Project Clean Green

Research Report

Productive Use Energy (PUE) and Smallholder Farming in Nigeria: Insights from Project Clean Green Implementation

AFEX

Shell Foundation

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BACKGROUND INFORMATION

1.1. Introduction – Global Impact of Climate Change

The unabated emissions of greenhouse gases has triggered a wave of global warming, with global surface temperature increasing by 1.1°C between 1850-1900 and 2011-2020 (IPCC, 2022). As a result, the world has been facing extreme weather and climate events. The situation has so deteriorated that these extreme events, which used to be described as unprecedented, have now become the "new normal". The United Nations Office for Disaster Risk Reduction reported that the number of climate-related events jumped from 3,656 between 1980 and 1999 to 6,681 between 2000 and 2019.

Today, the impacts of climate change are being felt across all aspects of life. Climate change has significantly contributed to the displacement of millions of vulnerable people, the diminishing of agricultural productivity, water scarcity, spread of infectious diseases, malnutrition, and damages to key economic sectors. With the largest impacts observed in many locations and/or communities in Africa, Asia, Central and South America, small Islands and the Arctic.

1.2. Africa: Food Security and Climate Change

Despite contributing only about 4% of global GHG emissions, largely from deforestation and poor land use practices, Africa remains the most vulnerable continent (AFDB, 2023). Recent disasters such as the devastating cyclones "Idai" and "Kenneth"; locust outbreaks in eastern Africa and droughts in southern and eastern Africa; and the Sahel's desertification, further spotlight the grim realities of climate change in Africa. The continent has reported record numbers of fatalities due to rising temperatures, persistent drought, catastrophic flooding, and destructive cyclones, among others.

While Africa continues to reel from the devastating effects of armed conflicts, religious-inspired insurgencies, terrorism, forced migration, state fragility, political and economic crises; climate change has added a new layer to the strain facing the continent's peace and security architecture. According to the ReliefWeb (2023), the effects of climate change have worsened livelihoods and pushed more people (especially nomadic pastoralists) into violent conflict in countries with on-going armed conflicts while transforming pre-existing latent conflicts into violent conflicts.

The African food system has suffered significantly from climate change. The dwindling access to resources, increasing water scarcity and disruption of trades have severely impacted agricultural productivity, especially crop yields and livestock productivity. The increasing Incidences of extreme weather condition have been associated with huge crops losses,

resulting in increased food insecurity and poverty. It is therefore not surprising when Blanc (2012) reported that maize yields in Africa are expected to fall by up to 22% by 2030

1.3. Nigeria: Agriculture, Food Security and Climate Change

In Nigeria, the impact of climate change has been equally devastating. Smallholder farmers who happen to be the pillar of domestic food production have been disproportionately vulnerable because of poverty, marginalisation, and reliance on natural resources. The northern states on the fringe of the Sahel are even worse off as they are contending with the double jeopardy of declining water availability, and desert encroachment.

A more recent trend is the short-term seizure of rain during the raining season, delayed onset of rainfall or flooding which undermines food production capacity in much of the world, particularly in poorer countries. The situation has been further hampered by decreased investment in the agricultural sector due to high exposure to risks. It is therefore not surprising that incidences of food insecurity and livelihood deterioration have risen over recent years.

According to the NBS, nearly 40% of the population are living in extreme poverty and the situation could get worse if urgent action is not taken. It is therefore important that measures are put in place to respond to climate change, safeguard the capacity of food systems and ensure sustainable food security. This is not only crucial to ensuring that our growing population is nourished, but also necessary for the system to remain productive, economically viable and climate resilient.

The continent's vulnerability has been further exacerbated by high incidences of poverty, governance challenges, limited access to basic services and resources, violent conflict, high levels of climate-sensitive livelihoods (e.g. smallholder farmers, pastoralists, fishing communities) and poor climate change resistance or adaptation, particularly in western, central and eastern regions (IPCC, 2022).

"Climate change is one of the key drivers of food insecurity with dire implications on agricultural productivity, rural livelihoods, and food systems at large. With more extreme weather patterns on the horizon, there is a need to invest in adaptative and mitigative measures."

PROJECT CLEAN GREEN (PCG)

2.1. Project Overview

Climate change is already a reality. The effects are happening real-time, and we need to be more proactive than ever. A key part of this is creating access to clean energy solutions. Project Clean Green (PCG) is a pilot that seeks to introduce and create access to Productive Use of Energy (PUE) assets – solar powered farming equipment such as pumps – to smallholder farmers. By creating financing products around the asset and providing technical assistance, farmers can access water required for crop production through clean energy especially considering the short- and long-term costs and effects of relying on fossil fuels that will be incurred with the use of mechanical pumps.

2.2. Project Goal

This pilot seeks to impact up to 10,000 smallholder farmers, 30% of which are women, currently earning below the living income in Nigeria, within two years.

2.3. Project Objectives

The aim of the pilot is to:

- Validate farmer adoption and willingness to pay for PUEs
- Validate the impact of PUEs on farmer income, compared to alternatives
- Validate the potential of the aggregated bundle in unlocking sustainability for PUE adoption

2.4. Operational Model

This initiative was conducted under a lease-to-own model, coupled with the provision of essential inputs like seeds and fertiliser, along with agronomic training.

- **Productivity Bundle:** a new additional product line – solar pumps, were added to AFEX's Input Financing programme which is normally a loan package that works by ensuring farmers have access to quality seeds, Crop Protection Products (CPP) and fertiliser.
- **Farmer Capacity Building:** Beyond agronomic training and support to farmers, the provision of After Sales services for the PUE assets.
- **Access to Storage:** With our solution, farmers can store products at our locations, and we manage the entire storage chain.

As part of this partnership, AFEX deployed solar water pumps to farmers allowing for year-round farming. Additionally, AFEX considered PUE assets such as solar-powered threshers, mills, and dehydrating machines. The project cuts across the rice, maize and vegetable value chain.

RESEARCH OBJECTIVE AND METHODOLOGY

3.1. Objective of the research

Given the novelty of the project, the broad objective is to understand the experience of the farmers at different stages during this pilot phase. The specific objectives of this paper are to

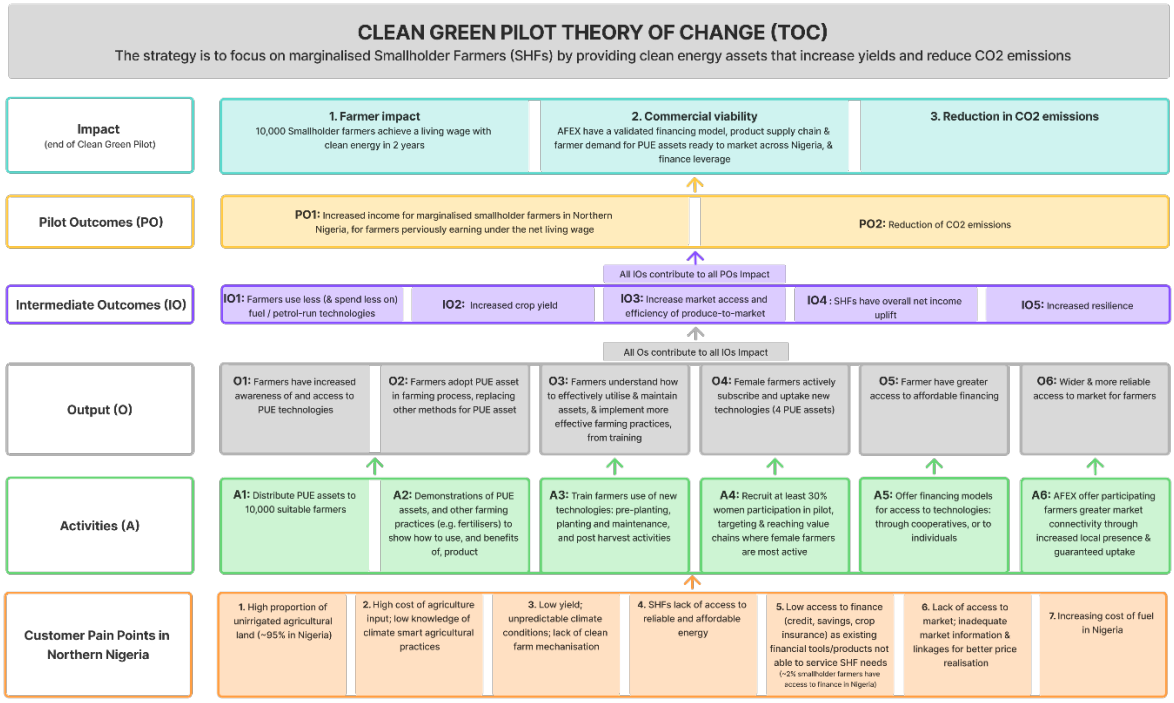
i. Explore the realities of rural farmers
ii. Capture how adoption of PUE assets impacts farmer income and crop yields
iii. Measure the impact of PUE asset adoption on fuel usage

3.2. Methodology

This research relies on information from two major sources. The first being a baseline survey carried out by Here I Am (HIA); a third-party MEAL Consultant engaged by Shell Foundation for the project. The AFEX team supported the exercise by reviewing the survey questions, mobilising the farmers and ensuring sensitisation prior to the field visit by HIA. The research survey covered 305 farmers drawn from Kaduna, Kebbi and Jigawa states. Data was collected using "Fatima" – HIA's research platform. Survey was carried out.

The periodic monitoring and evaluation report from AFEX's internal project implementation unit. This covers the field-test reports, community mapping, engagement, and farmer subscription/adoption from inception

3.3. PCG Theory of Change



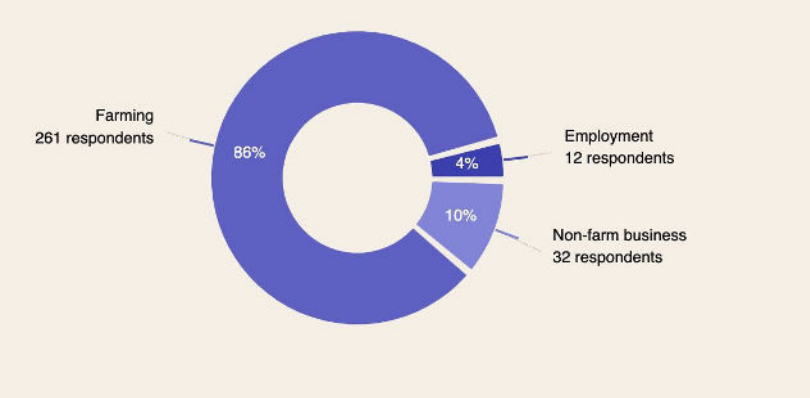
Source: HIA, 2025

FINDINGS

4.1. Farmers' Profile

4.1.1. Primary Source of Income

HIA reported that most of the farmers depend on agriculture as their main livelihood and source of income, and for those focused on non-agricultural work, farming remains a principal secondary income stream.

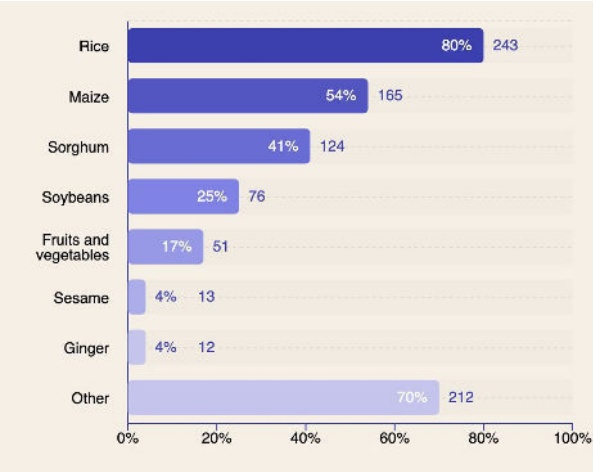


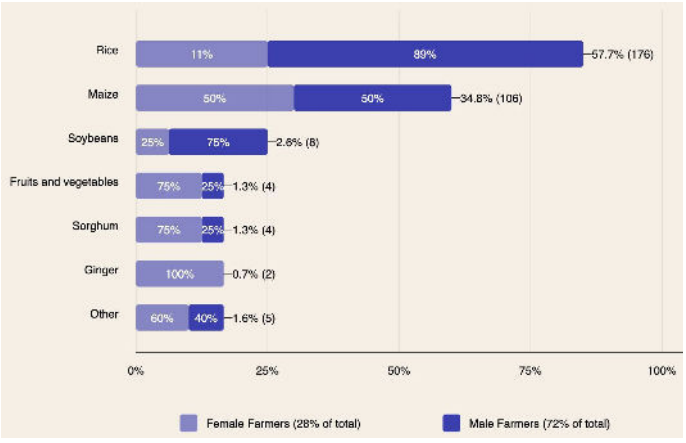
Source: HIA, 2025

4.1.2. Primary Crop Cultivation

According to the baseline study, farmers in the targeted locations cultivated a variety of crops, with Maize and Rice dominating. Rice is by far the most widely cultivated crop (80%), followed by maize (54%). Other crops like soybeans, fruits/vegetables, sorghum, and ginger are cultivated by much smaller percentages of farmers.

Rice and soyabean farming were male dominated while women are disproportionately represented in ginger, Fruits/vegetables and Sorghum farming.

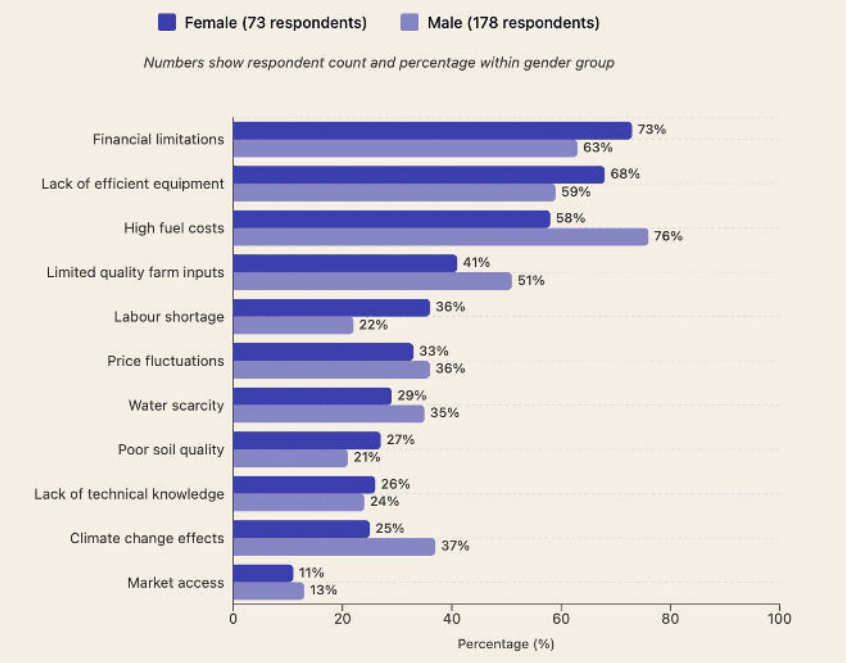




Source: HIA, 2025

4.1.3. Challenges Currently Affecting Crop Yields

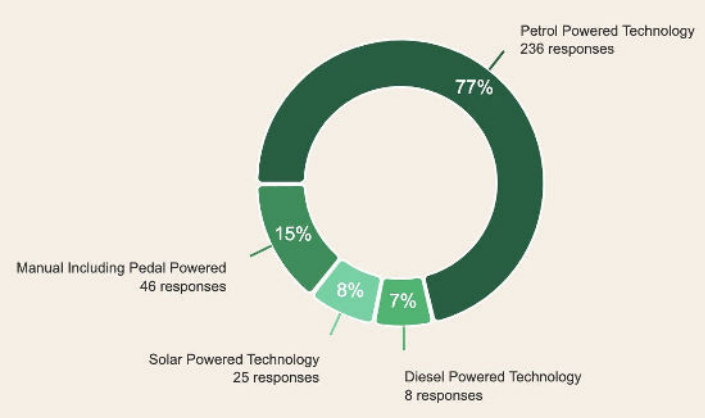
Farmers in the project region indicated that high fuel costs, lack of access to efficient equipment, and limited quality farm inputs were the major challenges hampering their yields. Climate change and water scarcity were also some of the significant challenges faced by farmers.



Source, HIA, 2025

4.1.4. Methods Used Last Season for Irrigation, Milling, Threshing, and Drying

Petrol-powered technology is the predominant method used for irrigation, milling, threshing, or drying, indicating a heavy reliance on fuel-based machinery. Manual methods (15%) still play a role, while solar-powered technology has limited adoption currently (8%) suggesting untapped potential.



Source: HIA, 2025

The average frequency of using petrol or diesel-powered machines is approximately 3.42 times per week. The proportion of respondents using petrol or diesel-powered machines daily is relatively consistent across these three farming activities:

- 30% for Drying
- 30% for Irrigation
- 29% for Threshing

4.1.5. Impact of Fuel Subsidy Removal and use of Productive technologies

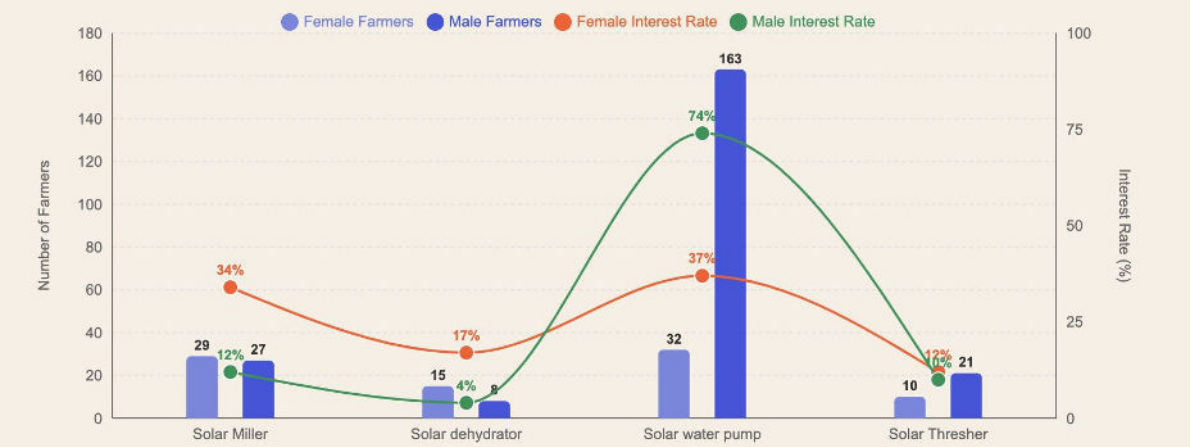
In June 2023, the cost of operating petrol-powered equipment in rural Nigeria skyrocketed by over 80%, due to the removal of a government subsidy on petrol prices. This has further hampered the already complicated situation. Farmers in some areas reported turning to the black market for fuel because of sharp price increases and limited access at filling stations, with one respondent reporting that sometimes, filling stations deliberately close during peak farming periods, to create artificial scarcity and crowding, forcing long queues. In the words of a farmer that was surveyed:

"In short, we are struggling with access to genuine fuel. In Nigeria, a litre of fuel typically costs around 1,150 naira, but availability is inconsistent – you might find it once every one or two days. I usually buy just a litre at a time. On the black market, prices vary significantly depending on supply. In some places, it sells for 1,700 naira per litre, while in more remote areas, it can go up to 2,000 naira or more."

4.2. Implementation Realities

4.2.1. PUE Assets' Selection - Farmer Interest in New Low Fuel Technologies

Most farmers indicated interest in solar water pumps and millers. 17% and 12% opted for dehydrators and threshers respectively. Women showed greater interest in millers, threshers, and dryers, reflecting their stronger role in post-harvest activities.



Source: HIA, 2025

4.2.2. Insights from Field Test of PUE Assets – Solar Pumps

Overall, solar pump units that might work best for smallholder farmers considering the types of farms they own and where the farms are located would be pumps that are smaller in size and still have the capacity to carry the water requirements of their farms per day. It is also important to note that during dry seasons farmers will resort to wells, especially when surface water starts to dry up. This means solar pumps that can use both surface water and irrigation wells will be best for smallholder farmers.

The farmers were more conversant with the type of pumps that are constructed like the petrol alternatives they are used to.

Over four months of monitoring, the project reported:

- **100% adoption rate**: All farmers transitioned from fuel-powered to solar pumps.
- **High utilisation**: Pumps were used on average more than five times per week.
- **Satisfaction**: Every respondent rated the pumps as easy, or very easy, to operate and expressed satisfaction with water pressure and reliability.
- **Willingness to invest**: 57% of farmers expressed readiness to purchase the demo units, signalling confidence and perceived value.

4.2.3. Shared ownership

The proposed model was for farmers to have shared ownership of the solar pumps to aid with affordability. The observations as far as regards shared ownership of the solar pump points to a possibility of both models (one farmer to one pump and multiple farmers to one pump) co-existing in the long run.

Most farmers opted for sole ownership of the solar pump while others decided to share. It is also observed that the farmers who currently share ownership have their farms located close

together which removes the inconvenience of having to move the pumps from one farm to the other.

4.2.4. Loan repayment

The PCG project has so far maintained an impressive scorecard in terms of loan repayment. While the repayment was structured for four (4) planting seasons over two (2) years, with farmers remitting 25% of outstanding balance each season, most of the farmers opted to pay more than the amount due. In some instances, farmers paid 50% of the outstanding balance in the first season alone.

This has further reinforced the assurance of the project's contribution to farmers' production capacity which has translated to higher earnings.

4.2.5. User Experience

According to AFEX's field monitoring reports, farmers have been using the solar water pump for several months without encountering any breakdowns or technical difficulties. The reliability of the solar pump has ensured consistent irrigation, providing stability. This positive experience has facilitated the training farmers received on how to use the pumps.

4.3. Impact

This section presents a detailed case study on three of the farmers who received a solar water pump as part of the test phase of the project.

4.3.1. Jafar Muhammad, Argungu, Kebbi State, Nigeria

Before adopting solar water pumps, Jafar Muhammad managed a one-hectare rice farm using a petrol-powered water pump. His irrigation schedule was heavily dependent on the availability of fuel, which fluctuated in price. He used more than five litres of fuel daily, which was a significant financial burden, especially when fuel prices spiked.

The transition to solar water pumps has brought about a significant change in Jafar Muhammad's farming operations. Although his farm size remained at one hectare and his yield did not increase, the financial savings from eliminating fuel costs have been substantial.

Jafar Muhammad previously spent a considerable amount on fuel, which fluctuated in price and availability. With the solar water pump, he no longer has to worry about these fluctuations or the associated costs, resulting in significant savings and more predictable operating expenses.

4.3.2. Danjuma Umar, Kokobese, Kebbi State, Nigeria

The introduction of solar water pumps marked a turning point for Danjuma Umar's farming practices. The solar-powered system provided a reliable and cost-effective alternative to petrol-powered pumps. With the new system in place, Danjuma Umar expanded his farm from five hectares to nine hectares, leveraging the efficiency and sustainability of solar energy. Danjuma Umar irrigates his nine-hectare farm over four times a week. During the four months he used the solar pump, he experienced no breakdowns or operational issues, demonstrating the reliability and efficiency of the solar pump system.

The consistent and efficient irrigation provided by the solar system has enabled Danjuma Umar to achieve a 44% increase in rice production, significantly enhancing his farm's productivity. Danjuma Umar's experience illustrates the profound benefits of adopting solar water pumps for irrigation. The transition has enabled him to expand his farm, increase his crop yield, and achieve greater financial stability. His success story serves as an inspiring example for other farmers in the region, showcasing the potential of renewable energy solutions to transform agricultural practices and improve livelihoods in rural communities.

CHALLENGES AND WAY-FORWARD

5.1. Challenges

Several challenges emerged during project implementation, including the limited availability of domestic vendors and manufacturers, the absence of insurance mechanisms for solar assets, and issues related to land fragmentation.

5.1.1. Insufficient Local Manufacturers of PUEs

One of the major barriers to smooth implementation was the shortage of domestic vendors and manufacturers. This limited both the availability and diversity of solar-powered agricultural equipment. The challenge became even more pronounced when considering other PUE assets beyond solar water pumps, where local supply chains and technical support were even less developed.

5.1.2. Insurance Cover

Being aware of the benefits of insurance, AFEX made attempts at insuring solar pumps. However, the following concerns arose:

- **Limited coverage**: the option available was a productivity insurance which would only cover incidences of adverse weather conditions, and crop loss due to pest infestation.
- **Theft Insurance**: To cover the loss in cases of theft, insurers insisted on the assets being housed in a particular area other than the farm, which makes it prone to theft and vandalisation. The problem associated with this option is that farmers can only keep the assets on the farms as there are no buildings around the farms for the assets to be kept.
- **Human Hazard**: insurers explained that damage might be done to the assets intentionally by the farmers in order to avoid payment of the assets. The solution to this would for AFEX to be custodian of the assets, meaning that farmers would have to return the assets every day after usage. Hence, an insurance on damage cannot to be issued to farmers.

5.1.3. Farm Fragmentation and Bulkiness of Assets

The fragmentation of farmlands is also a major obstacle to joint ownership and use of PUE assets. Most of the farmers own farmlands in different locations away from their homes. This would mean moving their solar pumps and the panels from location to location. To cover the distance, this is done using motor bikes. Due to the poor road networks in those regions, moving large size panels is not suitable as this could lead to the assets getting damaged.

5.2. Way Forward – Lessons for Scale-Up

To date, the solar-powered irrigation pump remains the only PUE technology successfully piloted under the project. Farmers showed strong recognition and appreciation of its advantages over conventional irrigation methods – particularly in terms of reduced operational costs.

Building on this success, the project remains committed to expanding the scope of PUE interventions by identifying and testing additional energy-enabled solutions tailored to farmers' needs. At the same time, it will intensify efforts to address persistent challenges such as the absence of insurance mechanisms for solar assets by fostering partnerships with insurers, financiers, and other key industry stakeholders. These efforts aim to create a more enabling environment for the sustainable and scalable use of solar-powered technologies in agriculture.

PHOTOGRAPHS