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INNOVATION, ADAPTATION AND ENGAGEMENT IN A CHANGING WORLD

A methodology for groundwater resource management at village level: a case study at Dassui Commune, Burkina Faso

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Collection of groundwater level and abstraction data are essential components of successful groundwater resource management, at local and regional scales. This paper describes the collection and use of data collected by villagers relating to an irrigated market gardening project in a remote community in Burkina Faso. It identifies important insights that can be gained into the behaviour of a groundwater system from these data and how this can result in improvements to project outcomes. It is shown that village-level data collection can be highly effective and inform future options to ensure that water resources are used sustainably. Data analysis also indicated that irrigation efficiency was low leading to the need to investigate alternative, improved methods.

Background

Introduction

Hafren Water is an independent consultancy which provides advice on a wide range of water issues both within the UK and internationally. Hafren Water provides support to organisations through consultation, technical input and knowledge transfer, working closely with NGOs and appropriate government bodies that have responsibility for water issues.

Self Help Africa (SHA) is a UK-based charity which promotes a range of initiatives focussing on agricultural improvement. It runs a Regional Programme in West Africa and has been working with Burkinabe NGO, Actions pour le Developement des Communes et des Collectivités Locales (ADECCOL), to support agricultural activities in the Commune of Dassui. The objective of the project is to support the expansion of small-scale, dry season, irrigated market gardening located in an area of shallow groundwater close to the village.

Hafren Water became involved with the project in 2009 after visiting Dassui during a trip to Burkina Faso for another international NGO. This involvement resulted in some additional research work being undertaken by V Finch and continued as part of an MSc project (Gillson, 2010).

Location

The Commune of Dassui is located 130 km to the southeast of Ouagadougou, in the Department of Dialgaye, Kourittenga Province (Figure 1). The village is accessed along an unsurfaced road, approximately 11 km from the main Koupela - Tenkodogo road (N16).

Existing situation

The market gardening plots are located in a seasonally dry valley which lies some 500 m to the south of the centre of the village (Figure 2). The characteristics of the soil and water supply within the dry valley are markedly different from the surrounding area, providing good conditions for the cultivation of high-value crops.

During the rainy season, the valley bottom is sufficiently wet for rice cultivation by the landowners. In the dry season, irrigated market gardening is undertaken by villagers in order to supplement their diet and to provide additional income at a time which is traditionally extremely difficult for the local population. Crops commonly grown include cabbages, carrots and onions. Market gardening has been undertaken for several years at a relatively small scale. The intervention by SHA/ADECCOL is intended to accelerate the expansion of the irrigated areas.

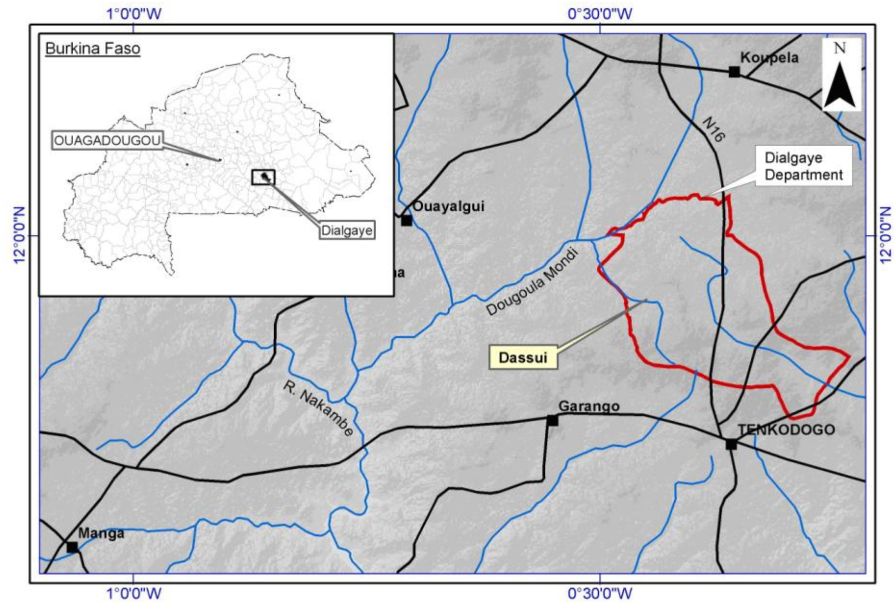

Figure 1. Location of Dassui village

Source: Hafren Water

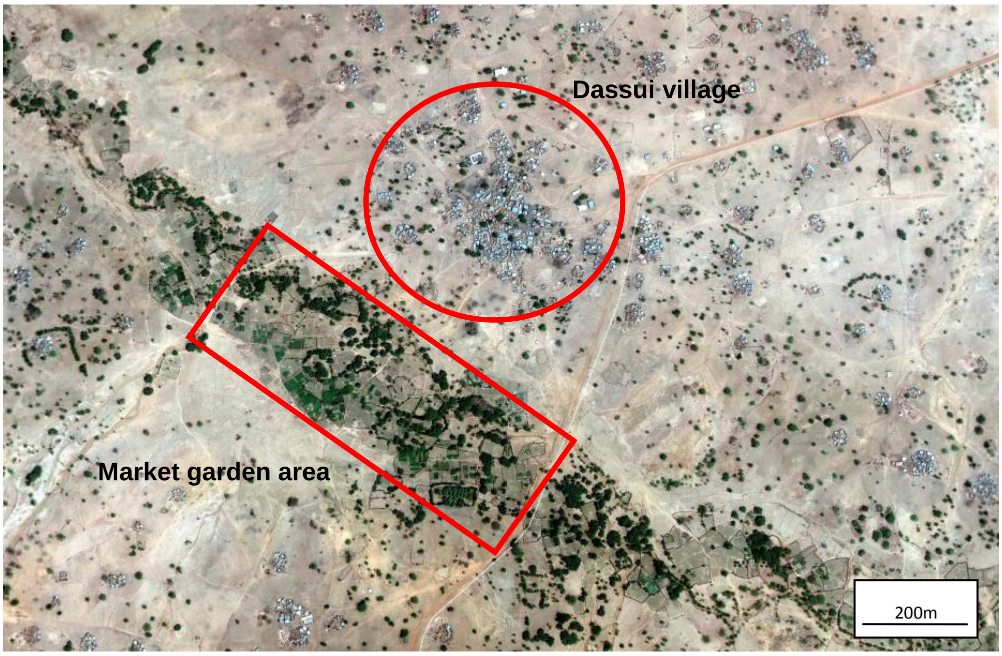

Figure 2. Location of market gardening area, Dassui (Lat: 11.94°, Lon: -0.47°)

Source: Image from GoogleEarth

The water supply for irrigation is drawn by hand from open, hand dug wells, with generally one well per plot. The individual irrigated plots are bunded, presumably to retain water for rice cultivation. Views of a typical plot, and a typical hand dug well, are shown on Photographs 1 and 2.

Photograph 1. Irrigating from hand dug well

Photograph 2. New hand dug well

Due to the success of the project to date the potential for further expansion is currently being considered. A key consideration of expansion of the scheme is the availability of a sustainable water supply of sufficient volume. Following a site visit by Hafren Water in October 2009 a programme of field measurement and investigation was instigated to examine current water use and the sustainability of water resources.

The input included the following:

- Set-up and remote overseeing of water level measurements in three open wells,
- Determination of water use in two irrigated plots,
- Data collection to understand the village setting in the context of the wider water environment.

Baseline data

Climate

The project area lies within the Soudanien climatic zone with an annual rainfall of between 800 and 1000 mm and an annual evapotranspiration ranging between 2200 and 2500 mm (Trinquard et al, 2003a). The rainy season extends between May and September and accounts for more than 80% of the annual rainfall.

Watercourses

Dassui Village lies within the catchment of the River Nakambe. The unnamed valley that passes through the village is a tributary of the Dougoula Mondi, which joins the River Nakambe 35 km to the southwest. According to Trinquard et al (2003a), there are no permanent rivers in this area. This is confirmed from flow data recorded on the Nakambe at Niagho, 35 km southwest of the village, which shows that this major river only flows for around 8 months of the year.

Satellite images show that the valleys contain denser vegetation cover than the surrounding area as well as evidence that the valleys are used for agriculture (Figure 2). It is uncertain if these valleys are ever subject to long periods of surface flow, however there is evidence of channel features in the area of the market gardens.

Geology

The regional geology (Trinquard et al, 2003b) comprises laterally extensive crystalline basement which is characteristic of vast regions of West and Central Africa. Superficial deposits are not widespread and generally occur within the larger river valleys, for example along the Dougoula Mondi to the northwest of the village.

There is little other information regarding the detail of the local geology and in particular on the sediments in the valley feature in which the market gardening area is located. However, information obtained during the site visit indicated that superficial sediments in the valley are of the order of 8-10 m thick and comprise poorly sorted fine to coarse sands.

Hydrogeology

The groundwater regime comprises two distinct but interconnected systems: (a) sandy sediments within the dry valley and (b) weathered and fresh crystalline basement. Based upon the large body of literature which exists relating to crystalline basement hydrogeology and sand rivers, together with extensive company experience, it is assumed that the salient characteristics of the aquifer system are as below:

Dry Valley aquifer
- Relatively high groundwater storage potential
- High hydraulic conductivity
- Limited areal extent

Crystalline basement aquifer
- Low groundwater storage potential
- Low hydraulic conductivity
- Laterally extensive

Data collection

Following the site visit by Hafren Water, it was recommended that water levels were recorded in three wells. Groundwater level monitoring was undertaken by villagers, supervised by ADECCOL, using a tape measure. The shallow depth to water within the wells meant that this simple method provided sufficiently accurate results for the purposes of the investigation.

Two wells (Well 1 and 2) are located in the valley deposits at the eastern edge of the market gardening area (Figure 3) and one (Well 3) approximately 600 m to the northeast, on the basement aquifer. At the two market garden wells, water levels were measured at the start and end of the two daily irrigation periods in the morning and afternoon. In the third well, which is used to supply water to the village, a single daily measurement was taken.

Figure 3. Location of monitored wells (Lat: 11.94°, Lon: -0.47°)

Source: Image from GoogleEarth

Monitoring commenced on 3rd January 2010 and has continued since then. The hydrograph for Well 2 is shown on Figure 4. Water levels are shown in terms of water depth within the well.

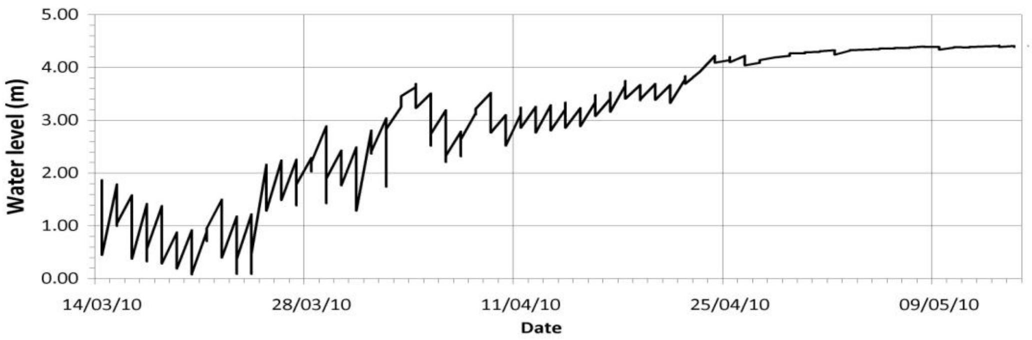

Figure 4. Water level measurements from well 2

Source: Hafren Water

The data show a high frequency water level variation superimposed on a long-term trend. The high frequency variation is in response to the twice-daily abstraction of water for irrigation use. These variations range between approximately 0 and 3 m, with an average of 1.5 m. A notable feature of the water levels in this well is that by the end of March water levels were at the base of the well after each irrigation period.

Data analysis

Water level trends

Long-term water level trends for all three wells are shown on Figure 5. To filter out the daily variations, only the first water level record of each day has been plotted.

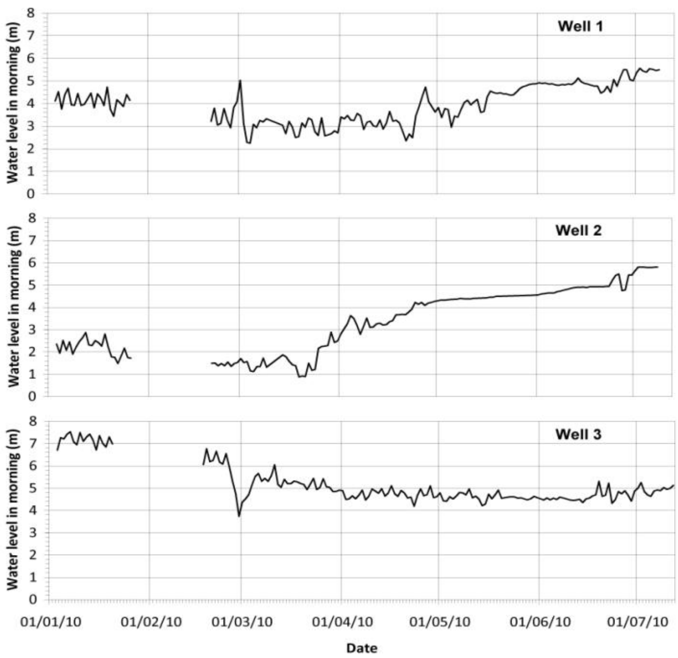

Figure 5. Water level trends for Wells 1, 2 and 3

Source: Hafren Water

The records show that in the wells located within the dry valley (Wells 1 and 2), groundwater levels declined until the end of March. In Well 1, groundwater levels then stabilised until the end of April, after which there was a slow rise. In Well 2, water levels began to rise earlier, at the end of March, and initially very rapidly. The reason for the difference in behaviour between wells is currently uncertain.

The water level decline in the basement aquifer extended to June before any rise was apparent.

Water use

An estimate of the volume of water abstracted for irrigation can be determined on the basis of the groundwater level data, which recorded water levels before and after irrigation, and the known diameter of the well. This assumes that the volume of water entering the well during abstraction is minimal, which is considered to be reasonable. A summary of water abstraction is given in Table 1.

Table 1. Estimated groundwater usage based on water level measurements (from 03/01/10 – 12/07/10)

	Well 1	Well 2	Well 3
Well diameter (m)	0.90	0.90	1.40
Maximum groundwater abstraction (m^3/day)	1.48	1.30	3.22
Average groundwater abstraction (m^3/day)	0.87	0.76	1.52
Average morning abstraction (m^3/day)	0.45	0.45	-
Average afternoon abstraction (m^3/day)	0.43	0.31	-
Total abstraction (litres)	58,248	48,864	185,157

A comparison between the actual water use and the optimum water use has been made to provide an indication of the effectiveness of the current irrigation methods. The theoretical optimum volumes of irrigation water use have been determined using the computer program CROPWAT (FAO, 2010a). The program, developed by the Food and Agricultural Organisation (FAO), uses climate, crop and soil characteristics to derive crop water requirements, reference evapotranspiration and irrigation requirements. It also produces soil moisture balances based on the water deficit incurred from the growing of crops. CROPWAT is used to estimate the optimum irrigation regime for different crop types and also determine the efficiency and impacts on crop yield resulting from different irrigation practices.

The climatic parameters for CROPWAT were obtained from rainfall records for the nearest weather station (Fada Ngourma, Lat: 12.03°, Lon: 0.36°) and the RETScreen program (Natural Resources Canada, 2010). Soil and crop inputs were taken from the FAO Irrigation and Drainage Paper (Allen et al., 1998). It is assumed that there is negligible initial soil moisture depletion as the CROPWAT simulation is run based on planting dates just after the wet season where the soil profile is at full field capacity. The associated CLIMWAT program (FAO, 2010b) was as the time not recognised as a resource for climatic input into CROPWAT. It is acknowledged that this program which is specifically catered for use with CROPWAT is the most suitable method for climatic data input.

CROPWAT indicated that daily, fixed-depth irrigation, as occurs at Dassui, is sub-optimal for onion and cabbage crop yield as well as being wasteful of water resources. Irrigation efficiency at Dassui may be as low as 70% due to excessive water application and crop yield 40% below its potential. This concurs with other studies (Mermoud et al., 2005) that have concluded daily irrigation can be detrimental to crop yields and that smaller volumes of water applied less frequently can improve crop yield and resource sustainability.

The FAO describes in the detail the ideal conditions and irrigation applications for cabbage and onion crops. The point at which to irrigate is given as a percentage depletion of the available soil water. When set to the FAO recommendations for irrigation, efficiency was increased to 100% with no reduction in crop yield and less frequent applications. This highlights there is potential to adopt a more sustainable approach to irrigation that may increase crop yield and reduce time spent watering.

Summary and conclusions

Prior to this study data was not available regarding any aspect of the market gardening (eg water use, irrigation rate use, crop yields, etc). The daily collection of water level and water use data has been invaluable to assess water resources and to inform future development, both at Dassui and similar projects elsewhere.

Based upon analysis of the groundwater level data several conclusions can be drawn, namely:

- The groundwater levels showed an overall decline throughout the dry season. The water level in one of the wells (Well 2) was very close to the base of the shaft, indicating that the resource at that location was close to exhaustion.
- The volume of water abstracted from each well could be estimated. Therefore the volume of water applied per unit area, hence the irrigation efficiency, could be calculated.
- The input of site-specific data to the computer program CROPWAT indicates that the current flood irrigation method is inefficient, leading to water resource wastage and sub-optimal crop yield. The use of more efficient irrigation practices could reduce water use significantly and increase crop yield.
- The proportions of the watertable decline attributable to natural recession due to the absence of rainfall and abstraction for irrigation cannot be determined
- Simple village level data collection, if well supervised, can provide valuable, high quality data. This in turn can provide a significant input to the viability of a project.
- The data collection and analysis undertaken to date has provided valuable insight into water use and the sustainability of water resources in the vicinity of Dassui. It is proposed to continue data collection to further increase the understanding of the local water environment.
- It is hoped that once more data have been collected simple operational rules can be developed to allow the villagers to make their own decisions regarding the management of water resources in the dry valley. The challenge will be to motivate the villagers to continue monitoring for their own benefit in managing the local groundwater resources.

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