

Status of the Use of Groundwater during the Dry Season at 5 and 7 Blocks of the Irrigated Rice Plain of Bama, Burkina Faso

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Abstract Water insufficiency in the irrigation canals during the dry season in the rice-growing plain of Bama means that barely 20% of the plots is cultivated with rice during this period, causing losses of over 1,500,000 US \$ per year. So, groundwater is used as an alternative by some producers without control. This study aims to assess the current use of groundwater for off-season production in blocks 5 and 7 of the Bama plain. The diagnosis was made during the 2019 dry season by means of focus group, then an individual survey in order to inventory the sinks and speculations produced. Then, around twenty large-diameter rice irrigation wells were followed to determine the volumes of water supplied. The results showed that, the small wells are mainly intended for manual irrigation of market gardening during the cold dry season and large-diameter wells for pumping rice cultivation in the hot dry season. Finally, over-irrigation of more than 2.5% of rice needs was observed.

Keywords: groundwater, irrigation, off-season, market gardening, rice, irrigated plain

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1. Introduction

In Burkina Faso, most of the large rice-growing plains are gravity areas where water comes from dams or rivers located upstream [1]. However, nowadays, the various pressures exerted on these water resources through domestic and industrial needs are increasingly strong. Also, the increase in demand for agricultural products and the rainfall variability which impacts the availability of surface water on the other hand [2,3,4], weakened the water potential of irrigated rice plains during the off-season. This is the case in the irrigated plain of Bama. In fact, in recent years, climate change has affected the perimeter through a continuous decrease each year in the flow of the river [3,5]. In addition, the siphoning of water in the main canal for the irrigation of more than 700 Ha of market gardening [6] amplifies the depletion of water on the plain. Consequently, we are seeing a drastic areas cultivated reduction during the dry season which have dropped from 1260 ha in the 1980s to less than 300 ha today [7,8,9,10] with lower yields [11]. To revitalize off-season rice production, some producers pump water

directly from the water table. This practice is common in the some countries of the Magreb [12,13], in Niger where it has been shown that nearly 160,000 ha could be developed for off-season irrigation by pumping groundwater [14] and in Burkina Faso where studies on the Karfilégua plain have shown that groundwater can be an alternative for off-season rice cultivation [15]. However, the quantification of the water needed to be pumped per ha to produce rice during the off-season by these producers in the Bama plain will help avoid wastage as these initiatives are individual. This is the logic of this study whose objective was to analyze the current practices of pumping water from the groundwater for off-season rice cultivation at the level of blocks 5 and 7, located downstream of the plain where water is almost non-existent in the irrigation canals during the off-season.

2. Material and Method

2.1. Presentation of the Study Area

The irrigated plot of Bama is located in the alluvial plain of Kou in western Burkina Faso precisely in the Kou

basin between longitudes 4°28'0" and 4°23'0" W and latitudes 11°20'0" and 11°11'0" N (Figure 1). It covers 1260 ha area. The climate of the Kou basin is the Sudanese type and it belongs to the wettest zone of Burkina Faso with an annual rainfall varying between 750 mm and 1200 mm. In this area, two very contrasting seasons can be observed: a dry season which extends from October to April and a rainy season which extends from May to September. The Kou watershed is part of the large Mouhoun basin which covers approximately 91,036 km² [16]. The Kou River, which is perennial, is fed by several sources which discharge 6000m³/h of water and constitute the bulk of the base flow [17]. Much of the water from this river is used to irrigate the Bama plain, which extends over 1260 ha. The Kou basin is based on an aquifer system of the ancient sedimentary zone with significant permeability, which makes them very productive [18].

2.2. Inventory of Blocks 5 and 7 of the Irrigated Plain of Bama

The diagnosis was made in two phases during the 2019 off-season: survey and measurements in the field. The first phase took the form of an investigation in order to inventory the speculations produced and to enumerate the existing underground water mobilization works. Then, the plots of twenty rice farmers using groundwater for irrigation were monitored, which made it possible to estimate the number of pumping hours, the frequency and the pumping rate by the volumetric method in order to evaluate the average volume withdrawn as follows:

$$V_{ep} = Q_{mes} * N_{hp} * N_{jp} * N_s$$

With

- V_{ep} = with drawn water Volume;
- Q_{mes} = flow rate measured in cubic meters per hour;
- N_{hp} = Number of pumping hours per irrigation in hours;
- N_{jp} = Number of pumping days per week;
- N_s = Number of weeks of pumping per season.

2.3. Evaluation of the Irrigation Dose during the 2019 Off-season

The average value of the saturated hydraulic conductivity considered is 34.98 mm / h on the two blocks with a useful reservoir of 125 mm / m [6,10]. The ET₀ was calculated by the modified Penman formula, and multiply by the K_c (varying between 0.8 and 1.2 depending on the stage of development) to obtain the ET_M. The respective values of the ET_M made it possible to choose the dry-off factor p according to Whithers and Vipond. We had assumed that the water table depth of 70 cm was usable by rice by capillary rise.

The dose to meet the water requirements of rice is therefore:

$$Dp(mm) = p * RU(mm) = p * Zr(mm) * (\theta_{fc} - \theta_{wp})$$

With:

- Dp = Dose
- RU= Useful Reserve
- θ_{fc} = Volumetric humidity at the field capacity
- θ_{wp} =Volumetric moisture at wilting point
- Zr= root depth of the crop
- P= drying-off factor depending on the type of crop and the ET_M.

Geographic localization

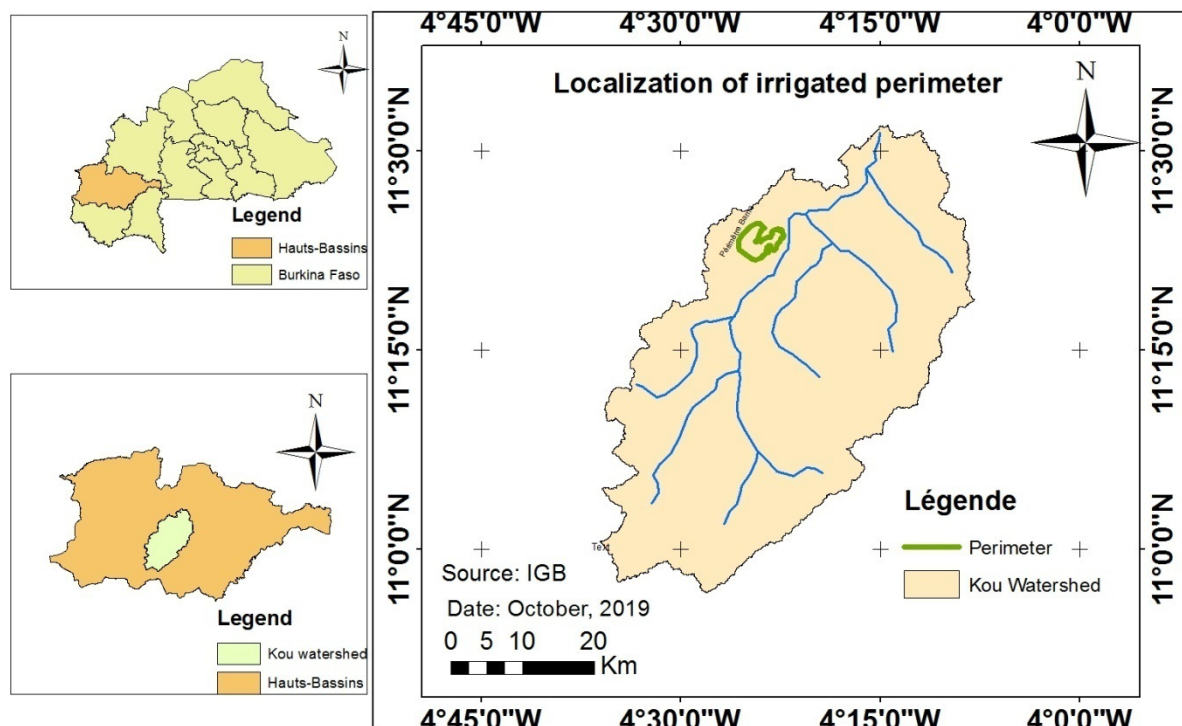


Figure 1. Location of the study area

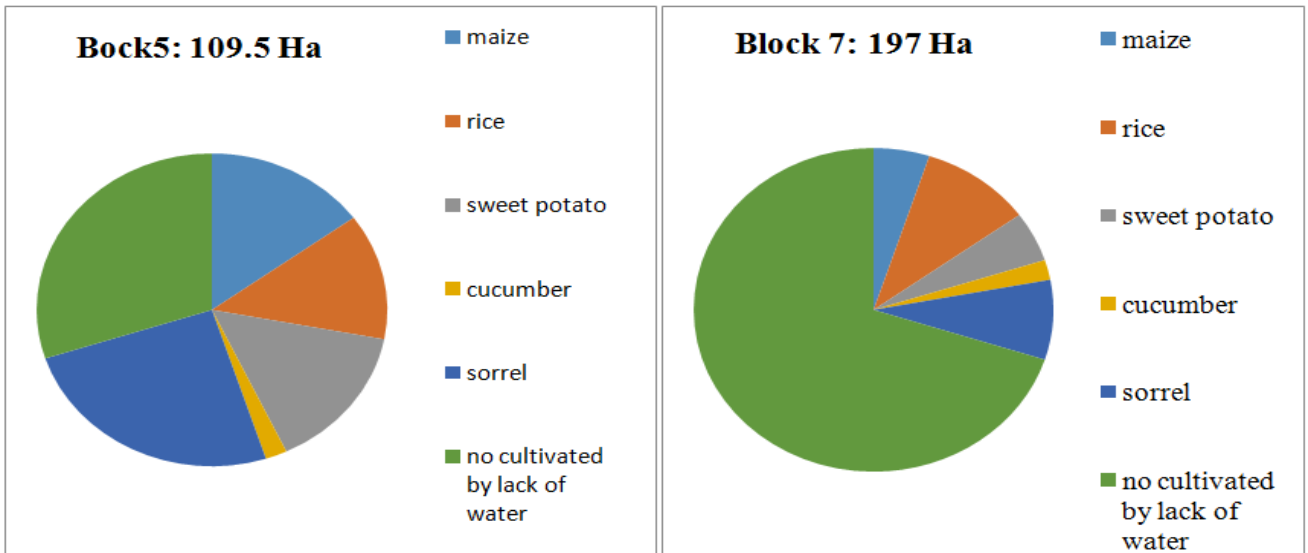


Figure 2. Proportion of crops on Study Blocks

Table 1. Cultural calendar for off-season crops on blocks 5 and 7

Crops	cold dry season				Hot dry season			
	Nov	Dec	Jan	Feb	March	April	May	June
Cabbage	[Bar]							
Onion	[Bar]							
Maize				[Bar]				
Sweet potato			[Bar]					
Rice			[Bar]					

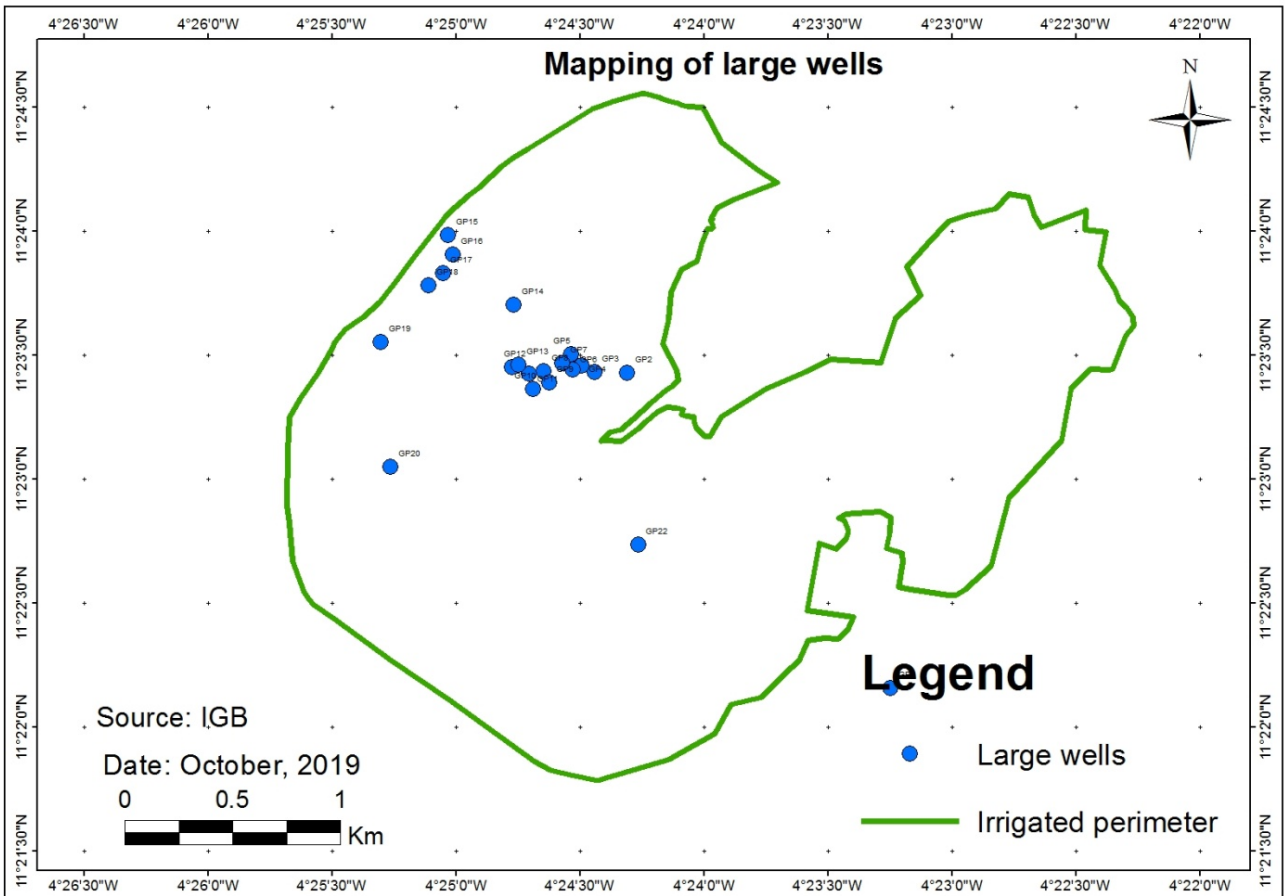


Figure 3. Mapping of large wells in blocks 5 and 7, Bama rice farming plain

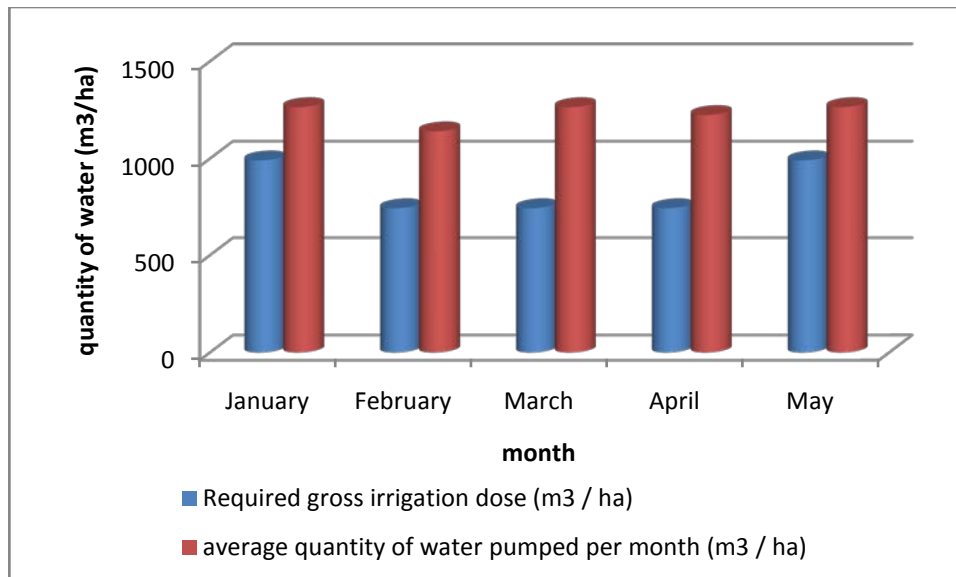


Figure 4. Water amount pumped vs monthly rice water requirement during off-season

3. Results and Discussion

3.1. Speculations Produced in Blocks 5 and 7 during the 2019 off Season

For lack of water from the existing irrigation system, more than half of the area of these two blocks was not cultivated during the 2019 off-season (Figure 2). At the level of blocks 5 and 7, only 13% and 10% of these areas were respectively cultivated with rice and irrigated by pumping at the level of the water table. Some producers have replaced off-season rice cultivation with market gardening (Figure 2). The results of the survey made it possible to draw up the cropping calendar (Table 1) of the main crops. It can be seen that after the rainy season, producers do market gardening during the cold dry season and off-season rice growing during the hot dry season.

3.2. Diagnosis of Current Practices for the Use of Groundwater Resources

Twenty-two large diameter wells and around forty small seasonal wells per ha for market gardening were listed on blocks 5 and 7 used for irrigation (Figure 3). Most of these wells have depths of up to 6m. The survey shows that 80% of these wells do not dry up during the dry season. Water is pumped for irrigation of rice plots and manual watering cans are used for market gardening. The volume of water pumped per ha is approximately 7699.05 m³ during the dry season for rice.

3.3. The Monthly Irrigation Doses Required for Rice during the Off-season

The comparison of withdrawing water volumes and the gross volume of water required to produce the rice (Figure 4) for two cropping cycles during the off-season shows an overestimation of the quantities of water pumped about 2.5%. In fact, the water table availability at a shallow depth in certain places of blocks 5 and 7 and at low cost, induce producers to irrigate more than necessary.

This is the case in several agricultural areas based on uncontrolled pumping [19]. Irrigation efficiencies are therefore low [20,21,22]. However, groundwater access saucerising during the off-season will increase yields and production volumes.

4. Conclusion

The study showed that the lack of irrigation water on blocks 5 and 7 of the Bama plain during the dry season induce producers to explore other alternatives so as not to abandon the 306 ha, surface of these blocks. In fact, small seasonal wells, about forty per ha, are dug every off-season for manual irrigation of crops such as sorrel, onion, cabbage, cucumber, mint and okra. While the large diameter wells, with an average depth of 6 m are intended for rice cultivation. However, because of lack of control of the volumes pumped or withdrawn manually, an over-irrigation of 2.5% of the rice needs was observed.

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