Completion Report

Closing the Nutrient Loop on Sustainable Aquaculture in Tanzania

Tanzania, NCF9 [NCF-C9-0647]

Grantee: *SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES*

Local Partner(s): *BIOBUU LTD & RUVU FARMS LTD*

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1. EXECUTIVE SUMMARY

Closing the nutrient loop on sustainable feed in Tanzania aimed to enable production of locally sourced fish feed for farmed tilapia. This since Tanzanian aquaculture has a potential to develop and greatly increase its production and sustainability, in turn contributing to increased food security, resilience and decreased climate impacts. The project has been carried out through a successful cooperation of partners in Tanzania and Sweden.

The main expected outcomes included enabling the production of sustainable tilapia feed based on Tanzanian raw materials and increased economic viability of feed producers and fish farmers. This since fish feed for Tanzanian aquaculture before the project was imported and to a higher extent sourced on less sustainable ingredients. The project has managed to reach most of preset targets in relation to developing the tilapia feed based on Tanzanian raw materials. It established a successful insect-based waste processing, including a feed processing plant with the local partner, BioBuu. The knowledge transfer through organized workshops and study visits resulted in enabling the local partner to manufacture tilapia diets for full tilapia production cycle. These diets are nutritionally balanced, are based on local feed ingredients, have a significantly lower environmental impact than the imported diets and are priced low, which is what the project has set as targets in the beginning. The local partner has started selling the diets to local farmers. The partner will have to continue to develop its insect-based feed as the trial conducted at the farm showed some weaknesses in regard to dietary recipes. In terms of employment, the project has enabled employment of additional staff with the local partner and has reached out to a total of 22 beneficiaries in Tanzania. In the long run, we expect the project to have a positive impact on local communities, especially local tilapia farmers who now have an option of sourcing their feeds locally, at lower cost while generating high production levels.

The project had some minor deviations in its execution as it was decided that on farm trials with several farms should be replaced with what the partners defined as a trial that would generate more reliable feedback, conducting a controlled trial at the farm with the local partner, using a scientific approach. In addition, the surveys that were planned before the beginning of the project were not conducted since the social science expert specialising in survey design at SLU concluded that such surveys would not result in reliable, usable data. To properly conduct such a study, the survey must include at least 100 participants (farmers). As the project did not have the budget for this, it was decided not to continue these activities because the data would have been unusable and results possibly misleading.

The project also succeeded in decreasing the CO2 emission by using locally sourced ingredients and has generated net GHG reductions during the course of the project lower than the original estimate. In addition, the results of LCA demonstrated that a reduction in CO2-e from 4.58 kg to 2.47 kg when insect larvae are used in the recipes. Such benefit should be considered in the future feed recipes relevant for Tanzania.

The project has a high chance of scaling up in the future, which will depend on the future sales, long-term results and additional funding. During the feed ingredient mapping in Tanzania, only a handful of larger companies bringing ingredients into Dar es Salaam region were identified. This can have implications on the local feed production as it can simplify communication with suppliers, but is likely to limit the supply and affect sourcing and price of fish feed ingredients.

2. ACHIEVEMENT OF RESULTS

2.1 Achievement of outcomes and outputs

Expected outcomes and outputs	**Indicators:**	**Achievement of outcomes and outputs:**
Outcome 1.1: Sustainable Tilapia feed based on Tanzanian raw materials	**1.1.1 Improved oil extraction from Black soldier fly (BSF) larvae 10%** **1.1.2 Increased waste to feed turnover 50%** **1.1.3 Decrease CO2 emission 265 GHG** **1.1.4 Increased inclusion rate of locally sourced raw materials in tilapia feed 50%**	**1.1.1 Successfully decreased fat content to under 10%** **1.1.2 Project has achieved 30% of waste to feed turnover during M3. Waste to feed ratio is normally 2-3%. This is wet feed to dry defatted meal. The insect meal itself is incorporated at the inclusion rates of 20-30%. The actual turnover is 30% of 3% for every 1kg of waste processed.** **1.1.3 Project decreasing CO2 emission with 129 ton.** **1.1.4 The project has surpassed the target of 50% inclusion rate for local ingredients and achieved a 67% inclusion rate.**
Output 1.1.1: Improved waste processing and larvae feeding practices	1.1.1.1 Confirmed purchase order for breeding nets and trays 1.1.1.2 Waste machinery installed and tested 1.1.1.3 2000 kg of waste processed /day	1.1.1.1 Project has sourced these items from a previous project. 1.1.1.2 All installed and tested. 1.1.1.3 project has by far exceeded initial waste processing targets (15 000 kg)
Output 1.1.2: Improved high quality (low fat) insect protein meal	1.1.2.1 confirmed purchase order of dryer, separator, shredder and expeller	1.1.2.1 purchase and delivery completed.

	1.1.2.2 chemical analysis of the insect protein meal	1.1.2.2 a total of 9 types of insect protein meal have been analysed and the optimal process identified.
Output 1.1.3 Customised list of local ingredients	1.1.3.1. ingredient sourcing report and qualification 1.1.3.2. laboratory sample results	1.1.3.1 Main suppliers identified. 1.1.3.2 identified 11 ingredients were carefully reviewed, and subjected to chemical analysis.
Output 1.1.4: Feed formulations composed	1.1.4.1. Fry feed recipes 1.1.4.2. Grow out feed recipes	1.1.4.1. Two dietary recipes for fry feed, including BSF meal, generated. 1.1.4.2. The project generated 6 recipes, both with and without BSF protein meal (surpassed the target of 2)
Output 1.1.5: Floating pellet production line	1.1.5.1 procurement report 1.1.5.2 indicator: SLU extrusion workshop report 1.1.5.3. Machinery installed and tested 1.1.5.4 Feed produced (5000 kg)	1.1.5.1 Procurement report completed, including information process description and full list of suppliers and associated information. 1.1.5.2 indicator: extrusion workshop and training completed, knowledge transfer initiated and report submitted. 1.1.5.3 All machinery installed and tested. 1.1.5.4. Partially achieved the goal, produced 3400 kg of feed.
Outcome 1.2: Increased economic viability of feed producers and fish farmers	**1.2.1 Tilapia feed priced competitively to imported feeds/feed priced less than imported feeds**	**1.2.1 Even without insect protein, it is possible to produce feed cheaper than imported feeds.**
Output 1.2.1. Trials conducted with fish farmers	1.2.1.1 Income increase 1.2.1.2 Farmer intention summary 1.2.1.3 Farmer satisfaction 1.2.1.4 Trial farmer identified 1.2.1.5 On-farm trials	1.2.1.1 Estimated potential saving of $0.20 USD per kg of fish produced. 1.2.1.2 to 1.2.1.3 partners have decided not to go proceed with this activity since such surveys would not result in reliable, usable data. To properly conduct such a study, the survey must include at least 100 participants (farmers). 1.2.1.4-1.2.1.5 Project partially achieved the targets. A controlled on farm trial has been performed at the local partner's farm.

Output 1.2.2 Go to market plan (scale up)	1.2.2.1 MOU's to buy feed 1.2.2.2 Social media paied advertisement 1.2.2.3 Product website 1.2.2.4 Business model documented	1.2.2.1 Partial fulfilment as the partner received first purchase for feed in 2023. 1.2.2.2 Partially fulfilled with one paid advertisement on social media. 1.2.2.3 Partially fulfilled with Instagram page as this is the main platform achieving highest traffic in Tanzania. The account currently has 452 followers. 1.2.2.4 project did not manage to successfully generate an insect-based feed with higher performance than the commercial diets, it was difficult to build a business plan.

2.2 Deviations from the planned outputs and activities

1.2.1.2 Farmer intention summary. After a thorough consultation with a social science expert specialising in survey design at SLU, it was concluded that such surveys would not result in reliable, usable data. To properly conduct such a study, the survey must include at least 100 participants (farmers). As the project did not have the budget for this, it was decided not to continue these activities because the data would have been unusable and results possibly misleading.

1.2.1.4-1.2.1.5 Trial farmer identified and on-farm trials. Well into the project, the project partners have agreed that running trials with Black soldier fly (BSF) supplemented feeds would generate more reliable data if done in practical, on-farm circumstances but under controlled conditions and well established protocols. As it was originally planned, the project would identify several farms in the Dar-Es Salaam region to run these trials. To increase the reliability of data acquired from such trials, it was decided that instead of running several trials at various private farms without supervision, it would be more beneficial for the trial to be more comprehensive and conducted at the local partner's facility. The partner employed permanent staff, who are adequately trained and the farm features a sufficient number of ponds for the trial to be conducted. In turn, a more scientific approach was taken during the trial, resulting even in a published MSc thesis. The results of these trials generated data which will serve for further development of nutritionally and technically optimized insect-based feed recipes.

2.3 Achievement of NCF indicators

NCF core indicator	Results (quantitative)			Clarifications/Means of verification
Number of beneficiaries reached	women		7	Number of people that have purchased feed
	men		15	
	total		22	
Number of people with increased resilience to climate change	women			Due to the stage at which the project ended, it is hard to predict the numbers, since the impact of the project is yet to be expected and augmented after the completion of the project.
	men			
	total			
Number of people with improved livelihoods	women		7	Improved situation for both farmers and newly employed people.
	men		19	
	total		26	
New decent jobs created	full-time	women		Direct employment at BioBuu
		men	4	
		total	4	
	part-time	women		
		men		
		total		
	seasonal	women		
		men		
		total		

3. CLIMATE CHANGE

Using the GHG emissions reduction template provided by NCF, the net GHG reductions during the course of the project are lower than the original estimate. Table below shows the net GHG calculations for the expected scenario. Initially, the project had estimated to process 900 tons of waste annually. Whilst the amount of waste received on site exceeded this, only 400 tons per year was processed using BSF. This is because the remaining waste was not suitable to be eaten by BSF. For the long-term reductions, the project does expect to increase its processing ability as it raises funds for expansion in 2024.

Year	Investment (EUR/year)	Net GHG emissions reductions (tCO_2e)	Carbon price (EUR/t)	Revenue (EUR)
1	300,000.00	37.75	9	339.78
2	150,000.00	38.38	9	345.45
3		52.86	9	475.70
4		113.26	9	1,019.35
5		113.26	9	1,019.35
6		113.26	9	1,019.35

In addition, the project also generated a Life Cycle assessment (LCA) on GHG emissions for the proposed feeds used in the fish trial, indicating a reduction in CO2-e from 4.58 kg for control diet to 2.47 kg for the high-BSF diet. This data is available in the MSc thesis published at https://stud.epsilon.slu.se/19032/.

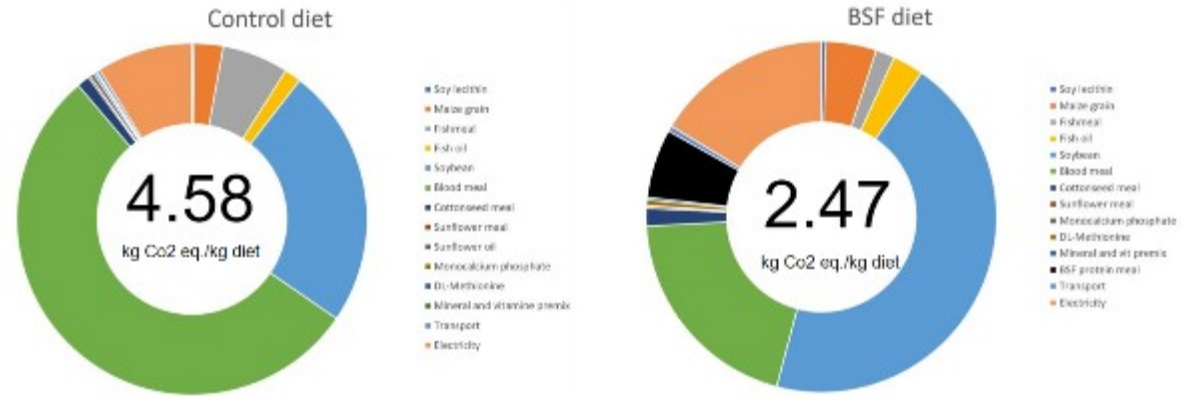

Figure 2. GHG emissions from the production of 1 kg Control diet and BSF diet, respectively.

These results are in line with the planned outcomes, however project partner will have to refine the inclusion levels of the BSF in dietary recipes in the future commercial diets in order to achieve near CO_2 reductions attained in the LCA.

4. DEVELOPMENT IMPACTS AND CROSS-CUTTING ISSUES

Under the project's scope, the first sustainably developed Tanzanian made fish feed has been developed, successfully marketed and sold. This has several implications that can potentially amplify in the long run. Most notably, through achieved local sourcing of feed ingredients and building of the production plant in Tanzania the prices of tilapia feed are *lower than those of imported feeds*. Project has set to achieve the goal of feed cost of under 1.4 EUR/kg and was able to do so as the resulting price of feed per kg is below this predefined goal. Details are given in table below.

		Comparative feed prices (protein content 37%)	
		Low BSF	High BSF
USD/TSH	2500		
	BioBuu	$ 1.25	$ 1.26
	Skretting	$ 1.52	$ 1.52
	Koudijs	$ 1.48	$ 1.48

Such prices *improve the resilience* of local tilapia farmers as they can adopt more efficient feeding practices and acquire high quality feed at a lower cost. In combination with stable feed supply available locally, the project has managed to *generate value* throughout the production chain.

The feed plant has also created new jobs and thus contribute to the improved livelihood. Overall, the results are projected to contribute to all three targeted sustainable development goals (zero hunger, climate action and life below water) through decreased environmental impact of local feeds and waste utilization, increased food production and lower nutrient leakage from feed at the farms.

5. ASSESSMENT OF THE RESULTS AND IMPACTS OF THE PROJECT

5.1 Relevance

Fish farming in Tanzania is in part constrained by limited access to high quality fish feed at acceptable prices. Small and medium size tilapia farmers are the ones who are most affected. By using the concept developed in the project, the feed ingredients are locally sourced and feed is produced in the Dar Es Salaam region and sold to regional farmers. These farmers will be able to increase their yield and expand business, thus creating new jobs. The competence developed within the project with a local partner will contribute to increasing the resilience of Tanzanian aquaculture, especially in regard to fish feed formulation, availability of feed to the local market and later on farmers in other parts of Tanzania as well.

As the project demonstrated tilapia feeds can be produced in a 'circular' system (converting waste into nutrients to be used in fish feed), and it should be there for be possible to continue the development of other similar circular feeds and contribute to food security in Tanzania. This is very much in line with the aim of the Tanzania Development Plan, Vision And Investment Priorities To Achieve Middle Income Status By 2025[1], where agricultural development is highlighted, as well as the 5 year plan issued by the Tanzanian government research institute; COSTECH, in which it details aquaculture specifically; "there is a need to carry out research on the development of high efficiency and environmental friendly aquaculture technologies, identify type of feeds and new species that can be efficiently cultured". Furthermore, the Tanzania National Government issued a National Environmental policy in 2021[2]. It states that municipal waste management continues to be a challenge. This is attributed to inadequate integrated waste management systems, lack of participation of private sector in municipal waste management, as well as investment in waste management systems that effectively address municipal waste challenge. Consequently, there is a need to promote investment in appropriate waste management technologies, enhance public awareness on effects of municipal waste, and strengthen institutions in terms of technical, human resource, and financial capacities to effectively manage municipal waste and enforce legislation. This project has achieved that by improving the ability of BioBuu to commercialise its operations around processing waste.

5.2 Effectiveness

The project delivered most of the present objectives with some constraints. The outreach in the fish farming community may have been slightly limited due to inability to conduct on-farm trials with several farmers but the partners agreed that the data reliability has higher priority in the development of the novel, climate friendly feed recipes. The weather conditions at the farm during the trial were sub-optimal and have likely somewhat negatively affected the performance of the fish, resulting in the higher feed conversion ratio (FCR.) values. The CO2 emission reduction goal was achieved and feed processing and formulation knowledge transfer transpired as planned. The project did not manage to generate the business plan as the insect-based feed did not perform as expected, however this is mitigated by resolving the technical challenges at the feed plant and additional feed formulations. The local partner will have to follow up on the use of insects in a more refined feed formulations following the end of the project.

5.3 Efficiency

Results have been delivered in a timely manner and within the available budget. The local partners have faced challenges in terms of purchasing all equipment needed for a fully functional fish feed production line but have managed to resolve them.

[1] https://www.tro.go.tz/wp-content/uploads/2021/06/FYDP-III-English.pdf
[2] https://www.vpo.go.tz/uploads/publications/en-1665473411-NATIONAL%20%20ENVIRONMENTAL%20POLICY%202021.pdf

5.4 Impact

The main developmental aspect of the current project is increasing the availability of feed that is affordable with a farming practice that is proven to work. This will have several impacts. The Tanzanian aquaculture is yet to be developed and the FAO[3] reports suggest that Tanzanian aquaculture is still in its infancy, therefore access to affordable good quality aquaculture feeds is crucial for further development. The aquaculture industry in Tanzania has a gender ratio of females to males of 70:30 and offers great employment possibilities for youth as well. Our model is now tried and tested and is making its way onto the market.

Although this was not assessed under the scope of this project, we expect the project results to indirectly contribute to new employment opportunities, mainly through lower costs of fish farming and creating new value chains for the locally available raw materials. This opens up new possibilities for a new farmer or a farmer that has had poor yields in the past. An increase in yields will generate new jobs. New jobs mean increased food security both through the ability to buy food and the fact that we are now producing a new, sustainable source of protein. By pushing the farmer away from using fish meal as the protein source, we are contributing to reducing the rate at which wild fish stocks are depleting.

Through the established feed plant in this project the local partner has created an employment for 4 people and with the upcoming plans for expansion and upscaling, this number will surely increase.

5.5 Sustainability

Using waste streams to produce protein for fish feed and thereby contribute to replacing imported and unsustainable practices such as imported soy and fish meal in feed is a sustainable concept and has proven to work within the scope of the project. We now have a product that is based on locally sourced feed ingredients, and we will continue to push the development of insect protein supplemented feeds. The waste to BSF concept is already proven to significantly decrease the environmental impact of feed but also in the long term will contribute to valorisation of waste streams. This in turn should secure that there are available waste streams for BSF production in the long run. The government will need to recognize this as an efficient mean to provide ecosystem services with several added benefits already described. With current ingredient availability and pending that ingredient prices won't rise significantly in the future, we should be able to assure a stable supply and further development of sustainable feeds. Another prerequisite towards assuring long-term sustainability and benefits is willingness of famers to adopt the new feed and future marketing

[3] https://www.fao.org/figis/pdf/fishery/countrysector/naso_tanzania/en?title=FAO%20National%20Aquaculture%20Sector%20Overview%20%28NASO%29

strategies. This will encourage other farmers to accept this and similar incentives more openly and should broaden the geographic outreach.

The plant that was built as a part of this project has helped the local partner move into a phase of producing finished feeds as a main revenue stream. The gains through this project means that the local partner can really benefit from the margin gains of producing a finished product. This is accentuated by the fact that the plant can also produce dog and chicken feeds. Knowledge transfer between project partners have also provided the local partner with a good foundation to identify technical needs that is required for future scale up. Lastly, the plant has trained personal in place that allows the local partner to continue the production to respond to the growing demand of fish feed and dog food on the Tanzanian market.

6. INNOVATION

Innovative aspect of the project can be defined as the use of local ingredients in feed formulation to fish and establishment of local producer that now has the means to and is already generating a product with lower environmental footprint than the ones available before the start of this project. Tilapia farmers can now better afford high quality sustainable tilapia feeds. Up until now, there were no domestic producers of tilapia feed but rather companies selling imported feed. In terms of regional development, the project is expected to have long term benefits for the farmers and their families and the climate.

Furthermore, the technology introduced during this project can also be considered highly innovative. In the Tanzanian context, twin screw extrusion, is a cutting-edge innovation. There are no other companies in Tanzania currently employing twin screw extrusion technology to produce high protein feed for Tilapia.

7. POTENTIAL FOR SCALING UP AND FOLLOW-UP INVESTMENTS

The project has a high chance of scaling up in the future, which will depend on the future sales, long-term results and additional funding. So far none of the buyers have stopped ordering feed which is encouraging. The waste processing efficiency using BSF larvae will be improved through securing additional funds for processing plant upgrades. There is a need for opening new sites for waste processing and the possibility for opening new sites is high. The feed production needs to be scaled up as the current capacity is not enough to allow for large scale production and therefore reaching out to a larger market. More focus will be also placed on optimizing the inclusion levels of BSF in tilapia feeds and the local partners are monitoring this. This will allow for decreased dependencies on other protein sources in fish feed, especially the ones that can be used in direct human consumption.

The project has already secured an additional EUR 200,000 in grant funding to explore the potential for using the insect oil in animal feed. This would replace the sunflower oil currently being used.

The project is also in the technical approval stage to build a customised facility that will combine all of the local partner's (BioBuu) activities in Tanzania. This would facilitate waste processing and final product preparation on the same site. This project is valued to be over $1m USD.

8. RISKS

Project has identified a number of risks at the beginning and during its course with only one risk partially materialising. The feed tested in farm trials in M4, while it was nutritionally appropriate it had higher FCR than expected. This is likely due to weather conditions as the water temperature during the trials were high, likely hindering the feed conversion. Another possibility is that he BSF inclusion level was too high to produce optimal floating pellet. A follow up extrusion test were performed at the local partner's feed plant in order to optimize the process and increase the pellet quality, thus mitigating any issues in relation to technical quality. Testing of this recipe in fish will have to be done outside the project.

9. MONITORING AND EVALUATION

Within the scope of the project, partners have conducted several evaluative activities focused on processes and product development.

Partners have worked together on assessment of the raw feed materials available in Tanzania. The feed materials were selected based on nominal composition issued by the producer and their value, shipped to the lead partner. The lead partner analysed the nutritional composition of the received feed materials and generated selection criteria based on nutritional quality, price and availability. The lead partner developed the dietary feed formulation using this data and the local partner sourced the necessary amounts and conducted several processing trials in order to develop and optimize the production process. In the process, several improvements have been made in the processing steps at the local partner's plant.

The local partner produced the BSF meal at its facility in Tanzania and the feed recipes were then developed by the lead partner for on-farm trials based on low to high inclusion of circularly produced BSF meal in the feed. During on-farm trials we tested these novel feeds and the focus was on assessment of growth performance of fish in production ponds and environmental impact of using the BSF as a protein source in Nile tilapia feed. In addition the lead partner conducted an evaluation of the physical feed quality of the feeds tested in the trial.

The life cycle assessment of the produced dietary recipes was also conducted, generating reference values regarding CO2 emissions for this type of feed.

These tests were conducted in accordance with scientific methods and principles. The results and the data obtained will be used by the local partner to optimize the recipes and feed processing in order to continue the product development.

During the visit to the local partner's feed production plant, the methodology and production process was evaluated during test production and optimized by the lead partner.

10. LESSONS LEARNT

The cooperation between partners have resulted in local feed production. Knowledge has been transferred to enable future local feed production in Tanzania. During the ingredient sourcing activities, it was identified that the majority of feed ingredient resellers are dependent on a handful of larger companies bringing ingredients into Dar es Salaam. This has implications for the project partner BioBuu; on one hand it will be easier to deal with fewer suppliers, but it will also mean that the ingredients may be harder to source.

The partners did not properly detail the flow of the project sequencing. Some of the deliverables were put in a timeline/deliverable that was not possible as it required other deliverables to be complete first.

The project partners did not properly understand the method of disbursement followed by NCF. After several communications the team is confident that they have a better understanding of the way NCF handles disbursements.

Procurement exercises require an appropriate and clear specification in order to avoid wasting time with suppliers who cannot fulfil the specifications.

The more detailed LCA calculations inform us what ingredients in the fish feed have a small and large carbon footprint. These results can help us to make feeds with lower GHG emissions in the future.

Experiences gained during the on-farm trials have given all partners valuable knowledge on this type of experiment and more systematic evaluations.

However, the trials were affected by high temperatures. In the future, trials should be run in the north of the country, where water temperatures stay within acceptable levels. Or the trials happen during the colder months (May-Oct) in a coastal region.

11. OUTREACH

Project has communicated the results through several means/channels.

The project did have its initial inauguration at its main site called Mabwepande. The site was inaugurated by the Regional Commissioner of Dar es Salaam and the German Ambassador. The ambassador was present because the City of Hamburg funded the building of the compost site.

- New items from inauguration

The local project partners were featured in the following media outlets in 2021:

- BBC Smart Money May 2021 (English)
- BBC Smart Money May 2021(Swahili)
- 60 Seconds Documentary January 2021

Results from the on-farm evaluation have been described in a master thesis from the Swedish University of Agricultural sciences. The results have also been presented at an online seminar where Tanzanian partners were invited to attend.

- Master thesis: Evaluation of novel climate-friendly feed for Nile tilapia in Tanzania

On social media, results and information on locally produced fish feed have been spread through BioBuu's Instagram account, including the following advertisement.

12. FINANCIAL SUMMARY

Table 1. Project financing per partner

Expenditures, EUR	NCF	SLU	BioBuu	Ruvu farm	Total
SLU	96.291	32.570			128.861
BioBuu	136.658		72.104		208.762
Ruvu farm	20.100			5.106	26.106
Total	253.949	32.570	72.104	5.106	363.729

13. CONCLUSIONS AND RECOMMENDATIONS

In the beginning of the project there were issues in the understanding of how NCF as a project works. Hence, by engaging in thorough communication between project partners and NCF following M1, the project partners have continued the project in better shape to deliver the outputs. Overall, the project progressed well through the remaining milestones and any arising issues were dealt with in timely manner.

The project has largely managed to fulfil most of the goals set in the beginning. The project enabled establishing novel competence and practices with the local partners in Tanzania through knowledge transfer and on-site experiences. It has identified and sourced the local feed ingredients and generated both the feed recipes and the actual feed of sufficient quality, as defined in output 1.1. Furthermore, the feed produced was priced competitively, even when made without the inclusion of insect protein, which corresponds well with the previously set outcome 1.2. The trial results demonstrated that insect feed is comparable to the commercially available feeds. It further indicated that including larvae in the feed should be additionally refined to ensure the highest quality feed and the best growth performance. Therefore, except for a few deliverables, the project has managed to fulfil most of the previously set goals.

Annex 1 Project completion fact sheet

Project Name:			
Project no.			
Country:		**Financing:**	
		EUR	**%**
Nordic Partner:	SLU	32.570	9%
Local Partner:	BioBuu	72.104	20%
Other Partner:	Ruvu Farms	5.106	1%
	NCF grant disbursed	253.949	70%
	Total		**100%**
Classification:	Mitigation		
Project cycle:	Project start date: 2021-04-01 Original closing date: 2023-09-30 Actual closing date: 2023-09-30		
Short project description:	This project aimed to transform organic waste into a high-quality protein ingredient for tilapia feeds and generate tailor-made Tanzanian fish feed to be offered on the existing market. By utilizing the organic waste as a substrate in insect production, the project led to decreased emissions of greenhouse gases and a high-quality protein ingredient. Aquaculture production in Tanzania relies heavily on expensive, unsustainable imported feed or inadequately produced local feed, having a negative impact on both the environment and the local economy. This project developed a Tilapia feed formulation that was a practical option for farming in Tanzania, based on locally produced ingredients from sustainable sources. Such feed was also economically viable from the farmer's perspective, at an expected price of less than 1.4 EUR/kg, similar to currently produced local feed. Main feed components were black soldier fly meal, produced on waste streams, together with local by-products. Furthermore, the local company was enticed into developing knowhow and capacity for feed production. Feed was produced in Tanzania; a nation with few fish feed producers and introduced to local small-scale fish farmers. On-farm visits and workshops were organized for farmers to improve management, boost yields, and increase knowledge on nutrition and aquaculture. The project established a more resilient, cost-effective method of tilapia farming, creating value at all stages of the value chain.		
Project performance:	**Expected Outcomes and Outputs**	**Achieved**	**End-of-project status**
	Outcome 1.1: Sustainable Tilapia feed based on Tanzanian raw materials	Yes	The project successfully reduced fat content to under 10% and achieved a 30% waste to feed turnover. Additionally, the project exceeded its target of 50% inclusion rate for local ingredients, achieving a 67% inclusion rate.
	Output 1.1.1: Improved waste processing and larvae feeding practices	Yes	The project has exceeded preset targets for waste processing by 700%
	Output 1.1.2: Improved high quality (low fat) insect protein meal	Yes	Equipment installed and 9 types of insect meal tested
	Output 1.1.3 Customised list of local ingredients	Yes	Suppliers identified and 11 ingredients reviewed
	Output 1.1.4: Feed formulations composed	Yes	Exceeded the target number of recipes by 4
	Output 1.1.5: Floating pellet production line	Partially	The amount of produced feed was 3.4 tonnes out of 5
	Outcome 1.2: Increased economic viability of feed producers and fish farmers	Partially	The project encountered challenges in fully developing insect-based feed within the project timeline. Despite this, the project developed locally made feed of competitive quality at lower prices than any available product on the Tanzanian market.
	Output 1.2.1. Trials conducted with fish farmers	Partially	Planned surveys were not completed due to the small sample size. Fish trials were completed successfully in Tanzania.
	Output 1.2.2 Go to market plan (scale up)	Partially	The first feed was purchased in 2023, and extensive social media advertisement

Climate change outcomes and impacts:	Utilizing the GHG emissions reduction template provided by NCF, the project has made significant strides in reducing net GHG emissions, although slightly below initial estimates. Originally projected to process 900 tons of waste annually, the project effectively processed 400 tons per year using BSF, showcasing progress despite challenges with unsuitable waste. Moreover, with plans for expansion in 2024, the project anticipates further enhancements in its processing capacity for long-term reductions. Furthermore, the project's Life Cycle Assessment (LCA) on GHG emissions for the proposed feeds used in the fish trial yielded promising results. The assessment revealed a notable reduction in CO2-e, from 4.58 kg for the control diet to 2.47 kg for the high-BSF diet, as documented in the MSc thesis. These findings not only align with projected outcomes but also highlight the project's positive impact. Moving forward, refining the inclusion levels of BSF in dietary recipes for future commercial diets will ensure continued success in achieving significant CO2 reductions, as indicated by the LCA.
Development outcomes and impacts:	Within the project's scope, the development of the first sustainably produced Tanzanian fish feed has been achieved, effectively marketed, and successfully sold. This achievement holds significant implications with potential long-term amplification. Notably, by locally sourcing feed ingredients and establishing a production plant in Tanzania, the prices of tilapia feed have been reduced compared to imported alternatives. The project aimed for a feed cost below 1.4 EUR/kg, a target successfully met as the resulting feed price per kg falls below this threshold. Such affordability enhances the resilience of local tilapia farmers, enabling them to adopt more efficient feeding practices and access high-quality feed at reduced costs. Furthermore, in conjunction with a stable local feed supply, the project has generated value across the production chain. Moreover, the establishment of the feed plant has created new employment opportunities, contributing to improved livelihoods. Overall, these results are anticipated to contribute significantly to the achievement of all three targeted sustainable development goals (zero hunger, climate action, and life below water). This contribution is facilitated through the reduced environmental impact of local feeds and waste utilization, increased food production, and decreased nutrient leakage from feed on farms.

NCF core indicators

NCF core indicator	Results (quantitative)			Clarifications/Means of verification
Number of beneficiaries reached	women		7	Number of people that have purchased feed.
	men		15	
	total		22	
Number of people with increased resilience to climate change	women		0	N/A
	men		0	
	total		0	
Number of people with improved livelihoods	women		7	Improved situation for both farmers and newly employed people.
	men		19	
	total		26	
New decent jobs created	full-time	women	0	Direct employment at BioBuu
		men	4	
		total	4	
	part-time	women	0	
		men	0	
		total	0	
	seaso-nal	women	0	
		men	0	
		total	0	

Annex 2 Updated Results Framework / Logical Framework Matrix

See updated framework in ‘Section 2. Achievement of results’ on page 4.

Annex 3 Pictures

Kigen Compton (BioBuu) in the feed technology lab at the Swedish University of Agricultural Sciences (SLU) in Uppsala Sweden, collecting sample material during workshop activities, photo Aleksandar Vidakovic

Sample of floating fish feed produced during the workshop**,** photo Aleksandar Vidakovic

Ketse 20/40, twin-screw extruder from Brabender GmBh at the feed technology laboratory at the Swedish University of Agricultural Sciences (SLU), Uppsala, photo Aleksandar Vidakovic

Drone image of the site for processing waste for this project. It is a 15 acre composting site managed by the project partners BioBuu, photo Kigen Compton

Processing waste site, plastic trays on the right hand side contain production of BSF larvae on locally sourced waste material. Photo Kigen Compton

Waste processing site inauguration (Regional Commissioner for Dar es Salaam and the German Ambassador to Tanzania), photos:

Waste processing site inauguration (Regional Commissioner for Dar es Salaam and the German Ambassador to Tanzania), photos:

The equipment that was purchased during the project and used to make floating fish feed. Photos taken by Kigen Compton during installation

The feed before cutting, produced during project activities at the BioBuu processing plant, photo: Kigen Compton

Experimental hapas used for on farm trial to evaluate Tilapia farming using the produced feeds at Ruvu fish farm. Photo: Vilma Johansson

End on trial at Ruvuu farm, in the process of capturing the fish for final weighing and measurement. Photo: Aleksandar Vidakovic

Final weighing and measuring of fish to evaluate growth performance of evaluated feeds at Ruvu Fish Ltd fish farm. Photo: Vilma Johansson

Above, test extrusion trial during lead partners visit to Biobuu feed plant, photo Aleksandar Vidakovic, left, Kigen Compton of Biobuu and Aleksandar Vidakovic of SLU with a sample of improved floating pellet produced during the test, photo: Hanna Carlberg

Annex 4 Other supplementary documentation

Not applicable

Annex 5 Impact story

Closing the Nutrient Loop on Sustainable Aquaculture in Tanzania

Aquaculture production in Tanzania heavily relies on costly imported feed or poorly produced local alternatives, which not only strain the economy but also harm the environment. To address this pressing challenge of unsustainable aquaculture feed practices in Tanzania, three partners joined forces and received grant financing from the Nordic Climate Facility to develop an alternative and sustainable solution.

The financing provided targeted two interventions. First, the development of a new recipe for Tilapia feed that introduced Black Soldier Fly (BSF) larvae as the main source of protein. Before turning the larvae into meal, they are grown by organic waste that would otherwise had ended up at landfills where the decomposition would have released greenhouse gasses. Second, the purchase of machinery to setup a production line in Dar es Salaam for the testing and production of the new feed.

The three partners each contributed with their own part and expertise to ensure successful delivery of the project. The Swedish University of Agricultural Sciences led the efforts in testing ingredient nutritional value, designing feed profiles, and provided training and guidance on the feed production technology. BioBuu, a local company in Dar es Salaam, hosted the new production line and facilitated market outreach. Ruvu Fish Farms, also based in Tanzania, played a crucial role in conducting smallholder farmer trials to test and quality assure the feed produced.

<u>Making an impact on the ground and in the ponds</u>

By project completion, the partners had successfully identified a price-competitive and high-quality recipe in the lab and initiated its production of Tilapia feed. The product has been made available to the market and is starting to make an impact on the ground.

Mwajuma Abdul Magoma and her husband Hija own a one-acre plot of land in Mabwepande, Tanzania, where they produce Tilapia. The couple has previously grappled with the unpredictable availability of fish feed in local markets. A persistent challenge that often left them facing prolonged periods without adequate feed due to shipment delays and other logistical hurdles.

With the new feed processing plant and the locally produced feed, Mwajuma and Hija are now seeing a notable transformation. Beyond merely ensuring a consistent and balanced diet for their Tilapia, Mwajuma and Hija have witnessed a notable uptick in their overall harvest yields. Encouraged by the tangible results, Hija is now keen on capitalising on their success story, not only by incorporating the feed into their own farming practices, but also by venturing into its distribution to fellow aquaculturists grappling with similar supply chain issues.

Turning waste into value

In Africa, waste is a real challenge for rapidly urbanising cities, including Dar es Salaam. The issue pertains to inadequate waste management systems and lack of capacities to address the problem. A large amount of the waste is organic waste and when it is not processed it constitutes a problem for the environment and the well-being of humans.

This project, with the installation of the new production line using BSF larvae to process waste, has managed to provide a tangible solution that can help address the problem going forward. During the last year of the project, the BSF larvae managed to process more than 400t organic waste that would otherwise have ended up at the landfill. Instead, it was turned into a valuable ingredient in the Tilapia feed recipe that helped keep costs competitive without compromising the quality of the feed.

Mwajuma Abdul Magoma and her husband Hija