

Analysis of Two Irrigation Water Pumping Systems on the Taddis Valley Site: Solar Kit and Motor Pump Unit (GMP) in Tahoua (Niger)

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Abstract

The study was carried out in the Tahoua region at the market gardening sites of the Taddis 1 and 2 valley. Small-scale pumping irrigation is one of the most interesting uses of solar energy. The objective of this study is to carry out a comparative analysis of two dewatering pumping systems (Solar Kit and GMP) for water mobilization on a certain number of criteria such as sustainable use, economic aspect and performance. To achieve this, the adapted methodology consisted first of all in the development of a data collection tool in the field. Then flow measurements, estimation of fuel consumption, pressure height, etc., were carried out. Thus, the data collection involved a sample of 120 irrigators who had to use the two (2) types of pumping systems. The collected data were analyzed and processed with appropriate software. The results of the study show that the two pumping systems studied have strengths and constraints. Thus, the solar pumping system has a significant investment cost, very low maintenance and a low operating cost. On the other hand, the system with a generator has a relatively low investment cost (25 to 30 times less than solar), but a relatively high operating, upkeep and maintenance cost. He adds that these assets and constraints must be taken into consideration when an investment is made. This study shows that 74% of producers use GMP compared to 26% who use the Solar Kit. But in practice, the Solar Kit is more reliable for producers from the point of view of planted area, environmental management and investment costs, supply of fuel and lubricant. These results indicate better performance of the solar pumping system compared to GMP at the study sites.

Keywords

Market Gardening Sites, Pumping Systems, Solar Kit, GMP, Taddis and

1. Introduction

A West African country, Niger is located in the heart of the Sahel. Agriculture remains and remains the main economic activity to combat food insecurity and achieve food self-sufficiency in Niger. Indeed, the very severe ecological and climatic conditions constitute the problems which hamper this activity. They result in a considerable drop in agricultural and pastoral production. This situation is accentuated by strong demographic growth which leads to the food deficit [1] (Zakaria *et al.*, 2021).

However, the production of market garden crops comes to fill the food deficit recorded each year during the rainy season. However, for sustainable development and good agricultural practice, it is necessary to have control and rational management in terms of irrigation water, which necessarily involves the techniques used to mobilize water or means of dissemination. Dewatering including the Solar Kit, the improved pulley system, the motor pump unit (GMP) using gasoline or gas as energy sources.

In Niger, the main sources of water pumping energy used at most market gardening sites and community sites are gasoline, gas and solar. But the areas planted with these irrigated systems (small-scale irrigation) are very minimal compared to large-scale hydraulics on public irrigated areas with total water control [2] (Ehrnrooth *et al.*, 2011). Unfortunately, due to the dilapidation of these developments, especially the hydraulic infrastructures, production is far from being satisfied. Today, agricultural policy is focused on their rehabilitation, otherwise during the last three (3) decades, the emphasis was placed on small-scale irrigation [3] [4] (World Bank, 2009, Ministry of Agriculture, 2015) reported by Assoumana [5] (2021).

The latter is done in the vicinity of surface water (river, pond, etc.) or with groundwater in the most remote areas where irrigators use several sources of energy which are within their reach for the mobilization of water intended for irrigation [6] [7] (Wydra *et al.*, 2019a; Wydra *et al.*, 2019b). The most common energy sources used by irrigators are thermal energy based on fossil fuels, photovoltaic energy, wind energy and biomass energy [8] (Shinde *et al.*, 2015). Thus, the chosen energy system must first demonstrate its competitiveness vis-à-vis other systems for the same service provided. Its credibility must be based on economic and technical bases [9] (Mohamed Lamine *et al.*, 2021).

The aim of this study is to carry out an investigation into two means of dewatering for the mobilization of water for the purposes of irrigated production on the market gardening sites of the Taddis valley. These means of drainage to be studied are: Solar Kit and Motor Pump Group (GMP).

The Solar Kit is made up of photovoltaic cells (solar panels) which allow it to

generate electric current when the sun’s rays hit it. These solar panels are mounted on the roof or at a height from the ground [1] (Zakaria *et al.*, 2021). As for the Motopompe Group (GMP) is an agricultural machine made up of a heat engine connected to a centrifugal pump and which is used to suck up water from a given point (a source) to pump it towards a plot to be irrigated [10] (Yvon Régis., 2005).

2. Materials and Methods

2.1. Hardware

- Presentation of the study area

Located in west-central Niger, the Tahoua region (571 km on the east side of Niamey the capital) is located between latitude 13°40' and 18°50' North and longitude 04°52' and 6°41' East. It is limited to the northwest by Mali, to the south by Nigeria, to the east by the regions of Agadez and Maradi and to the west by the regions of Dosso and Tillabéry. **Figure 1** illustrates the market gardening sites of the Taddis valley.

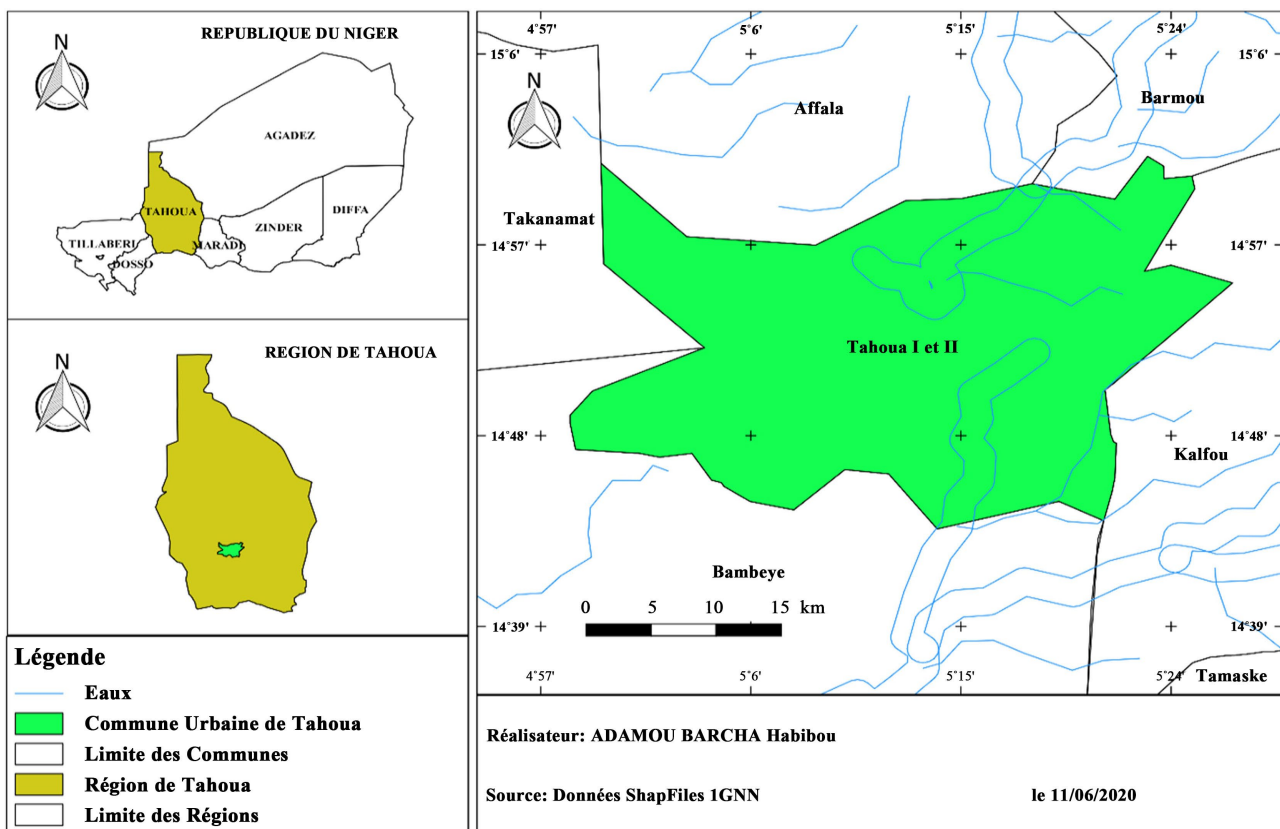


Figure 1. Map of the urban commune of Tahoua where the Taddis 1 and 2 sites are located.

- **Materials used**

The materials used to better conduct this study are:

- ✓ The target irrigators who have been identified in the market gardening site;

- ✓ A sheet developed and administered to irrigators for the collection of data in the field;
- ✓ A 10-liter container to measure the flow rates pumped by the two irrigation water pumping devices;
- ✓ And a Topographic Kit (an engineer's optical level, a staff, 6 milestones and a 50 m tape measure) for Manometric Height measurements for the installation of motor pumps and solar panels.

2.2. Methods

The methodological approach we adopted is as follows:

- In the first stage, we spent three (3) years to get to know the vast sites (1 and 2) of the Taddis valley from top to bottom.

This visit allowed us on the one hand to identify and locate the different cultivated plots of these study sites as well as the different aspects of the work. And on the other hand, to make contact with farmers and to know the spatial organization of the study sites.

- In the second stage, a survey coupled with various topographical measurements relating to the installation levels of motor pumps and solar panels was carried out to collect data from producers on the market gardening sites of the vast Taddis valley. Most of the content of the survey sheet focused on:
 - The characteristics of the drainage means to be studied;
 - The performance of these drainage means;
 - The technical-economic aspects of these means;
 - The advantages and disadvantages of these.
- In the third stage which concerned the analysis and processing of data.

This phase involved analyzing, processing, analyzing and interpreting the data collected in the field. Thus, the analysis of the survey sheets was first done with appropriate software and then followed by an interpretation of the results obtained.

It should be noted that only the most reliable results were retained.

3. Results and Discussion

3.1. Performance Assessment of Two Means of Drainage by Irrigators

During our investigation, we do not have at our disposal or we do not know the information relating to the nominal characteristics of the motor pumps used by irrigators of all brands. So due to the lack of this crucial information, we sought out performance from irrigators in the way they use it. Thus, on the market gardening sites of the Taddis valley, we sought the point of view of irrigators on the general appreciation by producers of two (2) means of dewatering. It emerges from the investigation that 74% of producers at the market gardening site in the Taddis valley admit that the motor pump unit is more efficient compared to the Solar Kit where only 26% of irrigators use it (**Figure 2**).

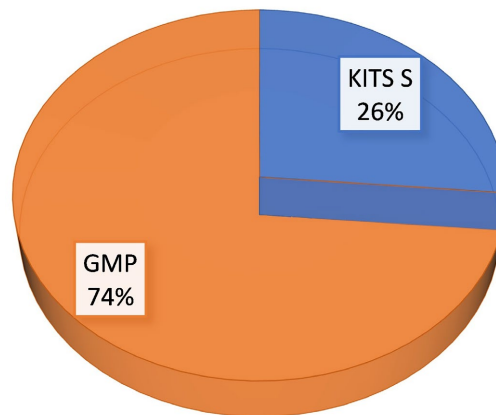


Figure 2. Assessment of the performance of dewatering means: KIT and GMP on sites 1 and 2 of the Taddis valley.

3.2. Endurance and Efficiency Kit Solar and GMP

According to the investigation, the means of dewatering which allows frequent irrigation with high efficiency is the Solar Kit. Indeed, from the analysis of **Figure 3**, there are 60% of irrigators who think that the Solar Kit is more durable (allows irrigation for a long time without the slightest problem) and the most efficient than the GMP on which 39.1% of operators make their choice.

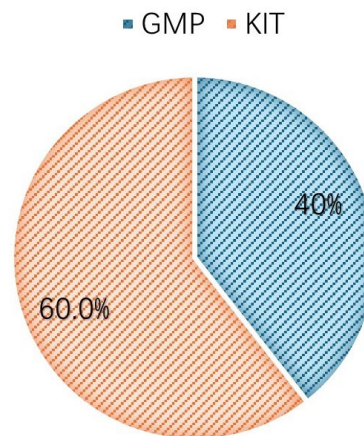


Figure 3. Point of view of irrigators on the endurance and efficiency of Solar Kit and the Motor Pump Group on sites 1 and 2 of the Taddis valley.

3.3. Sustainability of Drainage Means

Figure 4 illustrates the sustainability of 2 means of dewatering which were the subject of study on the Taddis site. From irrigator reviews, 89% say solar has incredible durability. It can be used for dozens of times and there are fewer breakdowns with this means of drainage. Unlike the first case, GMP has a short lifespan. According to a portion of respondents (11%), it is very difficult to see a GMP exceed 2 years of operation.

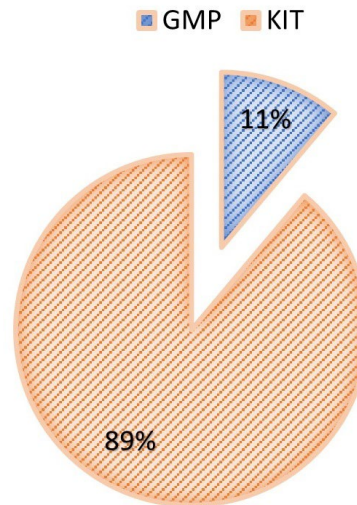


Figure 4. Sustainability of KIT and GMP dewatering means by irrigators of sites 1 and 2 of the Taddis valley.

3.4. Analysis of Technico-Economic Aspects of Two Devices

The gasoline motor pumps are started manually by pulling on a connected wire. It is started in 10 standard steps below:

- 1) Install the motor pump on a flexible support to minimize engine vibrations and contact with water;
- 2) Add fuel;
- 3) Checking the oil up to the recommended level;
- 4) Connect the pipes (exhaust and discharge);
- 5) Fill the pump body with water;
- 6) Open the fuel tap;
- 7) Place the choke knob (lever) to “ON”;
- 8) Turn the switch to “ON”;
- 9) Pull the starter handle and
- 10) Place the choke pull to “OFF”.

As for the technical aspect of the solar device, it is very simple only it must be placed on a fixed support and protected from water and the sun. It is turned on by pressing the switch fixed below the solar panels. However, it is necessary to ensure sufficient sunshine. For solar panels, their location is not easy, they require a certain positioning or angle in relation to the sun.

The motor pump is a pumping system that only requires human intervention when starting and stopping. Its operation requires permanent fuel refilling and engine maintenance (draining). The adoption of the energy source by operators depends above all on their financial means which are very limited. In rural areas, like our sites, fossil energy (petrol and gas) is the most used. The Solar Kit is mainly used in large private farms, particularly in peri-urban sites. In the case of the sites in our study, at least 90% of irrigators (9 out of 10 irrigators) installed their solar kits with financial or material support from development projects or

Non-Governmental Organizations (NGOs) which popularize the solar system. given its high cost.

On the economic aspect, it was impossible to carry out the investigation based on the following constraints: the economic study is based on the cost of the investment, the depreciation of the latter, the operating cost, the cost of water and permanent charges; none of these points are controlled by irrigators.

For the two (2) means of dewatering, we sought to measure the operating flow rates of the motor pumps, to evaluate the fuel consumption, to measure the pumping heights and the operating costs and this on an operator by operator basis. After 4 days of intense field work, we were forced to stop these measures for reasons that hold water at our level. These reasons are as follows: the plots to be irrigated vary and the motor pumps or solar pumping systems are of various brands or their operating states are different. For the solar pumping system, the flow rate depends on the sunshine which differs from one day to another. The water pumping times are not the same, there are irrigators who pump very early in the morning, some in the interval 11 a.m. - 2 p.m. and another category after 4 p.m. in the evening. Consequences are that even for equal pumping times and with motor pumps of the same brands, fuel consumption will not be the same.

Table 1. Advantages and constraints of the solar pumping system and GMP identified at the Taddis sites.

Pumping system	Strengths	Constraints
Solar pumping system	<ul style="list-style-type: none"> ✓ No operating costs; ✓ Long lifespan of the device; ✓ Possibility of reaching aquifers of medium depth; ✓ Possibility of irrigating large areas. 	<ul style="list-style-type: none"> ✓ Installation of the solar device requires proven knowledge which is not always available locally; ✓ Need to call a qualified service provider in the event of a breakdown; ✓ High investment cost; ✓ Limited irrigation time and low flow rate; ✓ period of low sunshine; ✓ Frequent cleaning of panels; ✓ dust period; ✓ Theft and vandalism of equipment; ✓ Less accessible to producers; ✓ Flow instability.
GMP	<ul style="list-style-type: none"> ✓ Availability and affordable price of pumps on the market; ✓ Availability of gasoline and repairers; ✓ Availability of spare parts; ✓ Does not require great technical skills; ✓ Constant and time-independent pumping flow. 	<ul style="list-style-type: none"> ✓ High price of gasoline, especially in times of shortage; ✓ Its operation requires permanent fuel recharging; ✓ Greenhouse gas emissions; ✓ Short lifespan of GMP (2 to 4 years); ✓ Emits noise pollution and dioxide; ✓ carbon; ✓ Requires daily maintenance to check the diesel level, lubricant level and condition; ✓ Periodic maintenance of filters (air and fuel); ✓ Generally requires priming at startup, which is very restrictive.

The motor pumps used by farmers are not all adapted to the pressure heads (HM) for GMPs, or solar panels of different qualities. For operating costs, here

too the data necessarily depends on the general condition of the Motopompe Group or the solar pumping system and the conditions of their operation. Finally, we were obliged to contact the irrigators through an interview. Therefore, we were interested in knowing the advantages and constraints of two (2) means of dewatering summarized in **Table 1**.

After listing these advantages and constraining two means of dewatering, the irrigators reiterated their preference for the Kit for the following main reasons:

- Long lifespan and few maintenance interventions;
- Easy to use and uncomplicated start-up.

4. Discussion

This study presents a comparative study of the means of dewatering the solar pumping system and the motor pump unit at the market garden site of the Taddis valley.

Despite its higher initial cost compared to the GMP pump set, the solar pumping system would be a good alternative for producers on the said valley site. This study, which deals with the analysis of two means of dewatering on irrigation and their socio-economic performance by the producers, made it possible to arrive at results from the site. It appears from the observation in the field that there are more irrigators who use GMP more than the solar pumping device. Indeed, the results of the study show that 74% of producers use the motor pump unit compared to 26% of those who use the solar pumping system. This is due to the fact on the one hand that the solar pumping system is a new technology for irrigators in the Tiddis valley. And on the other hand, the lack of control of this new means of drainage.

This corroborates the work of DARE [11] (1993) in Burkina Faso. According to the author, farmers prefer solar because GMP generates a financial effort 50% more than solar pumping. These results are also similar to those obtained by [12] SEOUSSOU (1993) in Burkina Faso and [13] ABBASSI in Algeria in 2017. It showed that irrigators choose solar rather than the pumping system with GMP. This choice is justified by the low maintenance requirements and reliability offered by the solar pumping system compared to the pumping system with the GMP which has the only advantage that it gives an observed flow according to the irrigators. For ABBASSI, he showed that the photovoltaic solar energy pumping technique seems to be the best and least expensive after 20 years in addition to that it has several advantages in its favor, in particular: Low operating cost (limited to maintenance and repair), low periodic cost, little mandatory regular maintenance, Low and easy maintenance.

Regarding the flow rate coming from two pumping systems, the flow rate is high when the installation is new and in addition depends on the sunshine for solar. These results are close to the work of [14] Mohamed Lakhdar (2008) in Algeria where he showed that the flow rate is a function of the characteristics of the pumping system and its condition and degree of sunshine. In relation to the forces

and constraints, we have seen in this study that for the solar system, it presents a significant investment cost, very low maintenance and a low operating cost. On the other hand, the system with a motor pump unit, the investment cost is low, but the upkeep and maintenance costs are relatively high.

This confirms the results obtained in Algeria by [15] Bouzidi *et al.*, (2006). Indeed, according to the author, the two pumping systems studied have advantages and disadvantages. The photovoltaic system has a high investment cost, very low maintenance and a low operating cost. On the other hand, the system with a generator has a relatively low investment cost, but a relatively high operating, upkeep and maintenance cost. He adds that these advantages and disadvantages must be taken into consideration when an investment is to be made.

5. Conclusion

This work was devoted to a comparative study between two means of dewatering: solar pumping system and GMP in the market gardening site of the Taddis valley. From this comparison, it clearly emerges that the solar pumping system presents undeniable advantages from a technical point of view such as the durability of the system (high reliability), operating costs (fuel) or running costs are obviously zero. There remains, however, a low or average portion for the maintenance costs. This composition is completely different in the case of fossil fuels (GMP) where the costs due to depreciation are low while the costs of fuel, operation and maintenance are preponderant. In addition, the Motopompe Group, its ease of use and operation, stability and independence of flow in relation to time are assets. The application example that we used to better understand each of the water mobilization techniques intended for irrigation showed us that GMP seems to be less expensive at the farm flow rate. The balance becomes clearly in favor of the solar pumping system pumping solution after approximately a few years of operation. The weak point of this last solution remains the initial investment which clearly favors the use of GMP on the site. This does not mean that GMP is the best but it is more widely used.

Authors' Contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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