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Assessing the Potential of Microfinanced Solar Water Pumping to Enable Productive Use of Energy in Rural Areas of Burkina Faso.

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Short Abstract

The population in Burkina Faso (BF) is rapidly adopting irrigation to adapt to negative impacts of climate change (CC) like prolonged drought, rainfall variability and desertification. However, due to high initial cost of solar water pumping systems (SWPS), population mainly uses diesel water pumps (DWPs) which accelerate CC. This study aims at assessing the potential of microfinanced SWPS for irrigation in the rural areas of BF. The main SWPS market-segments were identified. It was found that there are three main SWPS market-segments. For each market-segment, AC and DC SWPS with water storage were sized. Profitability analysis was conducted at 5.3% per year interest rate and 20 years system life span. It was found that water storage contributes enormously to SWPS capital cost. Furthermore, the study revealed that using SWPS with water storage to completely replace DWPs not profitable. It was found that replacing water storage with DWP to be used on cloudy days is profitable for all market-segments. Finally, main loan features for SWPS were determined. At 9.5% interest charged on agricultural equipment loans by microfinance institutions in BF, only SWPS for two market-segments can be fully financed through microloan without risk of long PBP (> 13 years).

Keywords: prolonged drought, diesel water pump, climate change adaptation, solar water pump, microfinance

1. Introduction

This section has literature review, problem statement, objectives, scope of study and summary of methods and results.

1.1. Literature review

Climate change (CC) has become a universal threat to mankind which requires urgent action. This has seen the replacement of the Millennium Development Goals (MDGs) by the Sustainable Development Goals (SDGs). The SDGs do not only target improving the social and economic life of the poor worldwide but also have additional emphasis on protecting the environment and ensuring sustainable use of resources (United Nations 2017). Kreft et al. (2015) assessed the global CC risk index of 183 countries and found that the developing countries where most of the poor at the bottom of the pyramid (BOP) live are the most vulnerable to negative impacts of CC. This is mainly because the poor at BOP have limited financial resources necessary to respond to the risks caused by CC as Hammill et al. (2008) found by assessing the role of microfinance in CC adaptation. Microfinance plays an important role in CC adaptation by providing financial services such as microloans, microinsurance and microsavings that allow the poor to acquire climate resilient techniques, accumulate assets and diversify income sources. World Bank (2015) report aimed at evaluating policies and progress on ending extreme poverty revealed that as of 2015, over 700 million people lived in extreme poverty (living on less than US$ 1.9 per day) and over 80% of those living in extreme poverty reside in Sub Saharan Africa and South Asia. The present research focuses on Burkina Faso which is one of the Sub-Saharan countries in West Africa.

1.2. Problem statement and objectives of the study

In Burkina Faso, severe variability in rainfall, prolonged drought and risk of desertification are the key CC impacts directly posing big challenge to livelihood (World Bank 2015). The population in the country is rapidly adopting irrigation as a method of CC adaptation (FAO 2014). However, it is mainly based on fossil fuel powered pumps (FAO, 2014; Fraiture et al., 2013) in spite of the existing renewable energy options such as solar water pumping. Much as SWPS has almost zero operating cost, according to Geslain (2014) in Burkina Faso and Senegal capital investment for SWPS represents a barrier to vulgarization of this technology. Hammill et al. (2008), revealed that microfinance could play a key role in solving the challenge of initial cost for such technologies. Therefore, the aim of this study is to determine the technical and economic potential of SWPS for irrigation in rural areas of BF and determine the main SWPS loan features to be developed by Microfinance Institutions (MFIs) with Korsimoro reservoir as a case study. The specific objectives include (1) identifying the main SWPS market segments in Korsimoro (2) sizing of SWPS for the main market segments (3) determining profitability of solar SWPS in the area and (4) determining the main features of SWPS loan for the MFIs in BF.

1.3. Scope of study

Geographically, the study focused on Korsimoro as a case study. Much as technical, economic and sociocultural aspects should be considered to fully assess potential of microfinanced SWPS, the study was limited to the first two aspects leaving out socio-cultural parameters such as willingness of farmers to accept the technology. Lastly, the study focused on water from surface reservoir. Simulation and optimizing was not done in this study

1.4. Summary of methods used and results

Data for the study was collected through literature review, surveys and focus group discussion. Climate data for calculating crop water requirement and irrigation schedules were got from CLIMWAT 2.0 and analysed using CROPWAT 8.0. Microsoft Excel 2016 was used to design the SWPS, economic analysis and calculating main loan features. The study found that there are three SWPS market segments around Korsimoro reservoir. Storage contributes between 45% and 63% of the initial cost of SWPS as such using SWPS with water storage to completely replace DWPs has negative NPV for all three market segments thus is not profitable. Replacing water storage with DWPs to be used on cloudy days makes the SWPS profitable for all three market segments. At the minimum annual interest of 9.5% charged on agricultural equipment loans by MFIs in BF, only SWPS for two market-segments can be fully financed through microloan without risks due to long PBP (> 13 years).

2. Methods

This section describes the logical framework of the study, data collection methods, data analysis to identify the SWPS market segment, sizing of the systems for the market segments and profitability analysis and determining the main loan features. Figure 2.1 shows the logical framework of the study.

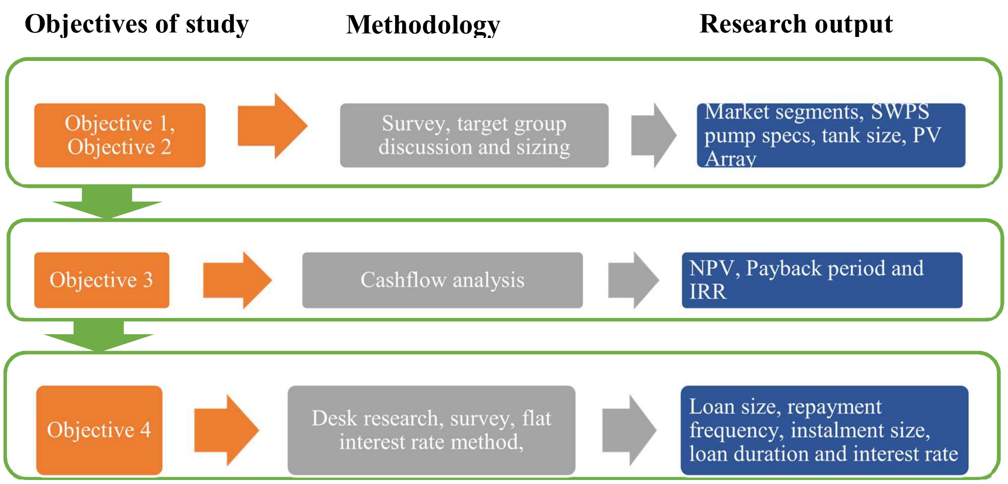

Figure 2.1: logical framework of the study

The logical framework shows the methods used to achieve the objectives and the results obtained. The logical framework also shows the linkage between the objectives.

2.1. Data collection and analysis

This study used both secondary and primary data. Secondary data was collected through literature review and it formed the basis of understanding any related research that has been done and fixing the scope of study. Secondary data sources included reports, web documents, journal articles, conference papers, books and working papers among others. Primary data was collected through field survey of 96 farmers at 10% confidence level and 95% confidence interval, focus group discussion with 15 farmers and interviewing of 16 SWPS dealers in Burkina Faso. The questionnaires for the survey were pretested for accuracy before taking them to the field. Focus group discussion was later used to verify the information collected during survey and collect missing data. Local climatic data was obtained from Food and Agriculture Organization (FAO) database CLIMWAT 2.0.

The climatic data was analyzed using CROPWAT 8.0 to determine crop water requirement and irrigation schedule, Microsoft Excel was used to group the farmers according to crops grown, cashflow, land area covered, pump type and ownership so as to obtain the market segments. The pumps were sized for the different market segments using excel. Excel was also used to determine profitability of SWPS and main loan features.

3. Results and discussion

This section shows the main findings of the study and their discussions. The main results in this study include the market segments for SWPS in Korsimoro, the sizes for each market segment, profitability analysis comparing AC and Dc SWPS for each segment with and without water storage tank. Finally, the main loan features for SWPS are discussed.

3.1. Main market segments for SWPS around Korsimoro reservoir

Based on the size of existing DWP, ownership of pumps and size of land cultivated by the farmers, the study found that there are three main market segments for SWPS around Korsimoro reservoir. Market segment 1 consists of farmers individually owning and using a DWP with rated power between 1.5 kW and 3 kW. In the present study, this market segment is represented by the farmers currently using 2.6 kW Robin and occupying an average area of 10,350 m^2. Market segment 2 is composed of farmers individually owning a DWP of rated power between 4 kW and 7.5 kW and using it to provide pumping services to a group of farmers at a fee. Market segment 2 is represented by a group of farmers sharing 5.5 kW Rhino/Kirloskar DWP. From the survey, it was found that on average a group of farmers in market segment 2 occupy 28,770 m^2 of land. Market segment 3 is that of a farmer cultivating on 400 m^2 piece of land and paying for pumping services offered by a pump owner in market segment 2. During the focus group discussion, it was found that the farmers in market segment 3 pay a fee of US$ 44.5 per crop cycle to a pump owner in market segment 2 for pumping services.

3.2. Appropriate sizes of SWPS for Market segments around Korsimoro reservoir

The equations in table 1 were used to determine the appropriate sizes of SWPS for the market segments both AC and DC configurations for each segment. Table 3.1 below summarises the SWPS for each market segment.

Table 3.1: Appropriate SWPS for the Market Segments.

SWPS components	Market segment 1		Market segment 2		Market segment 3	
	AC	DC	AC	DC	AC	DC
Pump (W)	2200	3000	3000	4000	120	120
Inverter (W)	2500	-	3500	-	180	-
Tank size (m³)	100	100	300	300	5	5
PV array (Wp)	2400	3120	3200	4160	160	160

Firstly, for each market segment, the AC system has the inverter as an additional component. This is necessary to convert the DC produced by PV panels into AC ready for use by the AC pump. Secondly, for each market segment, the size of the selected AC pumps match more closely to the design size of the DC pump for the same market segment. This is because the market for solar water pumps is mainly dominated by AC surface pumps and ground DC pumps. As such the DC pumps selected are significantly bigger than the AC pumps.

3.3. Economic analysis

Economic analysis was done in two stages. In the first stage, for each market segment, the AC and DC systems with water storage were compared. In the second stage, between DC and AC SWPS for each market segment, the system with low IRR was considered for further analysis. The interest rate 5.3% per annum provided by West African central bank was used at 20 years life span of the SWPS. Table below shows the capital cost, IRR, PBP and NPV of the SWSP with and without water storage tank.

Table 3.2: Capital cost, NPV, PBP and IRR of SWSP

SWPS	Capital cost (US$)	NPV (US$)	PBP (years)	IRR (%)
Market segment 1 AC SWPS	18,755.5	-4,499.1	>20	2.1%
Market segment 1 DC SWPS	21,937.7	-7,146.1	>20	0.9%
Market segment 1 AC SWPS/DWP	7,221.8	3,812.9	11.3	11.2%
Market segment 2 AC SWPS	41,487.7	-13,748.3	>20	0.8%
Market segment 2 DC SWPS	47,845.5	-18,202.2	>20	0.0%
Market segment 2 AC SWPS/DWP	12,025.5	8,425.2	10.1	13.0%
Market segment 3 AC SWPS	1,637.2	-0.6	>20	5.3%
Market segment 3 DC SWPS	1,512.8	270.9	15.6	7.4%
Market segment 3 DC SWPS	689.5	913.5	7.1	17.9%

The study found that, water storage tanks contribute enormously (45% to 63%) to initial cost of the SWPS. During the market survey in Ouagadougou, Burkina Faso, it was found that this could be because the PVC tanks are manufactured in Ghana and transported to Burkina Faso by road thus increasing the cost of the tanks. The study also found that SWPS with water storage tank has negative NPV for all the market segments. SWPS for all market segments have IRR below 5.3% and payback period more than 20 years. Negative NPV implies that SWPS with water storage are not profitable at 5.3% interest per annum, IRR below the interest charged means the farmers cannot recover their initial investment and finally payback period more than the lifespan of the SWPS means the farmers cannot recover their investment (Treephak et al. 2015). On the other hand, when the farmers replace the water storage tanks with DWP for pumping on cloudy days, all the systems have positive NPV, IRR more than the 5.3% interest used and PBP less than the lifespan of the SWPS. This implies that the SWPS without water storage but DWP used on cloudy days is profitable and the farmers can recover their initial investment.

3.4. Main Loan features for SWPS

The main loan features determined in this study were interest rate, loan size, loan duration, instalment size and repayment frequency. The least interest rate charged on agricultural equipment loans in Burkina Faso is 9.5% per year by *Federation Caisse Populaire du Burkina (FCPB)* (WFP 2016). At this interest rate, it was found that only SWPS for market segments 2 and 3 can be fully funded through loan without exposing farmers to risk of long PBP (> 13 years). As such, the subsequent loan features were only determined for market segment 2 and 3. According to Allderdice and Roggers (2000), the capital cost of clean energy technology is a good estimate for the loan size. Therefore, the capital cost of market segment 2 AC SWPS/DWP US$ 12,026.0 and that of market segment 3 DC SWPS/DWP US$ 689.0 were chosen as the loan size. The loan size US$ 12,026.0 for market segment 2 AC SWPS/DWP is more than the maximum loan provided by most MFIs in Burkina Faso (WFP 2016). However, according to Sacerdoti (2000), FCPB provides agricultural loans up to US$ 15,000.0 for equipment. Besides the capital cost, other costs such as replacement of pumps and inverter were considered. The size of instalment was determined based on recommendations by Bhattacharyya and Palit (2014) that MFIs should consider the cashflow of borrowers when setting the instalment size. The farmers in market segment 2 makes a profit of US$ 3,850.0 from providing pumping services and cultivation of onions over period of 6 months (Fraiture et al. 2013) and spends US$ 1,694.0 per year on fuel. The survey revealed that a farmer in market segment 3 occupying 400 m^2 of land earns profit between US$ 106.8 and US$ 356.0 over a period of 6 months and spends US$ 89 within the same period on pumping. Based on the cashflow of the farmers, the appropriate size of instalment was found to be US$ 1359.5 and US$ 89 semi-annually for farmers in market segment 2 and 3 respectively. Applying equation 18, the interest rate 9.5% per year is equivalent to 4.64% semi-annually and applying equation 19, the loan duration for farmer in market segment 2 and 3 are found to be 5 years and 4.5 years respectively.

4. Conclusions

The aim of the study was to assess the potential of microfinanced solar water pumping to enable productive use of energy in rural areas of Burkina Faso. The study found that there are three market segments for SWPS around Korsimoro reservoir. The study found that storage enormously contributes to the initial cost of SWPS. As such, using SWPS with water storage to completely replace diesel water pumps in the area is not profitable. On the other hand, using SWPS without storage but with DWPs for pumping on cloudy days is profitable venture with payback for all market segments. Of the three market segments, only the SWPS for two market segments can be completely financed through microcredit without exposing the farmers to risks due to long payback periods. Separate study should be conducted to determine the willingness of the farmers to purchase and accept microfinanced SWPS. The business models to support microfinanced SWPS in BF should be separately examined. The findings of this study are relevant in improving climate change adaptation of the population in study area through microfinance and clean energy technology. Cooperation between European institutions to support MFIs in BF so as to subsidise the initial cost of the SWPS could be vital in improving the profitability of the systems.

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