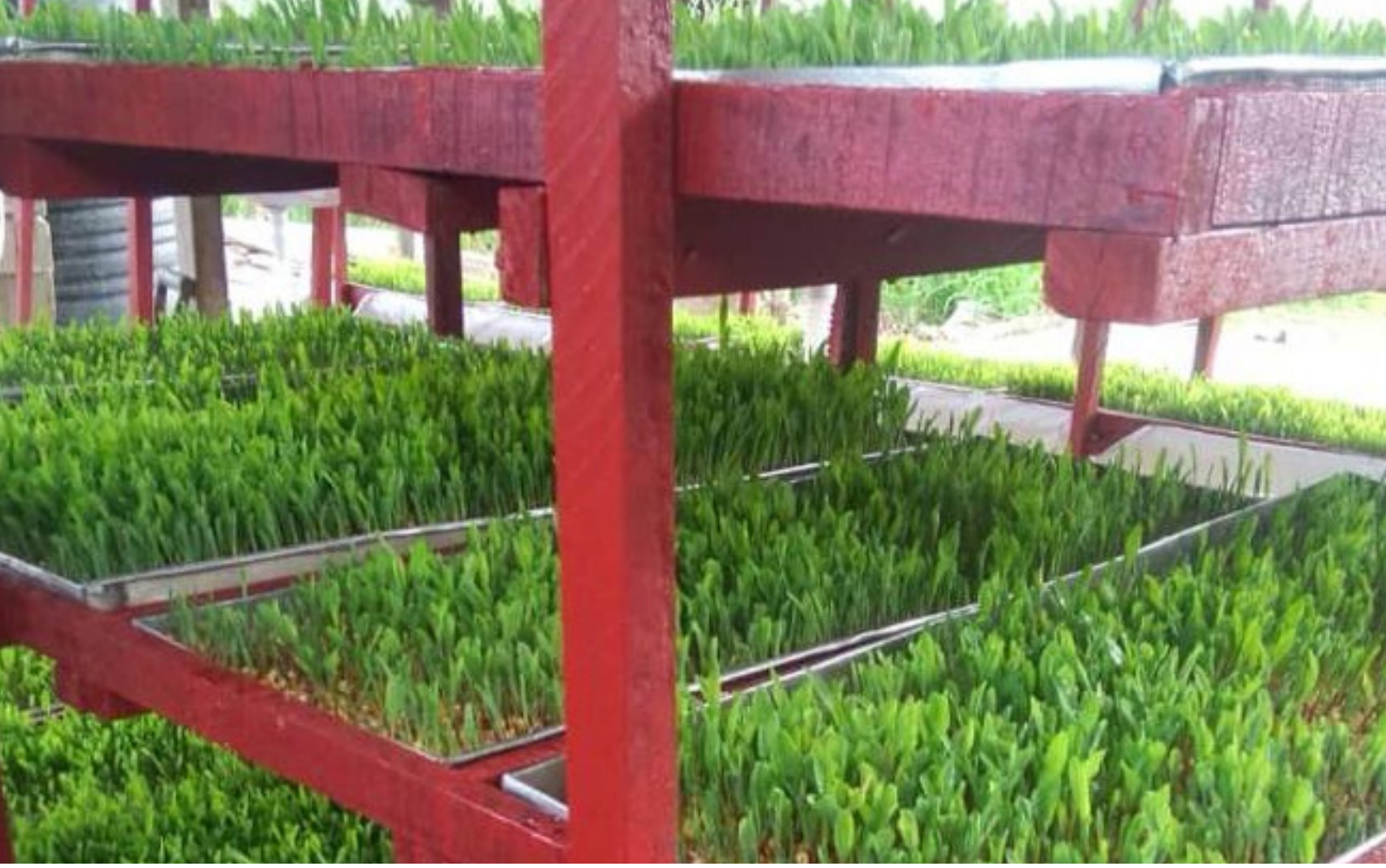


Testing the Production of Hydroponic Fodder for Cattle, Supporting Climate Resilience

Pilot Report

Start Date: January 2022

Completion date: March 2023

FRONTIER TECH HUB

M.E. Solutions

UK International Development

Partnership | Progress | Prosperity

CONTENTS

The Team

Pioneers: Ogechukwu Omeribe, Esohe Eigbike

Partner: M.E Solutions

The Context

The problem the pilot sought to address

Nigeria is host to numerous conflicts over access to land and water between cattle herders and farmers. In recent years, the level of conflict has flared up as herdsmen based predominantly in the north have roamed further south in search of greener pastures due to desertification. Additionally, former grazing routes are now being used as farmland, which has caused soil degradation and poor quality pasture, and with over 7 million nomadic herders and 25 million cattle in Nigeria, the number of conflicts surrounding resources is only increasing. While herders and farmers are technically co-dependent and could have a very symbiotic relationship, the current conflicts have become so extreme that certain states in Nigeria are now banning open grazing.

In addition to inter-group conflicts, there are production-specific challenges faced in Nigeria related to milk yields from local cows. In Nigeria, the breeds of cattle are classified as the dual purpose (meat and milk) and the most prominent of them all is the Bunaji (White Fulani) breed. The White Fulani are not producing desirable volumes of milk to the farmers and this production volume worsens with dry season effects. The dry season comes with a lot of challenges because natural pastures and crop residues are the major source of feed for cattle stocks, and this is severely reduced.

Feeding cows with quality green fodder could play an important role in sustainable and economical livestock production, particularly in the dairy sector. However, various constraints are faced by livestock farmers in its production. The constraints vary from factors such as small land holdings, unavailability of land for fodder cultivation, scarcity of water or saline water, non-availability of good quality fodder seeds, labour requirements, requirement of manure and fertiliser, longer growth period (45-60 days), fencing to prevent fodder crop from wild animals, and natural calamities. There is also the aspect of non-availability of constant quality fodder round the year, which limits sustainable livestock farming.

The idea conceived for this pilot

Hydroponic fodder is cattle feed made without the use of soil, either by using a nutrient rich-solution or water. Hydroponically grown grass grows quickly, in about 7 days, and produces a higher yield than grass grown in soil (45-60 days), while using 80% less water. Hydroponic fodder is an eco-friendly alternative to the traditional method of grass-growing for animal feed, but while it requires minimal manpower, can be expensive to set up, maintain and monitor.

Hydroponic fodder for cattle can have many positive impacts for climate adaptation, such as reduced soil degradation and water consumption from farming practices, and improved cattle diets, potentially reducing methane emissions. Hydroponically grown fodders (HGF) can also ameliorate the dry season feeding because it can be grown throughout the year.

The pilot idea was to develop a simplified hydroponic fodder system and associated business model that could be utilised in rural Nigeria to produce cattle fodder, easing the pressure on grazing lands with tangible benefits for both farmers and herders.

“Our innovation seeks to make a positive disruptive impact… by addressing a critical challenge for herders and farmers: how to access and use high quality fodder for cattle and other animals, at an affordable price, and in a way which enables sustainable use of water and energy, and helps to mitigate the impacts of climate change”

- Esohe Eigbike, original FCDO Pioneer

Goals of the pilot

The main goal of the pilot team was to develop a hydroponic system that connects herders and farmers to revive the dairy industry in Northern Nigeria, support climate resilient livelihoods, and reduce farmer/herder conflict. The specific objectives of this pilot were to:

- Prove that a hydroponic fodder system could outperform traditional farming methods in Nigeria
- Design a version of the system for much lower cost, tailored to local contexts
- Prove that farmers would be willing to work with a hydroponic system and that with it, could greatly increase their milk yields

Key Activities

Over six “sprints” - time-boxed units of experiments - the team was able to conduct two broad phases of work. The first phase was technical, assessing the hydroponic system setup with other methods of growing fodder, as well as assessing whether a system could be made with local materials and therefore save on construction costs. The purpose of the second phase was to set up a test site to understand how a system can operate in a rural setting, how the fodder grown would impact local cattle, and how local communities reacted to using the new system.

- Sprint 1 (February 2022 - April 2022): Set up open field structure and hydroponic system at initial testing site. Engage with different project stakeholders for collaboration.
- Sprint 2 (April 2022 - May 2022): Test different materials and drainage set ups for potential different end users. Speak to project managers about herder’s habits and behaviour.
- Sprint 3 (November 2022 - January 2023): Engage with private companies and financial institutions. Compare the hydroponic growing system to other methods of growing fodder at the initial test site.
- Sprint 4 (August 2022 - September 2022): Hold stakeholder meetings at potential test locations, source materials locally, and evaluate security plans for continuous implementation of the project. Develop a financial business model.
- Sprint 5 (October 2022 - December 2022): Build a Hydroponic system in collaboration with the local community and train community members to use the system. Evaluate the availability, suitability and price of local seeds. Share the financial model with commercial financial institutions.
- Sprint 6 (December 2022 - March 2023): Feed hydroponically grown fodder to cattle to compare weight and health gains. Continue to discuss financing options with different organisations based around the financial model.

Findings from pilot activities

Finding 1: a contextually-appropriate hydroponic model can be developed locally

Key questions the pilot sought to a test

- We can have optimised models for producing fodder that suit both ranchers and herders;
- We can make hydroponic fodder systems with attainable set up costs for different end users, while maintaining general efficiency;
- Sustainable and easily accessible materials can be sourced in the environment of the communities to build an efficient system;
- We can successfully install a Hydroponic Fodder system in a community utilising 50% community-based human resources for its construction.

The methods used for testing:

The methods used to test these questions were a combination of independent technical testing and on-site evaluation.

Initially, the team set up a greenhouse site with a water supply that efficiently supplies the seeds with water while ensuring minimal wastage. Work then focused on testing different materials for roofs, trays, racks and drainage solutions, to find the most cost efficient and environmentally friendly materials that were suitable for the initial use-cases (commercial ranchers, herdsmen and DIY farmers).

As the pilot moved towards in-field testing, these questions were assessed by scouting local markets and suppliers around the test site communities, in collaboration with guided by community members, and by working closely with local suppliers in construction of the hydroponic system.

Key findings from testing:

The team were able to show that changing the roofing and plumbing materials used in constructing the hydroponic system resulted in a small decrease in overall cost, and were also more attainable in rural communities. For example, in roofing the team tested the cover for the shed as a form of a mat (plastic, grass-woven straw mats or linked bamboo strips). It ended up not being a viable solution during the raining season and the team eventually had to revert back to standard zinc or aluminium roofing. For other materials, like the aluminium trays, it was not possible to find cost effective solutions.

One limitation that emerged regarding scalability was the construction of hydroponic structures themselves. Wood is a scarce resource in Northern Nigeria, but more acceptable than plastics, metals, or other building materials, so wood would appear to be the material to use. However, the water rich environment of a hydroponic structure means that wood will deteriorate over time without treatment. Accessing paint or other waterproofing materials will be expensive and complicated at scale.

Additionally, whilst the team was able to source labour within the community, some had to be outsourced from their surroundings. Unfortunately, at times the work of local artisans was deemed flawed and adjustments were needed to achieve a minimum standard. It was reflected that because it would not be possible to work as closely with workmen if the technology were to scale, and because the local communities were happy with the level of work supplied, variations of the system may be considered to ensure the lack of precision will not greatly affect the output of the system.

Finally, development of a contextually appropriate solution extended to the type of inputs used. Most important was the type of seed selected to trial, with care taken not to use seeds that were highly sought after for human consumption. Sorghum was chosen for this reason.

Picture 1: Locally-sourced bamboo roofing materials were trialled as part of the pilot. Photo credit: Bayo Imam

Finding 2: the impacts of conflict and climate change are significant, resulting in herders' willingness to break from tradition

Key Questions the pilot sort to test

- Herdsmen have an understanding of their general spending patterns and needs
- Communities are receptive to our proposed system both at the pilot stage and in the long term and are willing to collaborate and provide information relevant to the project and its viability
- Herder communities can manage the technical part of the hydroponic fodder system on a daily basis

The methods used for testing:

In early sprints, the team spoke to project managers who work with herder communities in order to get information on what herders tend to spend through a cow's growth cycle. Later, multiple meetings were held with both herder and farmer community leaders and members. For a herder group in Gwagwalada , for example, the first session was an introductory meeting, the second engaged with the communities more in depth, and the last took them through a stakeholder mapping exercise.

Finally, the team built a hydroponic system in collaboration with community members, and most importantly gave technical training on the daily management of the system, followed by a period of hands-off monitoring.

Key findings from testing:

The team reflected that early relationships built with organisations like CBI Innovations and the German development agency, GIZ, proved invaluable in facilitating meetings with herder communities in the Gwagwalada and Jos locations, with whom the organisations have existing programmes.

In both communities, attendance in meetings was very good and there was strong interest shown by the community. The team in return were able to learn more about the daily lives and concerns of community members. The meetings confirmed that herders have difficulties with gaining access to cattle fodder, especially during the dry season, and have general concerns about the negative impact of a lack of proper nutrition on the health of their cattle.

When it came to assessing the solution idea, community members also expressed their positivity around how the system could reduce tensions between herder and farmer groups. It was very interesting to learn that farmers and herders seem to get along and cooperate on many issues but land and grazing rights present a real source of tension.

The herdsmen articulated a desire to learn about new technologies and were keen to receive training on sustainable methods of providing fodder for their cattle. They also emphasised that any initiative should include opportunities for women and young people in their communities to participate. This was not a given for the pilot team as there was a high level of uncertainty on the reception of the solution given the traditionally nomadic lifestyle and where they may not have responded to a solution well that is counterintuitive to their culture. However, the impact of climate change and the prevalent conflict seems to have made them more flexible and open minded to the point that they were willing to try this, while still sceptical.

Picture 2: A community meeting with herdsmen in Gwagwalada. Photo credit: M.E Solutions

Comparatively, discussions with a farmer community in Gwagwalada were interesting because they took place in the Paikon Kore grazing reserve, which is itself a source of tension as farmers feel aggrieved at the non-compliance of the Government in the compensation of their farmlands for the grazing reserve. Indeed, one of the key things the team heard from farmers was a sense of unfairness that the Government was seeming to favour herders more than them in terms of social provision.

On the prospect of using hydroponic fodder, farmers felt their lands will now be preserved since herders will be able to feed their cattle without travelling long distances to get fodder. They also were grateful that the project could reduce the crisis between farmers and herders as a result of the encroachment on farmer-lands during grazing activities by herders.

The need for the peace-building component of the project was stressed as farmers expressed worry that they may not be able to cultivate their farmlands and sell the needed seeds for the project if the herders are not cooperative enough to allow them to harvest their crops. The farmers were also of the opinion that apart from the gains of having accessible market for their crops, peaceful co-existence with the herders and the income they will be generating from the sales, the project should be able to provide employment opportunities, improve the capacity of farmers and their ability to cultivate and sell fodder to herders, instead of just seeds.

Interestingly, farmers also expressed interest in the pilot project providing amenities such as boreholes, fencing, electricity and road fixing, which suggested a need to manage expectations around what the project was for and was able to influence.

Finally, when members of the community were trained to use the hydroponic system, there was an eagerness and openness to learn and under supervision the community was able to operate the system over the course of the final sprint.

Picture 3: Training and operation of the hydroponic system in Gwagwalada. Credit: Bayo Imam.

Finding 3: Hydroponically grown fodder was consumed by cattle and yielded increased milk production

Key questions the pilot sought to test

- Feeding hydroponic fodder to Nigerian semi nomadic cattle will increase their milk production and weight gain as well as overall health compared to the current pasture herders have access to

The methods used for testing

Apart from small-scale feeding of hydroponically-grown fodder to cows along the lifetime of the pilot, more scientific methods for assessing the impact of feeding cattle hydroponically grown grass came in research conducted towards the end of the pilot.

On the question of cows' appetite, the team simply recorded observational data about whether or not the cows consumed the fodder. On the question of milk production, the team took a more rigorous approach, comparing cows that consumed the fodder with those that grazed as normal. The econometric analysis included domains around the hydroponic fodder (e.g. mineral composition, fibre fractions, and gas production) as well as the health and production of the cows (e.g. haematology, digestibility, and lactation).

Key findings / outcomes from testing

The pilot team contracted a livestock nutrition specialist to conduct a rigorous quantitative evaluation of the pilot that would yield actionable findings. While the sample was small (24 treatment cows; 10 control cows), the findings were dramatic.

- Hydroponic fodder facilities were able to increase production over traditional methods. The system requires 98% less land and produces four times the fodder of a traditional field.
- Producing fodder by a new mechanism can have unexpected results when fed to the cows. The research team was pleased to see that cows were keen to consume the fodder and digestion was observed to be normal for all cows that consumed the hydroponic fodder.
- Cows that consumed hydroponic fodder produced about five times more milk than those that grazed under traditional management. Milk production from traditional management and grazing methods yields an average of 0.7L per cow per milking. After consuming the hydroponically grown fodder, cows were producing an average of 3.5L of milk (range: 2.2L to 4.7L). While this is a very small sample size, the change is so dramatic that it represents a statistically significant increase in milk production.
- Change in diet led to a 50% reduction in the average amount of methane gas produced by each cow. This represents another positive finding for climate change considerations.

Picture 4: Cows assessing the quality of hydroponically grown fodder. Photo credit: M.E Solutions

Finding 4: A sustainable business model will require additional evidence and meaningful stakeholder engagement

Key questions the pilot sought to test

- Hydroponic fodder is more cost effective than current methods of growing cattle fodder (higher yields, lower cost as a proportion of yield)
- Private sector companies and financial institutions see Hydroponic Fodder as a viable tool for an outgrower model
- A financial business model can be developed that meets the minimum requirements of the private sector and financial institutions
- Financial and private institutions see one of the selected business models as viable for financing
- Farmers surrounding the herder communities can produce enough seeds to supply the hydroponic system at a maximum price of N150/kg

The methods used for testing

At the beginning of the pilot, experiments were undertaken to assess the relative cost-effectiveness of growing hydroponic fodder vs. fodder grown by other means.

Throughout the pilot, the team engaged with private companies and financial institutions, informing them of pilot progress and financial models as they were developed.

To help build a basic financial model, a consultant was engaged to utilize existing data (budget, yield and harvest info). Market surveys were also made in order to obtain information on the current market value of fodder.

Key findings / outcomes from testing

While a full business model will only be finalised after completion of follow-on work in May 2024, the pilot team learned a lot about what a potential business model needs to succeed.

- A notable learning from the pilot is that existing policy and regulation prevents a simple business model from being successful. In particular, whilst dairy companies are able to price their goods on the market, pricing regulations appear to be constraining the value of raw milk sold to them by herders. With rampant inflation in recent years affecting, for example, the price of seeds needed to produce hydroponic fodder, but without a corresponding increase in the price of raw milk, it seems impossible to build a simple business model that does not involve third parties like dairy companies, whose pricing is more elastic.
- Dairy companies create value-added products such as yoghurt, cheese, pasteurised milk, butter etc., which can generate higher profit margins, particularly at scale. However, dairy companies disclosed that due to the low volumes of milk produced by local cows, it costs the companies more to work with increasing numbers of herders through advocacy etc. This suggests that there is an incentive to invest into improving the output of the individual cows already supplying them. A significant learning was, therefore, that there strong potential for dairy companies to support communities using hydroponics since a limiting factor in their profitability was the output of cows from the herders they work with. Such business models could be sustainable without donor funding, as the dairy company could act as an anchor and give due security as a loan-backing institution, which the informal and nomadic nature of herders cannot provide.
- Banks are also interested in the solution. This can be explained partly by the fact that in recent years, there has been more focus on the agriculture sector by the government, who have

incentivised banks to finance small holder farmers and other producers at the bottom of the value chain, like herders. However, the risk of providing loans to this informal sector has been quite high and banks constantly seek for opportunities that allow them to meet certain targets set by the government while managing their risk and exposure. A business model that puts the dairy company in the middle as a guarantor and the receiving party of the loan, while the final beneficiary is still the rural producers, creates a very attractive opportunity for financial institutions to cater and develop a product around the production of hydroponic fodder. Nevertheless, investors were still not fully convinced that this technology can flourish without donor funding to subsidise the model.

- Dairy companies remain sceptical of small holder farmers and herders to supply their milk, but stakeholder meetings demonstrated an openness on their part. After consultations with dairy companies, who more typically collaborate with commercial farmers, there was openness to engaging with the small holder farmers applying innovative techniques, but they require additional data related to the potential impact of hydroponic fodder on dairy company revenues.

Moving into the Follow-on Fund phase, a responsibility matrix including key performance indicators (KPIs) serves as the foundation for the business strategy:

Responsibility Matrix

Stakeholders	Responsibilities	KPI
Dairy Company	• Dairy milk processiing into Yoghurt, Milk, butter, cheese etc. • Distribution to off-takers	• Increased production • 30% profit margin
Financiers	• Funding • Monitoring impact of Fodder System	• Timely release of funds
	• Development of Fodder Systems • Training of Farmers	• 55.3 Cows feed from fodder system/day • Daily prod. output + 55.3 cow feeds
Herders	• Feeding and tending to the cattles • Milking and Supply	• Availability of cattle • Milk increase by 100%
Farmers	• Planning and cultivating fodders • Management of the system • Harvesting fodder for distribution	• Maximum amount of fodder harvested • Provision of sale to herders

Understanding the KPI's or data points stakeholders need to see for a solution to be viable for them will be useful to ensure data captured is relevant to their decision making. These data points cover the herders themselves and what would be "life changing" revenue from increased milk production to banks who need to see "x" return on investment over a period of time for a model to be viable.

Picture 5: The hydroponic system in Gwagwalada that was set up during the pilot. Photo credit: Bayo Imam

Conclusion

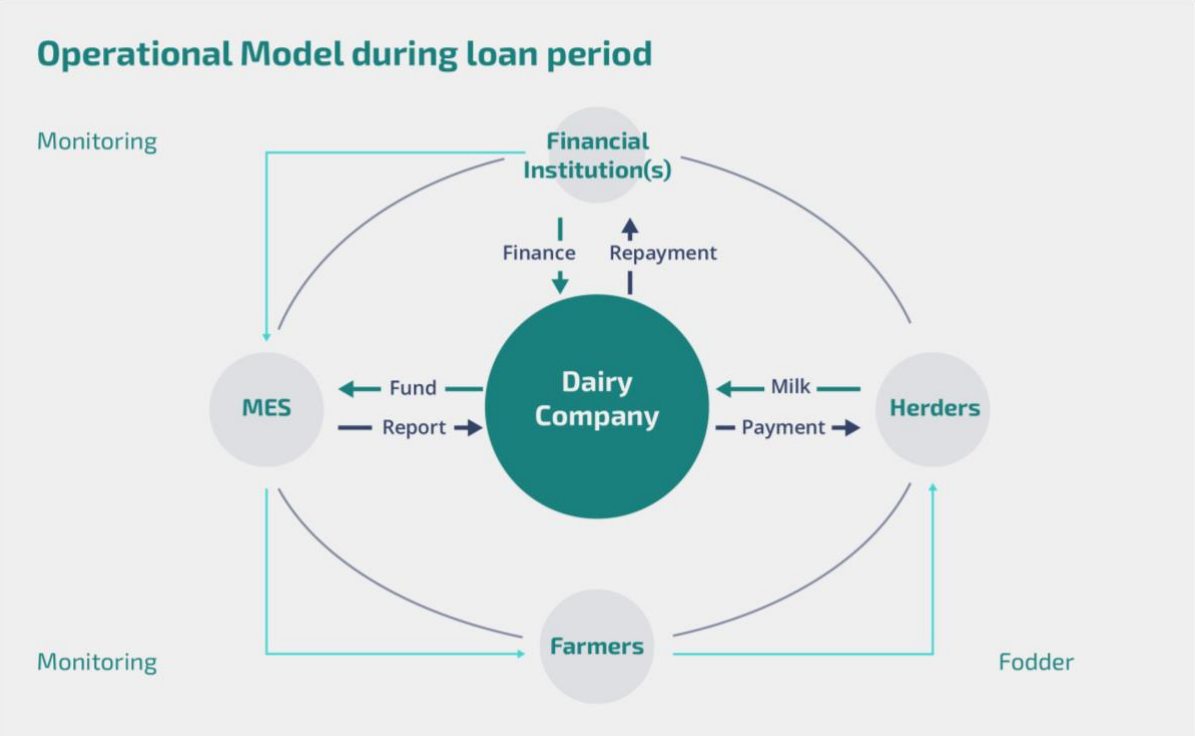
While this pilot was small, the amount of learning was significant and immediately following the pilot, a number of documents were created that capture the most significant learnings.

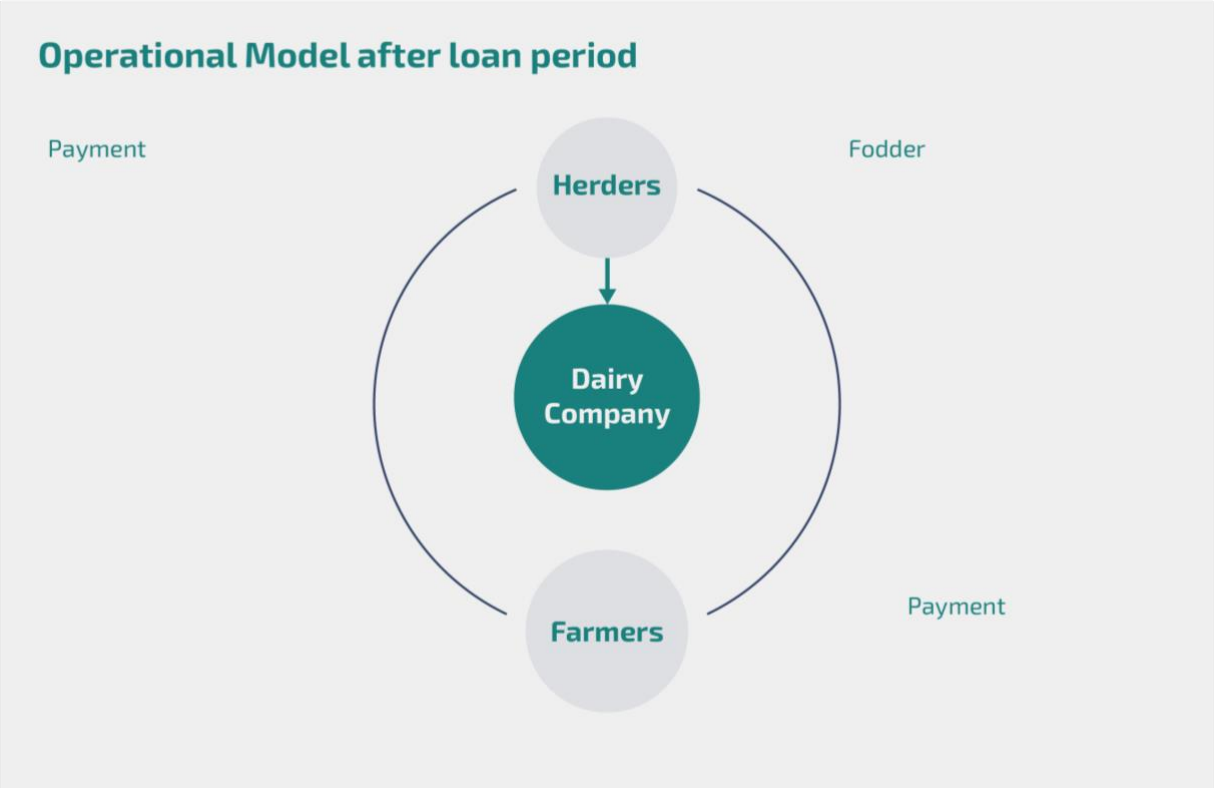
- A summary of pilot learnings
- A system set up guide will help deliver a replicable and scalable version of the pilot.
- Technical whitepaper focusing on experiments surrounding feeding cattle hydroponic fodder

The key findings were that the hydroponic fodder system can help improve the quality and quantity of milk production in order to:

- Use 98% less land to produce four times the fodder.
- Increase the likelihood that farmers can find a safe growing location (due to small space requirements)
- Decrease land disputes between farmers/herders/ government, communities etc.
- Decrease the migratory needs of families with cattle
- Early business models suggest initial investments can be recovered in 12-36 months depending on the approach chosen
- Modelling and data suggest that farmers and dairy companies can increase profits by approximately 30% due to significant increases in the amounts of milk produced by herders

After completing the pilot, the team began building out a business strategy and looking for opportunities to test and learn at a larger scale. The pilot allowed the team to begin drafting diagrams for how the business model could be constructed (see below), but further work can be done to build out these models and validate their approach.





Recommendations for further work

The hydroponic fodder team submitted a proposal for follow on funding and will continue building out the idea and business model. Suggestions for further work include:

1. Developing and testing a business model, including engagement with dairy companies. The business model will require a deep understanding of the minimum viable product to increase milk outputs and then get that milk into the market.
2. Draft a stakeholder map and engage stakeholders on a sustainability plan. Local stakeholders provided key insights during the pilot stage that gave the implementation team confidence that hydroponic grown fodder could work in Nigeria. However, many questions remain about technical elements of implementation (e.g. what is the minimum training support needed to scale up the growing system?) and logistical questions (e.g. how can this look on government land versus community owned land versus land owned by private corporations?)
3. This pilot did not focus on the beef industry, so further research would need to be done to understand the viability and impact of hydroponic fodder on beef production.
4. The same can be said of methane production, which was an interesting and unexpected finding of the work that might hold great promise in terms of a sustainable model built around carbon credits and climate-friendly cattle-rearing.

"It has been an interesting journey on this innovative pilot to test the production and use of hydroponic fodder for cattle to support livelihoods and reduce the growing land conflict between herders and farmers in Nigeria, while improving livelihoods for both groups, and helping to mitigate the impact of climate change.

Findings from the pilot were also amazing – more than a 100% increase in quality milk production, the nutritive value of the hydroponically grown fodders, and reduction in greenhouse emissions. It has been a useful learning for the FCDO following the interest from a couple of Advisers, in particular conflict related programmes, and programmes supporting the dairy sector.

We would hope to see the FCDO and donors explore further work along the recommendations above; including supporting the development of an effective private sector driven business model that is sustainable."

- Ogechukwu Omeribe, FCDO Pioneer


DT Global


BRINK


RESULTS FOR
DEVELOPMENT


UK International
Development
Partnership | Progress | Prosperity