waste materials in the water and has no carbon footprints.

I will give a brief presentation of our trials, for which one part takes place in a closed laboratory setting by Laikipia University and KMFRI in Sagana, and one part take place on farms at Mumias by help of NASIO Trust. Whereas the objective is to find how well spirulina growth on different types of manure in the closed laboratory setting in Sagana, the objective is to find out what challenges the farmers will face in a practical setting if growing spirulina in the farm setting in Mumias. Hence, in Mumias, farmers produced spirulina organically using materials within their reach, including manure (poultry, cow dung, or goat manure), salt, baking powder/lye. These were organic replacements to the conventional chemicals and nutrients used to produce spirulina for commercial use. Farmers were selected and trained by NASIO Trust on how to produce spirulina, which they later used to feed fish. To facilitate accessibility to farmers, the materials should be as affordable and accessible as possible. For a small greenhouse, they can use sticks from the farm and secondhand materials and the costs are low. With an opening in the greenhouse, it is possible to allow air flow when temperatures are getting too high (>32oC). In addition, spirulina uses less water, space and has fast growth rates.

Following successful production by farmers, trials were set up KMFRI-Sagana to validate production that was carried out by farmers. The objective for the trials at KMFRI-Sagana was compare production of spirulina using five manures including cow dung, pig manure, chicken manure, pig manure and goat manure. An experimental design including all the manures was set up in triplicates in addition to a trial with spirulina produced using chemicals(Zaruk media) which was used as a control. This trial began in January and ended in March, 2024. Comparisons were based on biomass harvested, cell counts, and proximate values. The spirulina culture was sourced from NASIO TRUST mother culture tanks and transported to KMFRI-Sagana to start the trials. Organic manure(goat, chicken, pig, cow dung) was collected from farms around KMFRI-Sagana. It was sun dried then from each sample 10kgs of dried organic manure was added to a 100ltr plastic tank to which 100ltr of distilled water was added and allowed to ferment for 14days. Five treatments were set up in triplicate including a treatment using a mixture of the inorganic chemicals (Zarouk media) which was used as the Control or reference CS; Goat Manure-GS; Chicken Manure-CHS. Three 100litre tanks were set up per treatment and in each tank 40litres of water was added. In the Control Treatment (CS) a mixture of inorganic chemicals (Zarouk media) was added, in the rest of the treatments (GS,CHS, CW, and PS) a filtered soup of fertilizer (devoid of debris) was added in addition to common salt and a solution of baking powder. The 40litre capacity mark was in equal concert with 15cm depth which was ideal for sunlight penetration for primary production of the Spirulina. This 15cm mark was consistently maintained by topping up a solution of water and fertilizer in the treatments so as to cater for the evaporation losses. In each treatment 200ml of Spirulina sourced from NASIO TRUST mother culture tanks was added. The mixture was stirred to have an even spread and every after 30mins stirring was done to prevent cells settling to the bottom. In addition to stirring by hand the mixture was agitated using an electricity powered stirrer which was allowed to keep the culture agitated. Harvesting started after 14days post inoculation, and the paste dried in a locally fabricated drying kiln. Comparisons on the value of spirulina produced will be based on the proximate values and biomass produced. Thank you so much.

3.5. Spirulina farm trials, by Maurice Onyango Nasio Trust

Thank you for this great opportunity. At Nasio Trust, we have been doing research on sustainable approaches to grow spirulina to find ways easier for smallholder farmers to grow it. The aim is to ensure that organic spirulina is achievable and sustainable. The method is to use organic materials to facilitate smallholder farmers to grow spirulina, which are cheaper, more cost effective and thus production costs are low compared with the commercial fertilizers. Also, the final production of fish or chicken fed on spirulina is more affordable to consumers when brought to the market.

One farmer uses goat manure to grow Spirulina which is then harvested and given to tilapia whose growth rate has since increased significantly compared with the tilapia raised on the commercial feed, which is too expensive. Another farmer uses goat waste to grow spirulina, which was then given to the chicken, which also grew significantly. The women group is using a different approach with chicken manure, and although they did not finish the trial, we believe also this will be a success. The women are also planning to use the spirulina to feed their chicken.

We at Nasio Trust provide capacity building to empower farmers to grow and culture spirulina. The opportunities for farmers to produce spirulina are great. They have informed that spirulina is a gift from nature.

Also, we at Nasio grow spirulina in controlled tanks, using synthetic fertilizers to compare with other tanks where we experiment with rabbit urine and goat manure, and it is a success based on the harvests that we have made. The idea is to show that it is doable, and it can become available to everyone who is interested and willing to do it. Moreover, science has shown that tilapia and chicken gain weight if fed on spirulina, and also, egg production increases.

Spirulina as feed has valuable components and can replace use of soybean as a meal for chicken and fish. Spirulina provides crude protein, amino acid, carotenes, vitamins, and minerals (e.g. calcium, magnesium and potassium). Note that some of the vitamins like B2(Riboflavin), B9(Folate), Vitamin E(Tocopherol), Pro-Vitamin A(Beta-Carotene), vitamin K1 and K2, Vitamin B12(Riboflavin) are not naturally available in conventional feed. And then there is a pigment called phycocyanin which changes the colors of e.g. eggs, and also lipids.

The farmers are interested in how spirulina can become accessible to them as smallholder farmer and what sustainability and climate impacts can be reduced if feeding chicken, fish and livestock on spirulina.

Another question is the affordability. Actually, it is affordable because at Nasio because we produce it in large quantities and farmers interested in growing spirulina can get in touch with us. Spirulina can also be accessible in Mukunda and Mombasa.

You can grow and harvest spirulina continually. When you culture it, you maintain good conditions for the culture medium, including the nutrient that spirulina gets. After two weeks you can already harvest it. (Soyabeans need three months). You harvest and then you dry it. You give it to your chicken and the fish. Then, after the first harvest, you harvest every three days.

The bottlenecks or the challenges, include that we have been able to optimize the term of organic manure that spirulina needs to grow on. First, when the organic manure begins to decompose, there are two things that can happen: 1) media can increase acidity level or 2) increase alkalinity level. So, we must balance within pH levels of 8-11. Second, we were able to grow spirulina using organic nutrients without using the synthesized fertilizers. We also found that it is easy to use rabbit urine, which is a good source of nutrients for spirulina. An urgent issue to solve was the needs for agitation, as you need to stir every 15-30 minutes. Farmers have no time to be inside the greenhouse every 30 minute. We got help from a student from Mumias West Technical and Vocational Training College, we were able to come out with this prototype agitator, which uses solar power, which can stir the water.

As I mentioned, growing spirulina is achievable, affordable, it is cheap, and it uses solar energy. Thank you so much.

3.6. Affordable-Recirculation Aquaculture systems (A-RAS), by Charles Mbauni Kanyuguto (FOSPA-Africa)

Thanks for this opportunity to present the Affordable Recirculation Aquaculture System (A-RAS). A-RAS was shown in a short film which will become available on YouTube shortly. Urgent challenges in sub-Saharan Africa include food and nutrition security. Currently the small-scale farmers are the main suppliers of food to the communities. Operating in conditions with no access to finance and technologies, they have hardly any chance to enhance and develop their livelihoods. The solar based A-RAS offers sustainable and climate neutral accessible and affordable fish production systems, to allow viable business models and increased contributions to food and nutrition security challenges locally. With increase in fish production, it becomes even more important to ensure high quality affordable, accessible and sustainable feed for the small-scale farmers.

The opportunities for scaling the A-RAS are many, given the high demand, the relatively low investment costs needed for the A-RAS construction, the accessibility locally, as well as the environmental impacts with no carbon emissions, no wastewater discharge and low use of water and land with highly increased production level of fish. The opportunities include:

- The technology is developed with the purpose of starting with a smaller investment, and then providing opportunities for increasing with more A-RAS systems. When income has been generated based on a first investment, it is possible to pay back in three to five years, before investing in more advanced technologies.
- A-RAS in greenhouse offers the possibility of farming fish near markets and in areas where land and water are expensive and not readily available, as well as in areas where water temperature is low.
- Following a circular economy approach, the constructions are designed in ways which are based on local accessibility of construction materials of the A-RAS system. They are mostly available in Kenya, which makes maintenance and upgrading very plausible.
- The technology developed in this project is very different than the existing recirculating aquaculture systems. It is designed to ensure it is accessible and affordable locally, and in this way make possible what has been judged difficult by experts in the field. We have ensured the new technology is of high quality, while investment costs are considerably lower.
- The A-RAS is in continuous improvement processes. The most urgent challenge currently is to improve the filtering system to ensure higher water quality and minimized water volumes used.
- The feed used in A-RAS must be floating pellets as feed will contribute to reduce the feed waste load to the filtration system, increase feed efficiency and uptake of feed nutrients by fish.
- Capacity building is a lot stronger with farmer to farmer learning, hence, the A-RAS farmers will pioneer the information dissemination among the farmer groups in their communities, in consultation locally with the Nyeri Fish Farmer Cooperative, Laikipia University, AquaFarmingConsult and FOSPA-Africa.
- By promoting local sourcing and creating local jobs, A-RAS can contribute to the economic development, and the food and nutrition security of local communities.

Thank you.

3.7. Black Soldier Fly Larvae (BSFL) – perceptions of farmers by Asaah Ndambi (WUR)

Thank you for this opportunity to present our paper (submitted) titled: Awareness, challenges and Prospects of Using Black Soldier Fly Larvae (BSFL) in animal feeding by smallholders in Nyeri County, Kenya.

In Kenya, food security is a challenge, with 36.5% of Kenyans considered food insecure and 35% of children below five years stunted. The main deficits include limiting proteins, especially those of animal origin in children's diets. The cost of production, and the price of animal feed containing high levels of proteins, is very high and sometimes prohibitive to low-income farmers. Black Soldier Fly Larvae (BSFL) used as a feed ingredient could provide a cheaper protein source alternative. BSFL is a sustainable protein source, whose production also contributes to waste management and yields an important organic fertiliser with numerous benefits to the soil, referred to as frass. However, because its use is fairly new in Kenya, information on its acceptability, and adoption bottlenecks is unclear. Characterization of these factors can be used to address interventions that promote its widespread adoption. The main aim of this study is to explore factors influencing awareness and acceptability of using BSFL as a feed ingredient, and also the challenges hindering its use by smallholder farmers in central Kenya. The study results show that group membership, income sources and education positively and significantly influenced awareness. Moreover, age had a negative significant influence on awareness of BSFL as a feed ingredient, with older people likely to be less aware compared with young people. BSFL acceptability is high, with 76% of farmers willing to produce it. The challenges associated with adoption were related to the low availability of raw materials such as larvae and production kits and the lack of capacity building in the form of training. The study recommends targeting farmers in groups to improve awareness. The provision of technical training on BSFL production should be implemented. Finally, there should be facilitation of initial production starter kits to encourage uptake and to bridge the initial capital requirements.

Thank you.

3.8. Questions & Answers, by Felicia Yieke Laikipia University

Q1: From your perspective, how can alternative protein sources to feed support the small-scale farmers in Kenya?

Erick Ogello, Maseno University:

Indeed, we are at a very critical time. I am happy because we have the farmers with us here. We also have the other stakeholders present, and we are talking about how we can use local materials that are available within our reach to enhance production and to enhance our livelihoods. That to me is very touching. Having worked as a consultant for world Bank in a task to establish aquaculture development pathways in China compared to Africa in 2022 in China on a World Bank project, I learnt they had this kind of conversation long time ago and today they have progressed a lot more than Africa. But now we are here talking about how we can use information, available materials to enhance our own livelihoods, and promote aquaculture.

By using the local materials, we are reducing the cost of production, which is very key given that the feed costs take up to 70% of the production costs for a small-scale farmer in aquaculture. The cost of commercial feed is very high. With reduced costs, positive margins in terms of profitability is very important. We are talking about accessibility, how these materials are accessible to us, affordability and of course and sustainability, of for example, the BSFL and spirulina.

How can we use spirulina, for example, to mass produce feed for poultry, fish and pigs? This will lead to improved animal health given the nutrition properties of spirulina, as well as increased productivity.

I also want to mention sustainability of farming practices. We are currently working on an agroecology project funded by EU, about organic farming and how to enhance, for example, biodiversity by improving soil health. Farmers told me here today that they use red worms for feed, which improve the soil conditions by increasing aeration, and also, improving soil condition. Using local materials like BSFL produce frass, which is an organic manure, which can be used to feed catfish as well.

Income diversification and profits can increase by using the locally available materials, for instance, such as BSFL to feed fish, and to earn an extra income from the frass. As such different economic modes can develop, also in terms of selling and buying the BSF eggs. Using locally available materials also enhances sustainable livelihoods and food security. With BSFL replacing, for instance, soya bean, we are conserving natural resources.

Thank you so much.

Q2: How can we integrate the alternative sources of protein into the feed production systems in Kenya?

Fredrick Juma, Maseno University and Hydro Victoria Fish Hatchery Farm Ltd:

Thank you very much for that wonderful question. Here we have researchers, farmers, private sector, the government and they are all trying to see how to address this challenge. We have the opportunities to turn challenges into opportunities.

One challenge is that feed Millers, who produce feed for fish, poultry and other livestock are primarily located in the urban areas and their main business mainly focused on producing human food. By accident they realize that there are remnants, there is waste, which they can sell, so they buy machines and produce feeds for our farmers. This problem we can turn into an opportunity, because with all these technologies that are being presented here in terms of alternative feed, and protein as an ingredient to feed, farmers should use them to process and produce the feed instead of the Millers, instead of sitting and waiting until the Millers are going to solve our own problems.

How can we scale some of these technologies, such as BSFL or Azolla? There is high demand for feed and there is high demand for protein in the feed. Note that the feed Millers that are producing our fish and poultry feed do not have enough of these feed ingredients. This is why the prices are so high.

For instance, a feed Miller who is in Nairobi buy soya from a farmer in the rural village in Zambia. So, he has to import that soya from Zambia, kilometres away, for so to make the feed for you, before distributing it within Kenya. As a result, the feed is very expensive. Also, if instead using fishmeal it is problematic because it is not available and it has a lot of competition, so also for this protein source the feed gets very expensive. So, the farmers have an opportunity in terms of adopting these technologies and start producing feed in small quantities.

We have talked about the food system thinking, looking at the whole horizon. The food we eat today in the hotel here is coming from a smallholder farmer, who has produced vegetables and chicken, which have found their way into the market. We need to incrementally produce small quantities, aggregating, looking at it in terms of the pipeline to ensure how do we bring it together. The question to address is: How do we streamline the value chain to ensure that all these small productions of the feed ingredients, such as spirulina, BSFL and Azola?

Many tanks.

3.9. Group breakout/ presentations, by Felicia Yieke Laikipia University

After group discussions, each group presented their main points responding to a total of five questions, which are summarized in Table 4.

Table 4. Group discussion outcomes

Questions	Group 1	Group 2	Group 3	Group 4	Group 5
1) What are your sources of feed currently?	a) Own production (azolla, red worms. worms, bark weed, cassava leaves, BSFL, spirulina) b) Commercial feeds c) Local farmers	a) Spirulina b) Home-made feed c) BSFL d) Azolla e) Maggots f) Ochong'a (freshwater shrimps-*Caridenea niloticus*) g) Termites	a) Mixture of spirulina & commercial feed b) Azolla, spirulina & potato vines c) Own formulated feed (shrimp, soya, maize, sunflower, BSFL)	a) Rotten maize b) Vines for fish c) Ochonga (fish&chicken) d) Market waste (pigs, cows, goat) e) Termites for chicken f) BSFL g) Azolla (fish&chicken)	a) Microphytes from Lake Victoria b) BSFL c) Azolla d) Redworms (Pultry&fish) e) Commercial feed f) Spirulina g) Maize
2) What are your experiences in using alternative proteins in fish feeds?	a) Readily available b) Difficult to evaluate growth compared with commercial feed	a) Best to feed fish with alternative protein sources when water temperature is high b) Best to feed fish with alternative protein sources when water quality is good c) Good business when feeding at the same time fish and BSFL with chicken droppings/manure/ faecal matter d) Using alternatives proteins reduces infection	a) Increased growth rate & reduced costs of production b) Additional source of income c) Increased production d) Inadequate skills in feed formulation	a) Rapid weight gain b) Cost reduction (50-60%) c) Accessibility d) Competition with other market waste users e) Lack of sufficient knowledge of feed ratio/ input of BSFL production/ nutritional components	a) High growth rate (spirulina) b) Low cost of production resulting in high profitability c) Used as biofertilizer d) Locally available e) It is sustainable
3) Have you used BSFL or Spirulina in fish feed? If yes, what are your experiences?	a) Readily available. b) affordable c) Not labour intensive d) A waste management initiative e) Little space required f) Cheap to start up g) Fast growth	a) Growth rate higher compared to commercial feed b) Saving on costs and time to access feed c) Both fit well into circular economy	a) Used BSFL and spirulina in fish feed b) Increased growth rate & reduced costs of investment	Use BSFL and spirulina a) High growth b) Rapid Growth Weight Gain: GWG)	
4) In adoption of alternative	ABDP training, which included:	Training from: a) Practical Action NGO	a) Participated in spirulina trials	a) One person benefited from	a) The first culture for spirulina (Nasio

Questions	Group 1	Group 2	Group 3	Group 4	Group 5
proteins - what kind of support have you received so far, and from who?	a) Training of youth champions – capacity building b) Farmer training	b) Farm Africa c) EU supported project d) ABDP e) County Government	(Nasio trust & partners: this project) b) Support from Hydro-Victoria	Hydro Victoria (infrastructure & inputs) b) One person benefitted from Egmond trust (finance)	trust and the installations, this project) b) Capacity building c) Feed formulation machine (EcoNetwork) d) BSFL (Hydro Victoria)
5) What are your proposals/ comments about using alternative proteins in fish production in future?	a) Funding b) Capacity building – intro training c) Marketing linkages d) Bench marking, farmers/team of farmers visiting other successful farmers/organizations or facilities e) Sensitization, providing more information to the target people through/by creating awareness	a) Farmers should do value addition to BSFL and Spirulina to optimize production instead of using raw products (processing to incorporate in feed formulation) b) Support to get initial material to produce c) Training and equipment to measure water quality, and d) Marketing and networking e) Specialisation of farmers into production for commercialisation	a) More opportunities to upscale production b) More training in production techniques c) Follow-up activities d) More demonstration sites to support production of alternative protein.	a) Technical advise/ training extension services b) Financial support c) Awareness raising on alternative feeds d) Creating a community of practice e) Market linkages	a) Training and capacity building b) Create awareness to small scale farmers c) Farmers to be given the seeds at a subsidised cost d) Government should create an enabling environment when formulating policies that support small scale farmers

3.10. Final remarks, by Eugene Rurangwa

Thanks for all the great contributions, both for the active engagements in the interactive sessions, as well as for the interesting talks provided by the speakers during the online session. The urgencies of making use of locally available protein sources, such as BSFL, Azolla, spirulina and redworms, etc., are acknowledged not only among the farmers themselves, but also by the Dutch Embassy in Nairobi, a larger research community, as well as by the private and public sectors. See the summary speeches in this workshop report.

The 30 farmers who attended the workshop and actively contributed with insights are forerunners in making progress in using the available protein sources as local alternatives to commercial feed. They contributed with valuable insights.

First, as responses to the question asked about what sources of feed the farmers currently use, all the groups informed that members of the group produced feed themselves. This included own production including azolla, red worms, worms, bark weed, cassava leaves, BSFL, spirulina, shrimp (also referred to as Ochong'a, freshwater shrimps, Caridenea niloticus), soya, maize, sunflower, potato vines, maggots (larva of a brachycera fly), termites, rotten maize, and just maize. Some of this was fed to fish and chicken (e.g. Azolla, spirulina, redworms), whereas others were fed to chicken only (e.g. termites), and some mentioned market waste, which was given to pigs, cows and goats. Besides, microphytes from Lake Victoria, and purchase of community made feed by local farmers, were mentioned. Three groups used commercial feed, and some mixed commercial feed with spirulina.

Second, the responses to the questions about experiences in using alternative proteins in fish feeds, included both positive and challenging experiences. On the positive side, the alternative protein sources were readily and locally available, accessible, sustainable, and they contributed to increased production, weight gain and growth rate, reduced costs of production (50-60%), increased profitability, provided additional source of income, and reduced infection. Moreover, the farmers could use biproducts (e.g. frass) as biofertilizer, which is a very valuable biproduct of, for instance, the BSFL production. On the challenging side, they informed it was difficult to evaluate growth compared with commercial feed, they had inadequate skills in feed formulation and lack of sufficient knowledge of feed ratio/ input of BSFL production/ nutritional components. As for BSFL, they had experienced competition with other market waste users. Further they advised that it is best to feed fish with alternative protein sources when water temperature is high and when water quality is good, and that it is a good business when feeding at the same time fish with BSFL, and the BSFL with chicken droppings/manure/ faecal matter.

Third, in response to the question about whether they had experience in used BSFL or Spirulina in fish feed, all groups responded positively, implying that some farmers in each group had the experience. Their experiences included that it is readily available, affordable, not labour intensive, little space is required, cheap to start up, it has fast and high growth, and Rapid Growth Weight Gain: (GWG). Moreover, the informed that they could save costs and time to access feed, that the growth rate was even higher compared to when they used commercial feed and that costs of investment reduced. They also informed that BSFL complies with a waste management initiative, and that both spirulina and BSFL fit well into circular economy.

Fourth, to the question about what kind of support the farmers had received so far, and from who, when adoption of alternative proteins, the responses across the groups

differed. Two groups mentioned that they had gotten training from Nasio Trust to grow spirulina, who is part of this project. Two groups mentioned that they had gotten training by ABDP training programme, which included capacity building in terms of training of youth champions and farmer training. Hydro Victoria had given support to farmers in three different groups, including on infrastructure, inputs and BSFL. The resisting options were mentioned only by one group each and included training from: Practical Action (NGO), Farm Africa, EU supported project, County Government, Egmond trust (finance), as well as EcoNetwork on feed formulation machine.

Fifth, all the groups of farmers responding to the question about proposing/ commenting about using alternative proteins in fish production in future, informed that training in terms of capacity building, introductory training, training of using equipment to measure water quality, training in production techniques, technical advice/ training extension services and training with capacity building. Another topic provided by three groups related with marketing, including market linkages, and marketing and networking. Another topic relevant to more groups related with needs for support, which included financial support, funding, support to get initial material to produce, as well as to get seeds at a subsidised cost. Awareness raising was yet another topic shared by more groups, explained as: Creating awareness to small scale farmers, awareness raising on alternative feeds, sensitization, providing more information to the target people through/by creating awareness, as well as creation of a community of practice. Only one group mentioned the government, and it was advised they should create an enabling environment when formulating policies that support small scale farmers. The farmers further explained there are needs for bench marking, farmers/team of farmers visiting other successful farmers/organizations or facilities, farmers involvement in value addition of BSFL and Spirulina to optimize production instead of using raw products (processing to incorporate in feed formulation), specialisation of farmers into production for commercialisation, more opportunities to upscale production, more demonstration sites to support production of alternative protein, and they are expecting follow-up activities to this workshop.

While the current project is reaching the end, new opportunities will merge in the upcoming year, and we look forward to new opportunities and partnership, for we have many excellent experiences to build on! In the meantime, we will distribute two YouTube films; one for A-RAS, which will increase demand for affordable, accessible and sustainable feed, and one for the feed itself, including the documentation of farmer contributions among the participants of the workshop.

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Appendix 1. Slides used during the online presentations

(please see separate PDF)

APPENDIX 1. Feed future – Alternative sustainable protein-rich sources of feed for smallholder farmers in Kenya

- Explore the opportunities and challenges among smallholder farmers in Kenya to use black soldier fly larvae (BSFL) and microalgae as feed

7 November 2024

at 11.00-12.40 EAT/ 9.00-10.40 CET

Online workshop, Acacia hotel, Kisumu

Organised by
- FOSPA
- Laikipia University
- Wageningen University and Research

Financed by:
- Dutch Ministry of Agriculture, Fisheries, Food security and Nature (LVVN)

Contributors to project
- Wageningen University and Research (WUR)
- Laikipia University
- Nasio Trust
- FOSPA/ Nyeri Fish Farmer Cooperative
- Kenyan Marine and Fisheries Institute (KMFRI)

1

Overview of presentations

PROGRAMME:

11.00-12.45 (EAT) Online meeting		
11.00-11.05	Welcome	WUR, Katrine Soma
11.05-11.15	Motivation	LVVN, Bart Pauwels
11.15-11.20	Overview	WUR, Siemen van Berkum
11.20-11.30	Introducing the small-scale farmers	Laikipia University (short film)
11.30-11.40	Access, affordability and sustainability	WUR, Katrine Soma
11.40-11.55	Spirulina feed trials	Laikipia University, Benson Obwanga
11.55-12.10	Spirulina farm trials	Nasio Trust, Maurice Onyango
12.10-12.20	Affordable-Recirculation Aquaculture systems (A-RAS)	FOSPA, Charles Mbauni Kanyuguto
12.20-12.30	Black Soldier Fly Larvae (BSFL) – perceptions of farmers	WUR, Asaah Ndambi
12.30-12.40	Questions & Answers	Laikipia University, Felicia Yieke
12.40-12.50	Wrapping up	WUR, Eugene Rurangwa

2

Motivation

- By Bart Pauwels, LVVN

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Welcome

- Siemen van Berkum, WUR

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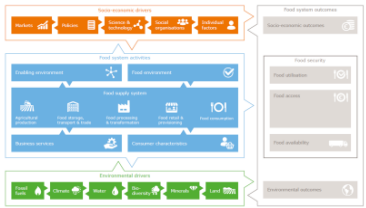
4

Introduction

- Feed future: alternative sustainable protein-rich sources of feed for smallholder farmers in Kenya
- An international research project that is part of Wageningen's research to help increasing food and nutrition security in the global south
- Food systems thinking broadens perspectives of finding solutions for sustainably producing sufficient healthy food



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What makes it a Systems Approach ?

1. Understanding the *drivers* of system performance
2. Identifying solutions in *another area* than where the problem occurs
3. Linking pathways of *technical and behavioural* change

Applying a food system approach can help seeking the most effective, efficient and just intervention to enhance food and nutrition security for smallholder households

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Short film

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Accessibility, affordability and sustainability

- By Katrine Soma

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Research approach - methodological approach

Source: Kusters et al., 2017

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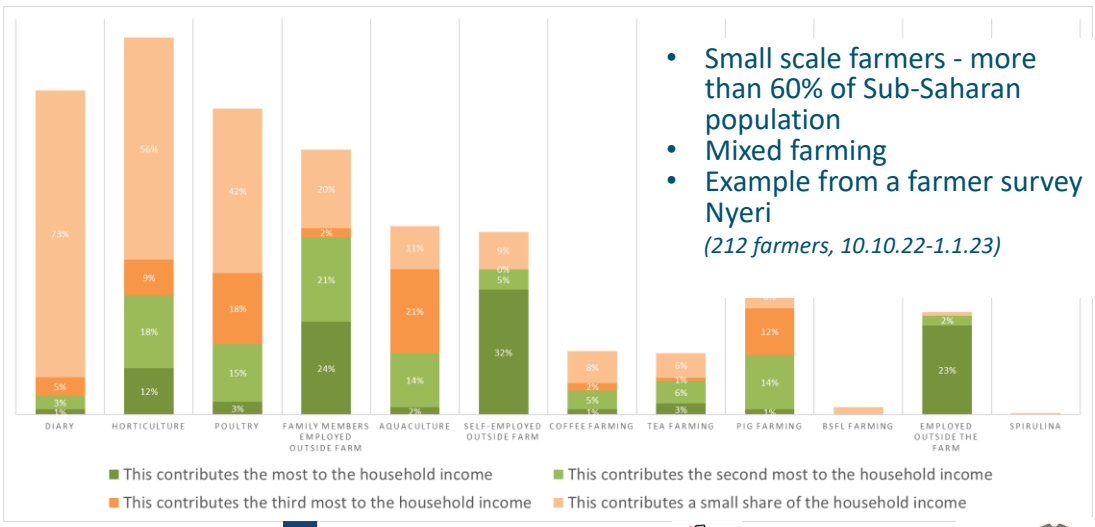
Nyeri – example of mixed farming



- Small scale farmers - more than 60% of Sub-Saharan population
- Mixed farming
- Example from a farmer survey Nyeri
  (212 farmers, 10.10.22-1.1.23)

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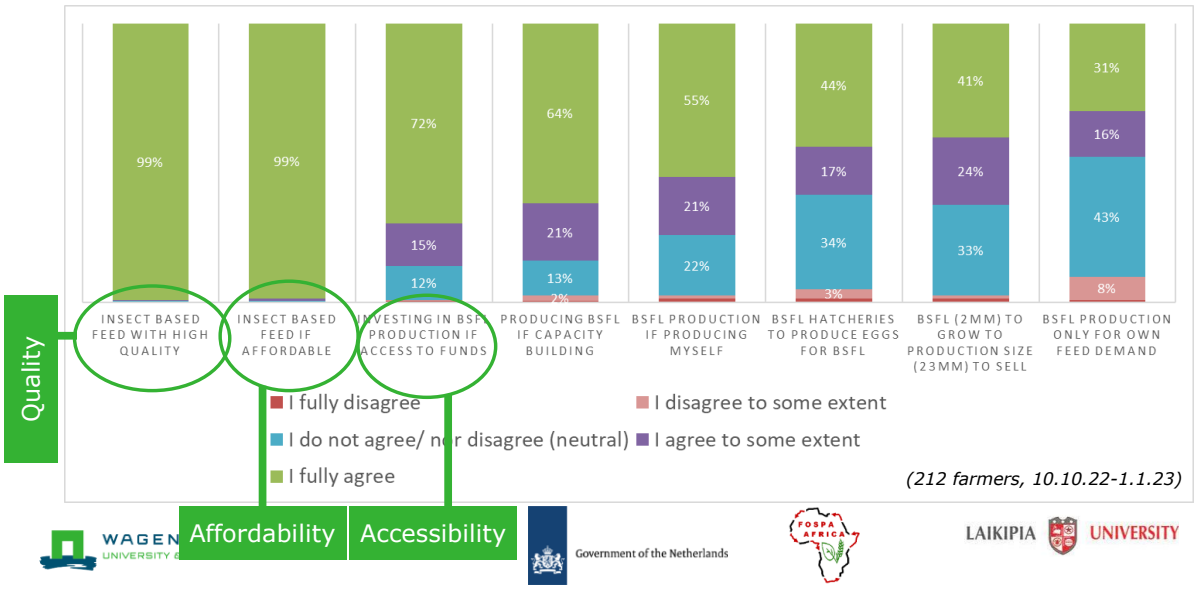
Nyeri –Interest in Black Soldier Fly Larvae in feed?



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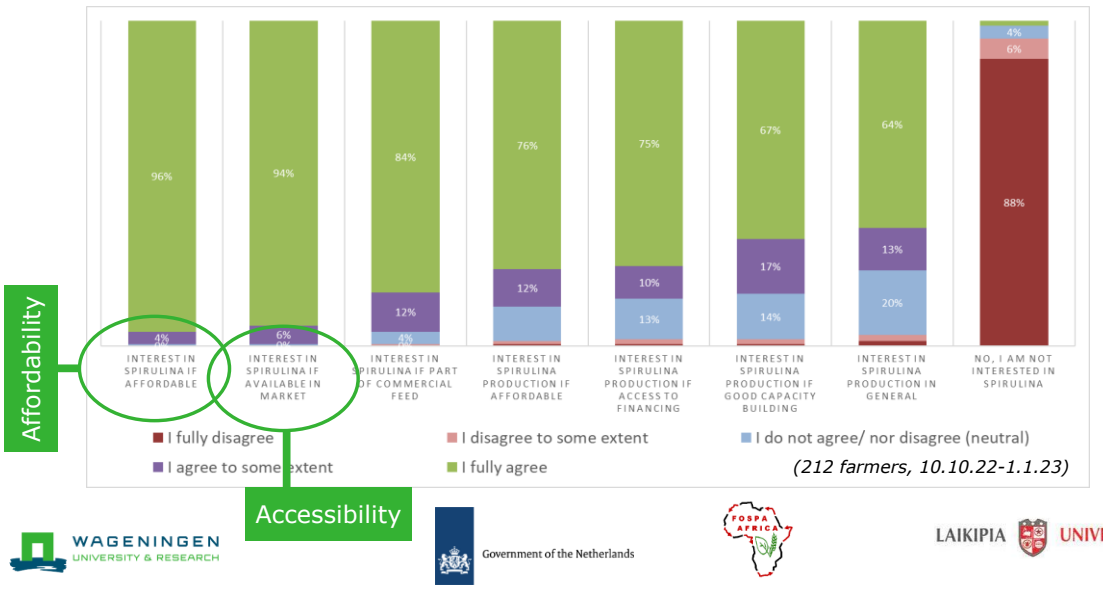
Nyeri – Interest in spirulina in feed?



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Feed quality

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KMFRI Kenya Marine and Fisheries Research Institute

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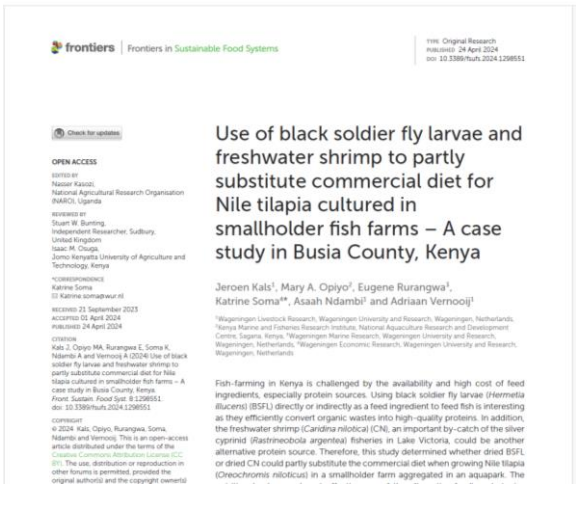

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TYPE Original Research
PUBLISHED 24 April 2024
DOI 10.3389/frsufs.2024.1298551

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OPEN ACCESS

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RECEIVED 21 September 2023
ACCEPTED 02 April 2024
PUBLISHED 24 April 2024

CITATION
Kals J, Opiyo MA, Rurangwa E, Soma K, Ndambi A and Vernooij A (2024) Use of black soldier fly larvae and freshwater shrimp to partly substitute commercial diet for Nile tilapia cultured in smallholder fish farms – A case study in Busia County, Kenya. *Front. Sustain. Food Syst.* 8:1298551. doi: 10.3389/frsufs.2024.1298551

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Use of black soldier fly larvae and freshwater shrimp to partly substitute commercial diet for Nile tilapia cultured in smallholder fish farms – A case study in Busia County, Kenya

Jeroen Kals[1], Mary A. Opiyo[2], Eugene Rurangwa[3], Katrine Soma[4]*, Asaah Ndambi[1] and Adriaan Vernooij[1]

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Fish-farming in Kenya is challenged by the availability and high cost of feed ingredients, especially protein sources. Using black soldier fly larvae (*Hermetia illucens*) (BSFL) directly or indirectly as a feed ingredient to feed fish is interesting as they efficiently convert organic wastes into high-quality proteins. In addition, the freshwater shrimp (*Caridina nilotica*) (CN), an important by-catch of the silver cyprinid (*Rastrineobola argentea*) fisheries in Lake Victoria, could be another alternative protein source. Therefore, this study determined whether dried BSFL or dried CN could partly substitute the commercial diet when growing Nile tilapia (*Oreochromis niloticus*) in a smallholder farm aggregated in an aquapark. The

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TYPE Original Research
PUBLISHED 05 March 2024
DOI 10.3389/frsufs.2024.1283150

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OPEN ACCESS

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RECEIVED 29 August 2023
ACCEPTED 09 February 2024
PUBLISHED 05 March 2024

CITATION
Soma K, Kals J, Opiyo MA, Ndambi A, Garcia-Cubero R, Barbosa MJ, Rurangwa E and Vernooij A (2024) Toward sustainable food systems: can spirulina (*Arthrospira platensis*) become a sustainable source of protein to enhance the nutritional benefits of cultured Nile tilapia (*Oreochromis niloticus*)? *Front. Sustain. Food Syst.* 8:1283150. doi: 10.3389/frsufs.2024.1283150

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Toward sustainable food systems: can spirulina (*Arthrospira platensis*) become a sustainable source of protein to enhance the nutritional benefits of cultured Nile tilapia (*Oreochromis niloticus*)?

Katrine Soma[1]*, Jeroen Kals[2], Mary A. Opiyo[3], Asaah Ndambi[2], Rafael Garcia-Cubero[4], Maria J. Barbosa[4], Eugene Rurangwa[5] and Adriaan Vernooij[2]

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Hunger affected 278 million people in Africa in 2021, and in Kenya, the proportion of the population unable to afford a healthy diet is 81%. To combat hunger and increase resilience throughout the food system, spirulina (*Arthrospira platensis*) has been shown to have remarkable properties. The main aim of this study is to investigate whether protein from spirulina is a suitable alternative to protein sourced from fish meal in fish feed for juvenile Nile tilapia (*Oreochromis*

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Trials Spirulina in controlled environment (KMFRI/Sagana, Kenya)

- Manure instead of chemical fertiliser
- Growth parameters of spirulina

Trials Spirulina - farm level (Kakamega/Nyeri, Kenya)

- Manure instead of chemical fertiliser
- What challenges appear for the farmers

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Affordability – why?

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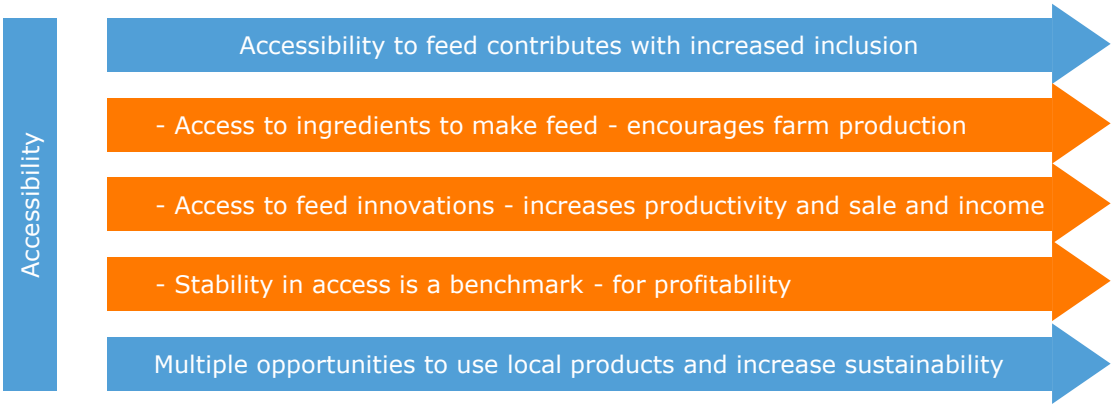
Accessibility – why?



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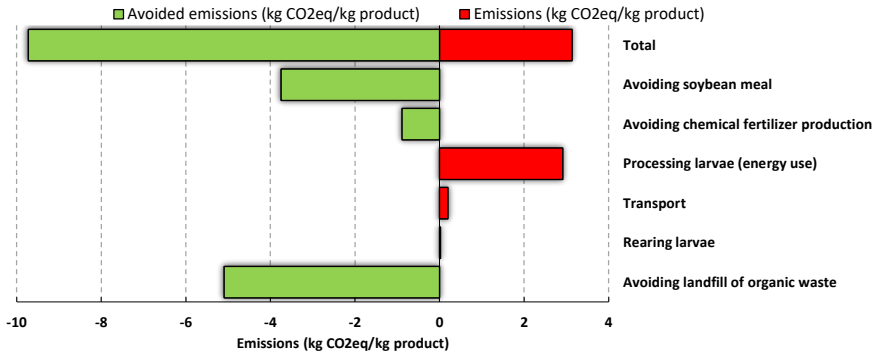
Environmental impacts of replacing soymeal with Black Soldier Fly Larvae (BSFL) as protein source

- Local circular economy approach
- High quality protein sources are available locally such as BSFL and spirulina



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Hassan Pishgar Komleh, et al., WUR

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Inclusion of small-scale farmers in feed production

- Accessibility to feed production systems
- Affordability of feed production systems
- Sustainability of feed production systems

- Local ownership
- Co-creation
- Communication
- Operationalisation
- Farm business model

- Small scale farmers
- Local communities
- Consumers
- Environment
- Climate

Combined

Impacts

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Spirulina feed trials

- By Benson Obwanga, Laikipia University

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What is Spirulina

- A blue green **ALGAE** dominant in alkaline volcanic **East African lakes (Lakes Nakuru & Elementaita-Kenya)**
- Has been used as **HUMAN FOOD** (***rich in protein, boosts immunity***)
- Requires high pH (**8.5-11.5**), Salinity ≥ 30g/L
- Used as **animal feed** (poultry, pig, fish)

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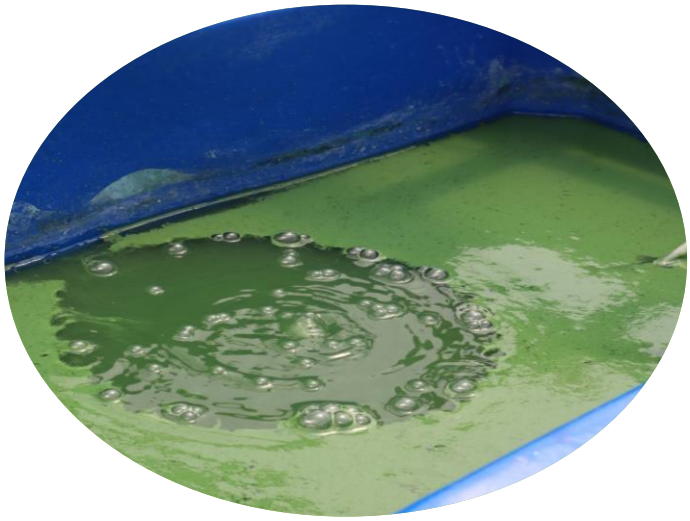
Why Spirulina



Spirulina platensis

- Excellent **CYCLIC FARMING** candidate
- Minimal **CARBON FOOTPRINT**
- Minimal production **SPACE**

Recycle of organic manure from farm	Zero carbon emissions during production	Minimal Space for production (backyard)

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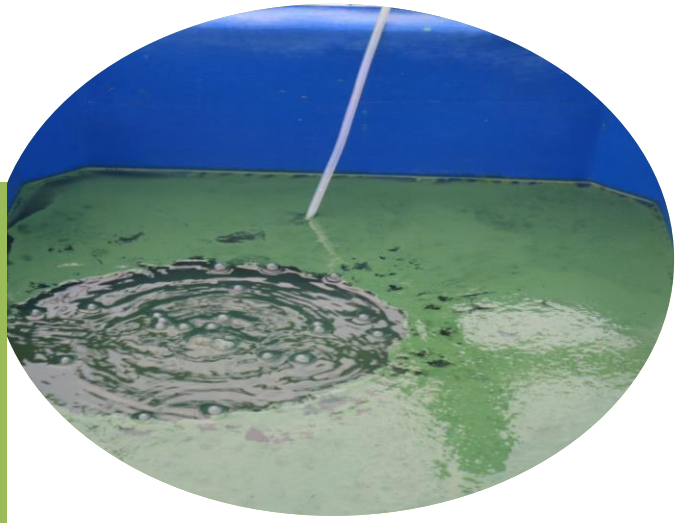
Why Spirulina in aquaculture



- High growth rates
- Versatility, can be farmed indoors and outdoors
- Has been used to replace fishmeal and Soya in diets for poultry, livestock and fish production
- Most cultivated Algae in the world
  - Crude protein 55-70%
  - 62% amino acids
  - Dietary supplement
  - Immune booster
  - Phytopigments
  - Has key vitamins and minerals

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Why Spirulina

- Production does not require fertile **land** or complex production systems
- Uses less water per kilo of protein(approximately 100l/kg protein) than crops

Excellent candidate for climate smart aquaculture

- Water can be **recycled** and only water loss is through evaporation

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Spirulina production Trials

NASIO TRUST identified farmers for Organic spirulina production

Farmers produced organic Spirulina using locally available organic fertilizers

3 Organic fertilizers were identified (Cowdung, Chicken manure, and Goat manure)

Laikipia University validated the outcomes of farmer production at KMFRI Sagana using manure locally available

4 Manure sources were used (Cowdung (**CWS**), Chicken (**CHS**), Goat (**GS**) & Pig (**PS**)

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Trials and validation at KMFRI Sagana

Set up determined the ideal proportions physical chemical conditions for Organic Spirulina production

- Source of fertilizer (**manure**)
- How to raise pH to 8.5-11.0 **baking soda** or **lye**
- Salinity (common salt)
- 5 treatments were set up
  - Control (Inorganic chemicals), **CHS**,**CWS**,**PS**,**GS**
- Comparison based on
  - Proximate composition (**CP, Lipids, CF, NFE, Ash)**
  - Algal cell counts
  - Biomass

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Trials and validation

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Trials and validation

- Manures were fermented & the liquid sieved to get an even liquid for mixing with water before innoculation
- pH and temperature monitored daily
- Stirring done every 30 mins
- Crashing /death / slow growth of the culture may result from
  - Excess manure
  - Lack of stirring
  - Unstable pH

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Spirulina farm trials

- By Maurice Onyango, Nasio Trust

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THE ORGANIC SPIRULINA TRIALS

Presentations By: **Maurice Onyango**

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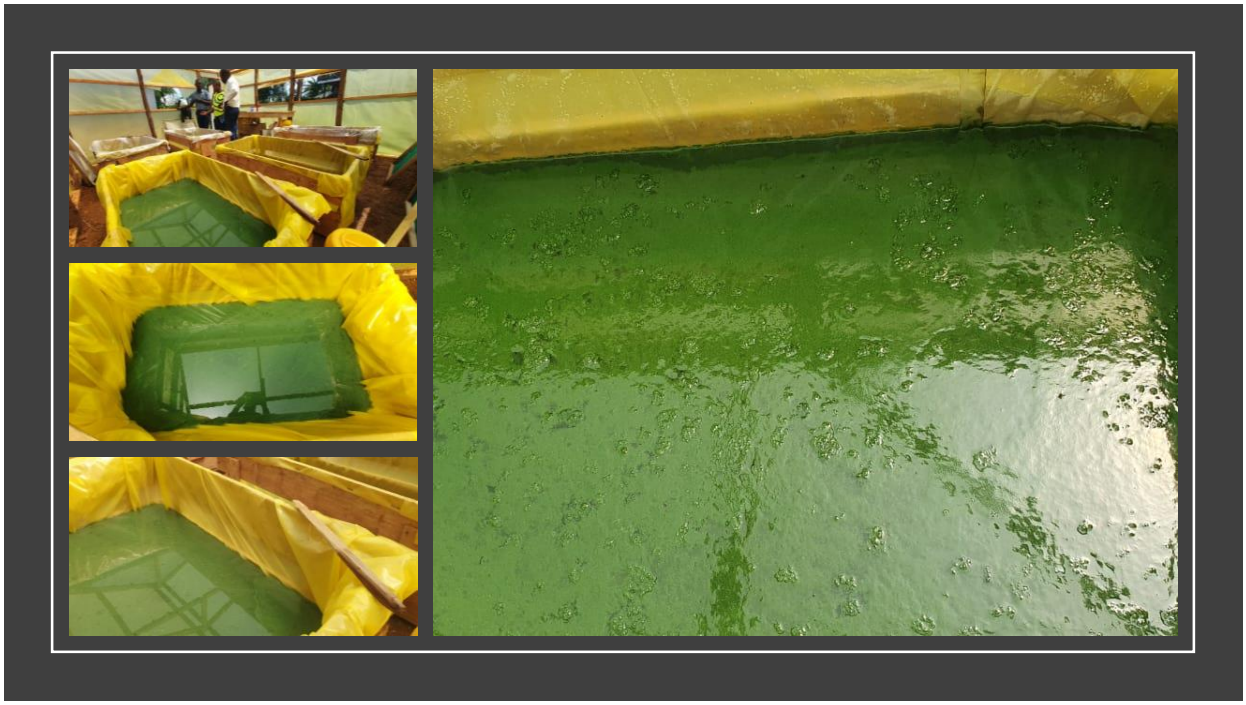

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Affordable-Recirculation Aquaculture systems (A-RAS)

- By Charles Mbauni Kanyuguto, FOSPA

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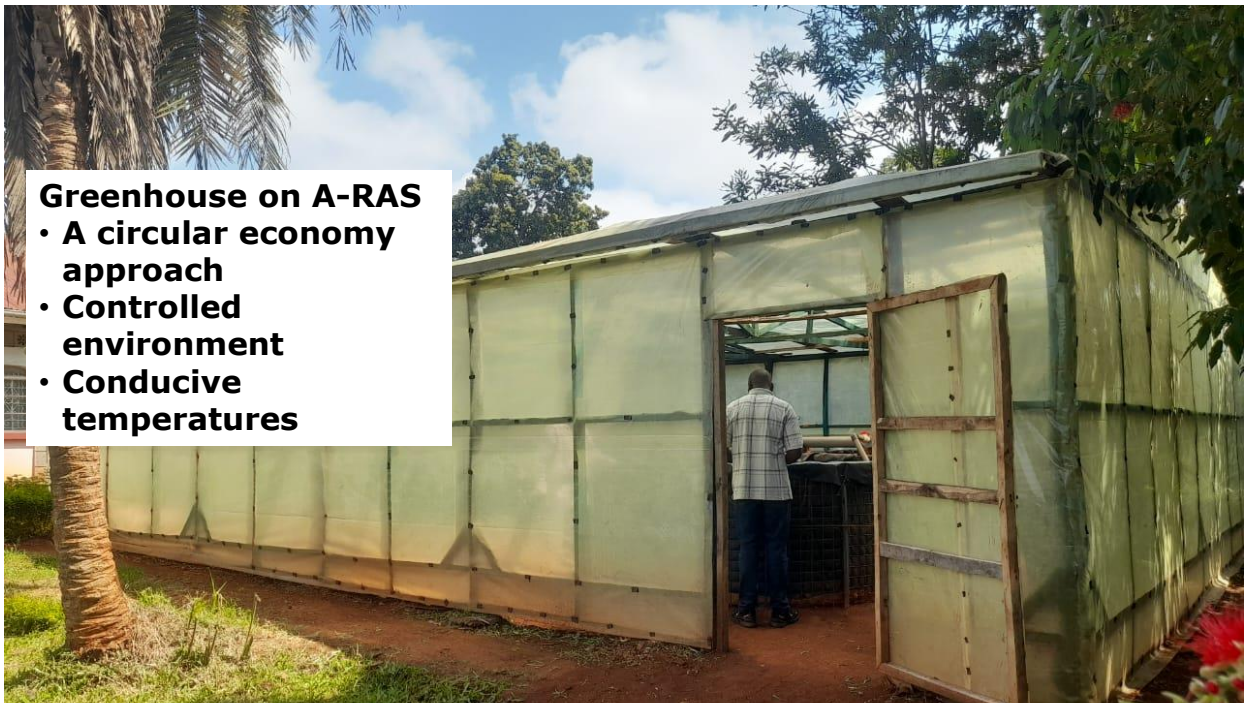
Greenhouse on A-RAS
• A circular economy approach
• Controlled environment
• Conducive temperatures

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Construction A-RAS
• Water filtration system
• Energy sources
• Recirculatory system

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Fish production A-RAS
• Achieved stocking density 100 fingerlings/m³

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• Challenges
• Potential of improving the system

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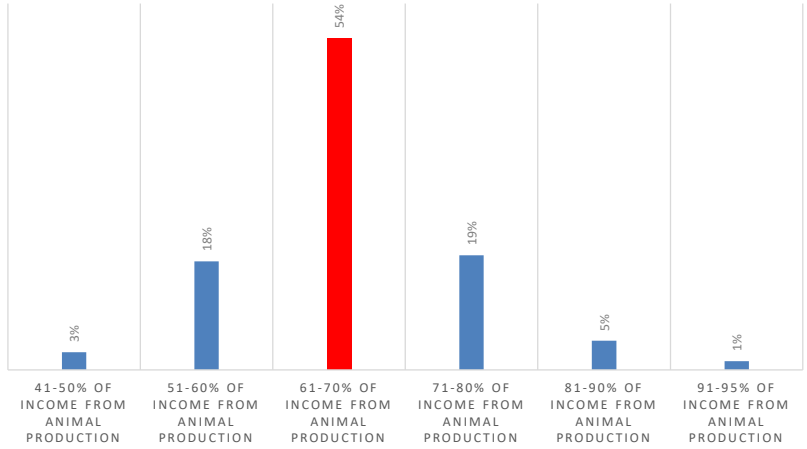
Affordability of feed to small-scale farmers

- **Use of expensive commercial feed is high**
- **More than 50% use 60-70% of income from animal production on feed**



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(212 farmers, 10.10.22-1.1.23)

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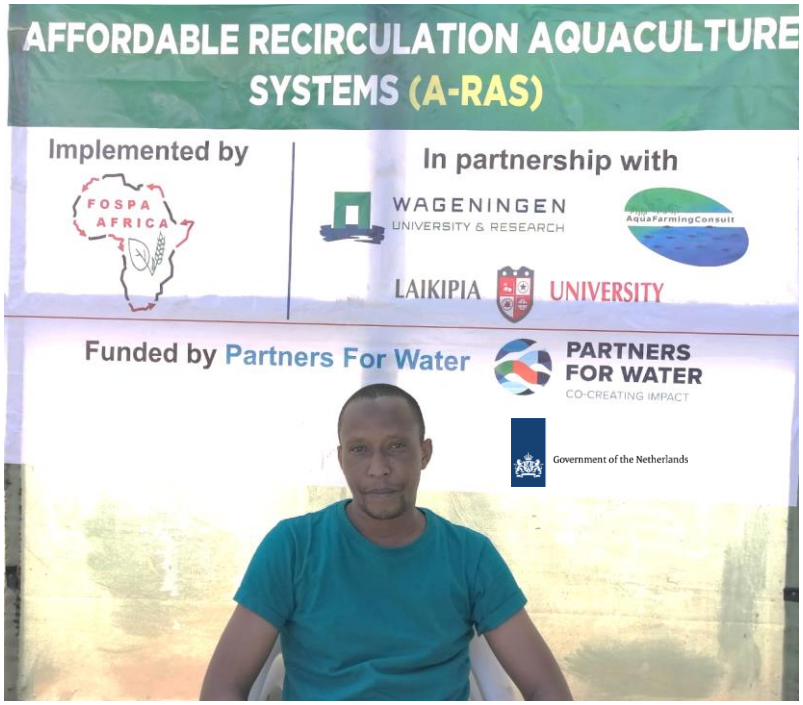
- **Experiments with locally produced feed Spirulina/BSFL**



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Black Soldier Fly Larvae (BSFL) – perceptions of farmers

- By Asaah Ndambi, WUR

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Awareness and prospects for Black Soldier Fly Larvae use as feed ingredient in Nyeri County Kenya

Asaah Ndambi
Katrine Soma
Asunta Gitari
Eugene Rurangwa
Benson Obwanga

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Introduction – the problem

- High rates of stunting and food insecurity in Kenya (UNICEF, 2017)
- Kenya's annual per capita fish consumption is 4.5kg, far below the FAO recommended consumption of 20kg per capita (Ogello *et al.*, 2022)
- Cost of production of proteins is high
- This makes products of animal proteins high which makes them unaffordable especially for low-income consumers (Cornelsen *et al.*, 2016).

World Bank, 2023

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Introduction – a possible solution

- Alternative sources of proteins should be explored, in the face of sustainability concerns for Fish Meal and soybean
- Black Soldier Fly Larvae (BSFL) has been touted as an alternative protein source
- BSFL is a sustainable protein source whose production also contributes to waste management and yields an important organic fertiliser with numerous benefits to the soil, referred to as frass (Abro *et al.*, 2020).

Sanergy, 2024

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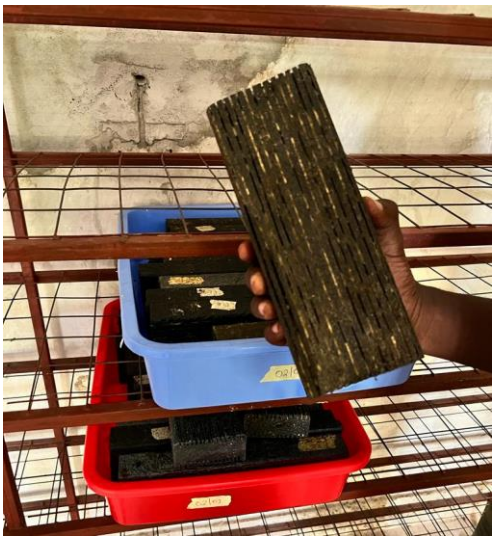
Objective

- Because BSFL use is fairly new in Kenya, information on its acceptability, and adoption bottlenecks are unclear
- Characterization of these factors can be used to address interventions that promote its widespread adoption
- This study explores factors influencing awareness and acceptability of BSFL as a feed ingredient by smallholder farmers in central Kenya



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Methodology

- The study applied a systematic random sampling and carried out household surveys in Central Kenya, yielding 212 respondents
- Data was analyzed using descriptive statistics, probit and Principal Component Analysis (PCA)

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Results – Characterisation of respondents

Variables	Share (%)	Variables	Share (%)	Variables	Share (%)
Gender of respondent		**Education level of respondent**		**Feed costs (% of total production costs)**	
Male	53.30	Primary school	22.64	41-50	2.88
Female	46.70	Secondary school	48.11	51-60	17.79
Age (years) of respondent		College	28.77	61-70	54.33
25-34	11.79	University	0.47	71-80	18.75
35-44	21.23	**Group Membership**		81-90	4.81
45-54	41.51	No group	2.37	91-95	1.44
55-64	24.06	Women's group	41.71	**Weekly Feed needs**	
65+	1.42	Mixed community group	47.87	1-5 kg	0.96
Farming experience (years)		Youth group	8.06	6-10 kg	9.13
1-2	2.83	**Frequency of feed shortages**		11-20 kg	13.46
>2-5	10.85	Never	0.96	21-30 kg	12.98
6-10	36.79	Once in three months	5.26	31-40 kg	16.35
>10	49.53	Once in a month	10.05	41-50 kg	11.54
Marital status of the respondent		Once in a week	1.44	>50 kg	35.58
Married	70.75	I always struggle	82.3	**Acceptability of BSF as feed**	
Not married	29.25			Farmers willing to use BSF as a feed	76

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Principal Component Analysis (PCA) results

Variables/Statements	Component 1	Component 2	Component 3	Component 4	Component 5
	Poor access to BSFL and inputs	BSFL business case	BSFL adoption requirements	BSFL price & quality	Human & financial capital
I'm interested in BSFL production	-0.025	**0.934**	0.158	0.061	0.051
I'm interested in getting BSFL larvae and sell	0.012	**0.899**	0.165	0.027	-0.065
Would like BSFL hatcheries to produce and sell	-0.013	**0.882**	0.131	0.006	-0.028
Would be interested if I could get funds	0.046	**0.824**	0.180	0.050	0.183
Would buy BSFL if cheaper than available feed	-0.140	-0.023	-0.051	**0.909**	0.023
Would buy BSFL if the quality is as good as the available feed	0.028	0.119	0.208	**0.822**	-0.104
Need for capacity building - demos is a need	0.208	0.066	**0.721**	-0.120	-0.060
Need for capacity building - training	0.092	0.071	**0.605**	-0.064	-0.056
Need for capacity building - group gathering	-0.068	0.154	0.298	0.254	**0.544**
Availability of startup capital is a need	0.162	-0.031	0.006	-0.194	**0.815**
Availability of BSFL seed is a need	-0.397	0.196	**0.528**	0.363	0.248
Need for raw materials for BSFL production	-0.201	0.320	**0.698**	0.287	0.250
Need for BSFL packaging materials	-0.090	0.322	**0.833**	0.226	0.273
Availability of the BSFL market is a need	-0.216	0.233	**0.640**	0.447	0.125
Availability of dried larvae too low	**0.959**	0.011	-0.001	-0.068	0.062
BSFL price is too high	**0.519**	0.044	-0.135	-0.344	0.055
Availability of BSFL pellets too low	**0.949**	0.050	-0.076	-0.150	0.029
Availability of BSFL eggs too low	**0.844**	-0.110	-0.088	0.195	0.058
Availability of organic waste too low	**0.641**	0.072	0.253	-0.384	-0.165
Availability of small larvae for growth too low	**0.950**	-0.018	-0.004	0.023	0.075
Percentage of variation explained	28.519	21.788	10.754	7.808	5.187
Cumulative variation	28.519	50.307	61.061	68.869	74.056
Eigen Values	5.704	4.358	2.151	1.562	1.037

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What do farmers consider as opportunities and challenges for adoption?

Poor Access to BSFL and Inputs

eggs, larvae and feed

BSFL Price & Quality

cheaper & of higher quality than existing feed

Knowledge Requirements

demonstrations, training & group support

BSFL Business Case

business opportunity + economic value for potential farmers.

Human & Financial Capital

funding & support for startup costs

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Factors influencing awareness

Variables	Margins (dy/dx)	z-statistic
Gender of the Household head	-0.047 (0.080)	-0.59
Education level of household head	0.070*** (0.019)	3.62
Age of the household head	-0.011** (0.05)	-2.24
Experience of the Household head	-0.008(0.064)	-0.13
Group membership	0.467* (0.281)	1.67
Number of income sources	0.079** (0.038)	2.09
Main farm activity		
Dairy farming	0.425*** (0.160)	2.66
Pig farming	0.138 (0.117)	1.18
Aquaculture farming	0.125 (0.096)	1.31
Constant	-3.286*** (1.177)	-2.79

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Recommendations

- Capacity building to farmers through training, and offering start-up production kits, larvae and eggs.
- Farmers to join groups – source of awareness of BSF, use of public meetings & vernacular radios to create awareness of BSF among old and less educated farmers.
- Farmers are keen on quality → the government should consolidate policies to develop and implement regulatory standards for quality BSFL feed.
- Partnerships should be made between government/policymakers and the private sector (financial providers, input manufacturers, established farmers)

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Questions & Answers

- Felicia Yieke, Laikipia University

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Wrapping up

- Eugene Rurangwa, WUR

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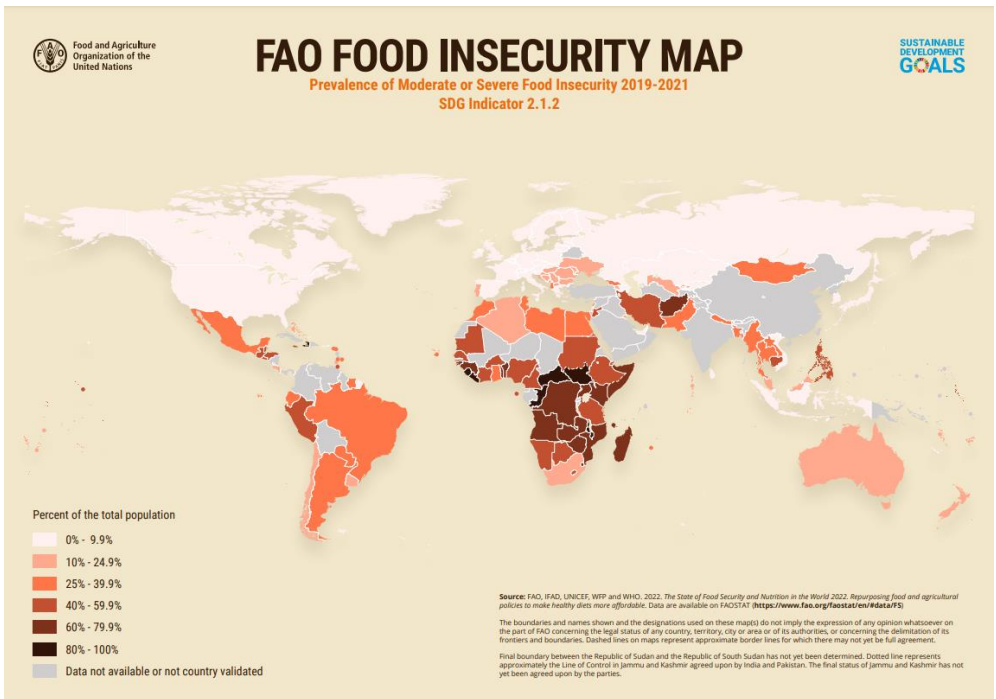
2 ZERO HUNGER

14 LIFE BELOW WATER

11 SUSTAINABLE CITIES AND COMMUNITIES

1 NO POVERTY



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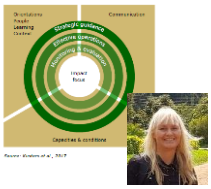
Overview

- Thanks to all for interesting insights shared during this meeting

Bart Pauwels

Siemen van Berkum

Katrine Soma



Benson Obwanga

Maurice Onyango

Charles Kanyuguto

Asaah Ndambi

Felicia Yieke

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Thank you for attending!

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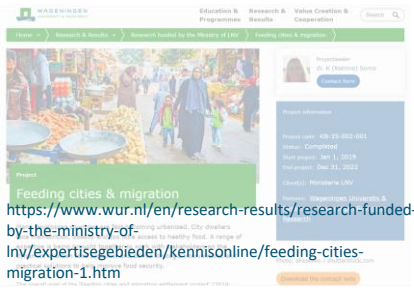
KMFRI Kenya Marine and Fisheries Research Institute

NASIO TRUST CHANGING LIVES FOR GOOD

3RKenya; the aquaculture part (2016-2020) → KB35: Feeding cities and migration settlements (2019-2022) → KB35: Alternative fish feed sources from local resources in Lake Victoria region (2022), → KB35: Food and Nutrition Security to Low Income Groups in Rural-Urban Food Systems in the Global South (2023-2024) → SMP 2022 Recirculation Aquaculture Systems (RAS) in Kenya (Seed money) (2022) → Affordable Recirculation Aquaculture Systems (A-RAS) to small-scale fish farmers in Nyeri, Kenya (Short title: A-RAS) (PvW) (2023)

Food & nutrition security for low-
https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksprojecten-lnv/soorten-onderzoek/kennisonline/food-nutrition-security-for-low-income-groups-in-rural-urban-food-systems.htm

3RKenya: https://edepot.wur.nl/519215



https://www.wur.nl/en/research-results/research-funded-by-the-ministry-of-lnv/expertisegebieden/kennisonline/feeding-cities-migration-1.htm

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More films

1) A NEW FISH VALUE CHAIN NYERI-KIBERA:
(https://www.youtube.com/watch?v=2MYOUZdjKVs&t=1s)

2) HIGH LEVEL UN Food system summit
(https://www.youtube.com/watch?v=b4oGoYuCnJ0)

Nyeri-Kibera – series of aquaculture Kenya:
(https://www.youtube.com/watch?v=2MYOUZdjKVs&list=PLz_ZBMIqwkG6dgXtreklICZdRMfTJ5fFj)

Kibera documentary:
(https://www.youtube.com/watch?v=K_goJu2encg&t=6s)

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