SI-1b

The contribution of solar energy to environmental protection and poverty reduction.

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1 Abstract

The neighborhood population pressure one Djamdè reserve is investigated in this paper. After noting and observing changes in the microclimate of Djamdè, a survey was conducted. At the end of this survey, market gardening was proposed not only to remove the increased pressure on the reserve, but also to provide an income generating activity for this very vulnerable population.

The collection of data on existing wells in the vicinity of the site shows that the availability of water for market gardening can be ensured by drilling. A comparative study between a pumping system with a petrol-powered pump and a photovoltaic system in the town of Kara has been carried out.

The solar pumping system is by far the most interesting for Djamdè site. Considering the very high initial investment cost of the components of the solar pumping system, its size can be reduced by organizing and planning the watering of the crops.

Keyword: Renewable energies, environmental protection, solar pumping.

2 Introduction

The majority of the population of Kara (North of Togo) are farmers [1]. But the development effort in this farming sector is reduced by many problems [1] [2]. Indeed, most of the work is done manually. The production capacity using this method is drastically limited. Their capacity to process agricultural products is embryonic with a reduced water control [3]. This results in a significant loss of production, expedited crop sales, flooding in the wet season and drying out of surface water in the dry season. The few irrigation systems for market gardening are also forced to shut down because of this drying up of easily exploitable surface water.

All these difficulties mark a part of the year in northern Togo called the "lean season" characterized by the absence of agricultural activities, food and financial difficulties in several families. During this period protected areas such as Djamdè's neighborhood break the law and cut firewood and make charcoal for sale in surrounding towns [3] [4]. This reserve, which contributed to the regulation of the microclimate in the area [4], is gradually losing this role and over the years signs of global warming have been felt.

The purpose of this study is to formulate a mature and economically viable technique that will enable the residents of the Djamdè Reserve to resolve their difficulties during the lean season

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while relieving pressure on the reserve. The proposed solution for solar-powered irrigation is the result of a comparison study of different irrigation systems in the town of Kara.

Solar-powered irrigation as a development tool will enable the population to diversify their source of income and increase the autonomy of women, who are the main actors in the cutting of firewood.

3 Methodology

The diagram below (figure 1) summarizes the process followed in this work. This study involves two sites: The first one is located in the Djamdè area. The climatic conditions, which are very specific to the area due to the presence of the nature reserve, have changed in recent years. A survey was then carried out among the population followed by a visit to a certain part of the reserve to witness the pressure exerted by the local residents on the reserve [3] [4]. The data collected on the increased pressure from the population led to the proposal of a market gardening system. Thus, in order to provide this very vulnerable population with an economically viable and ecologically acceptable solution, a second site was defined in the town of Kara. It is an area of 0.75 hectares on the banks of the Kara's River where market gardening was already practiced using water from the river through a small generator (figure 2) for water pumping.

Therefore, the study ascertained the availability of water in the vicinity of the surveyed sites by recording a sample of wells and boreholes, their depths and, for wells, the time of year they dry out. Rainfall data were provided by the ASECNA metrological station of Niamtougou, supplemented by sunshine data obtained from the RETScreen International database.

Figure 1: diagram of the process followed in this work

Figure 2: moto pump generator set

The amount of water needed for irrigation is determined based on different crops water requirements [7]. The water requirement (in mm or liters/m²) is then calculated by the equation (1):

$$\text{Daily water requirement of a crop} = ETP \times K_c \times \text{Surface} \quad (1)$$

Where K_c is culture coefficient and ETP is potential evapotranspiration

From this flow rate and the manometric height (HMT), the daily energy required (E_{elec}) to extract this amount of water is easily determined by the formula (2):

$$E_{elec} = \frac{\text{Hydraulic constant} \times \text{daily flow rate} \times \text{HMT}}{\text{Motopump unit efficiency}} \quad (2)$$

The manufacturer's datasheet allow to determine the generating set from the previous calculations. The photovoltaic field power required for a pumping system is given by the equation (3):

$$P_{modul} = \frac{E_{elec}}{\text{irradiation} \times (1 - \text{losses})} \quad (3)$$

To estimate the costs of the irrigation system, an economic analysis is necessary. In this case, this analysis takes into account the information collected on the study site. Two types of information can be extracted from the economic analysis: the updated cost, significant from the investor's point of view and the annual cost, for the system user's evaluation. The updated cost incorporates the cost of capital financing, operating, maintenance and replacement costs over the expected life of the pumping system. Thus, to investigate and propose an economically acceptable pumping system for Djamdè, the determination of the updated cost provides a good indicator of choice. Indeed, some systems such as solar-power systems may require a large initial investment and relatively low operating and maintenance costs, while others have the opposite situation. Investments for the installation and operation of an irrigation system include one-off and annual investments [8].

The update of one-off costs is calculated from the equation (4):

$$D_{acs} = D_{ini}(1 + \sigma)^{-\alpha} \quad (4)$$

With D_{acs} the simple present value of the expenditure, D_{ini} the initial value of the expenditure, σ the update rate and α the lifetime of the expenditure component. The update rate is a difference between the investment rate and the inflation rate.

The annual update costs is obtained from the equation (5) where D_{acu} is the uniform present value of the annuity, D_{ann} the value of the annuity and n the lifetime of the system.

$$D_{acu} = \frac{D_{ann}(1 - (1 + \sigma)^{-n})}{\sigma} \quad (5)$$

The value of the annuity is the product of the value of the annual expenditure by a coefficient called the annuity coefficient calculated by:

$$\text{Coeff. ann} = \frac{(1 + i)^n \times i}{(1 + i)^n - 1} \quad (6)$$

With i the investment rate.

4 Results and discussions

At the date of publication of this article, the study is still ongoing. So the results we present here should be considered as preliminary results.

The Djamdè field visit made it possible to observe the onset of desertification due to woodcutting. Figure 3 shows the cutting of wood on the reserve and its purpose for sale. The survey also revealed that some streams/rivers that not dry out are drying out more rapidly as they are gradually being blocked by the erosion phenomenon. This wood cutting activity is mostly carried out by women who are the most exposed to financial insecurity.

Figure 3: Woodcutting in the reserve of Djamdè

Figure 4: Sale of cut firewood

The proposed market gardening solution will not only release the pressure on the reserve but will also guarantee the local resident alternative and income-generating activities with a low impact on the environment.

The figure 5 shows the different depths of wells and drilling in the vicinity of the study areas as well as the periods during which they were dewatered.

Wells usually dug by hand are shallow due to the rocky structure of the subsoil. The permanence of water is not linearly related to the depth of the well. This can be explained by the morphology of the aquifer, which does not have the same depth at all levels. Thus with an adequate method for digging wells such as drilling, water availability will not be a major problem.

Figure 5: different depths of wells and drying up period.

The season in Northern Togo is divided into two: the rainy season covering the months from mid-May to the end of October and the dry season which extends from November to mid-May. During this dry season, the need for vegetables is provided by the market gardening products of Kara and other towns. At the study site in Kara, the most dominant vegetables are tomatoes, cabbage and lettuce. Based on these, we have determined their water requirement (figure 6).

Figure 6: Water requirement for some vegetables

By comparing the water needs of the different crops and the rainfall in Kara, we can notice that the period from June to September is favorable for market gardening without irrigation. But this period cannot solve the problem of pressure on the Djamdè reserve.

Indeed, from the beginning of May to October, the residents of the study area, mainly agricultural, devote themselves to their work in the fields. The pressure on the reserve is at its peak in the other half of the year, matching with the absence of this agricultural work. Thus, for the market gardening solution to be effective, it should cover the months from October to May. As seen in the figure 6, to meet the water needs of different crops in this dry period, an irrigation system is needed. Several techniques can be used to irrigate market gardening [8]: buckets or watering cans (at the edge of a river or dam), manual pumps, motor pump units, pumps powered by solar or wind energy or the network. The first two not only require a great human effort but are also less suitable for large areas such as those under study. In fact, they are by far the most used in the city of Kara. This choice is specifically of a financial nature. For this reason, in order to cover the needs for fresh vegetables and fruit in the dry season, it is necessary to resort to the neighboring towns of Kara, including that of Benin and Ghana. On the other hand, the study site in Kara, thanks to the use of the generator, allows us to compare the performance of this system with that equipped with a solar-powered irrigation system.

Table 1 presents the components that made it possible to analyze the costs for this market garden operation on the Kara site.

	Solar pump unit			Gasoline Pump unit		
	Duration	Valeur	Update Value	Duration	Valeur	Update Value
Solar pump + tank		993,09				
Generating set					114,59	
Annuity	15	130,57	1355,22	15	15,07	156,38
Maintenance	15	0,00	0	15	30,56	317,20
Gasoline + motor oil				15	479,74	4979,54
Replacing the group				7	114,59	663,06
Control system replacement	7	152,78	884,04			

Updated Cost	2239,27		6116,18
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Table 1: Different components used for the comparison

One can note the absence of many components necessary for irrigation, such as water pipes as an example. Since these components are the same on site regardless of the type of system, they are not included in the cost analysis. Referring to the crop water requirements for the 0.75 hectare area shown in the figures, the pumping systems proposed here seem insufficient to cover these needs. The reduction in the size of the pumping systems benefited from a perfect organization in the field.

In fact, the production of fresh vegetables at the Kara site is programmed to be able to satisfy customer demand at times when demand explodes such as December 25th (Christmas), January 1st (New Year's Day), April (Easter) and May 1st for Workers' Day. Thus, taking into account the irrigation dose of these soils, the amount of water demanded by this area can be spread over several days.

One outcome we had on the table is that for the exploitation of this plot, solar energy without surprise requires a very high initial investment fund. But the high cost of operation and maintenance of the irrigation system with the generator make it less profitable over the 15-year pay-off period. Over this period, the petrol-driven pump system is 2.7 times more expensive than the solar-powered pumping system.

5 Conclusion

The study presented here is a case of daily based problem of vulnerable populations in the northern of Togo. The pressure of neighborhood population living in that area on Djamdè's nature reserve has been studied and discussed.

With a view to reducing population pressure on the reserve, market gardening activities operating with solar pumping systems is proposed as solution to overcome the issues encountered by the population. Considering the very high initial investment cost of the components of the solar pumping system, its size can be reduced by organizing and planning the watering of the crops.

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