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MECHANISMS FOR REDISTRIBUTING POSSIBLE WATER SAVINGS FROM WATER DEMAND MANAGEMENT IN SWAZILAND: THE CASE OF IYSIS CANAL

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ABSTRACT

An exploratory study to investigate alternative ways of redistributing possible water savings through Water Demand Management (WDM) in large scale irrigated areas in Swaziland was conducted along the Inyoni Yami Sugar Irrigation Scheme (IYSIS) canal. The objectives of the study were to: identify and locate communities along the IYSIS canal and around the large scale irrigated areas; map community boundaries, homesteads, fields, and open areas that could possibly be supplied by the canal through the gravity flow method; and establish possible water abstraction points and conveyor routes from the canal to communities and open areas. The data of this study was mainly spatial. A Global Positioning System (GPS) was used to capture physical location of the homesteads and their fields that did not have irrigation water, sub-canal routes, possible abstraction points, or boundaries of the communities. Other data was sourced from Seamless Image Database (SID) files, topographic and orthophotographic maps. The data was analyzed using Geographical Information System (GIS) where the analysis was based on Microstation and ArcMap 9.0 software. The results were presented in map form and they indicate that a major part of the study area is Title Deed Land (private owned) except for Sihhoye, Mafucula and Tsambokhulu communities. In all the communities there are homesteads situated where it is possible to access water by the gravity flow method. The IYSIS canal traverses along the 300 meters contour line and in all communities there were possible abstraction points from the canal. Each conveyor route from the canal can be broken down into sub-routes as it crosses into the homesteads. Finally, a majority of the homesteads were located at distances less than five kilometers from possible abstraction points. From the findings in some communities it is possible to redistribute water saved through WDM in Swaziland using the simple gravity flow method, thus averting heavy construction and costs.

Keywords: Abstraction Point, Geographic Information Systems (GIS), Gravity Flow Method, Water Demand Management, Water Redistribution, Water Savings

INTRODUCTION

In most countries, water is a scarce resource due to various reasons, including population growth, land degradation, and recently climate change. Water scarcity induced by a decline in rainfall has led to decreased food production from rain fed agriculture. This has impelled nations to come up with solutions to the crisis, such as irrigation technology. In addition, it is imperative to note that in general, water as a resource is unevenly distributed in time and space. As a result, in many countries water supply is falling behind the demand for a growing population (Fakir, 2004). The fact that water is an essence of life, yet its scarcity is ever-increasing (Vidal and Comean, 2000), implies that there is a need to develop effective mechanisms of managing it.

Sustainable water resource management is also an important element of regional security and internal stability (Reed and de Wit, 2003). The conventional approaches to water management have been to construct reservoirs to increase the supply in order to meet demand. Given that water supply is diminishing and building reservoirs is an expensive option for most countries, there is a strong need to explore different water management strategies. Water Demand Management (WDM) is a management approach that aims to meet water demand at all times, as efficiently as possible.

WDM involves the application of selective, economic incentives, to promote efficient and equitable use of water, as well as, a number of water conservation measures aimed at raising awareness on the scarcity and finite nature of this resource (Fakir, 2004; Mwendera, Manyatsi, Magwenzi, & Dhlamini, 2002). WDM also embraces a wide range of measures leading to sustainable management. These among others are protection of water quality, reduction of waste, improved allocation of water among competing users, appropriate pricing mechanisms, and water conservation measures. Furthermore, WDM enhances equitable access to safe, more reliable and adequate quantities of water, thus it is a driving force to poverty eradication.

According to Fakir (2004) and Mwendera, Manyatsi, Magwenzi, and Dhlamini (2002), through WDM implementation in existing water services, water resources and the funds to bulk infrastructure (storage and transportation) can be reallocated for the provision of water services to areas currently lacking access to water (water 'have nots'). There is a possibility of supplying water 'have not' communities with water savings from the IYSIS canal through the gravity flow method. The canal belongs to Mhlume Water Company and is 65km long. It draws water from the Komati River and stores it in the Sand River Dam for both domestic and irrigation purposes. Areas irrigated include Tabankulu; Vuvulane irrigated farms; Mhlume Sugar Estate; and sugar associations around Tshaneni, Sihhoye, and Thunzini. The canal has a carrying capacity of 12.5m^3/s and its sides are not totally made of earth, but partly filled. It traverses around the 300m contour from its source at the Komati River to its mouth at the dam where it ends at the Tabankulu estate.

Sand River Dam was constructed in 1965 for mainly irrigation purposes under the IYSIS scheme. The reservoir is made of earth with a dam wall level of 1,478m and a height of 25m. The surface area covered at full supply level is 590 hectares and its capacity is 50x106m^3. Tshaneni, Mhlume, Tabankulu, and Vuvulane irrigated areas fully rely on water derived from the IYSIS canal and Sand River Dam for both irrigation and domestic purposes. In addition, communities within the study area rely on hand pump systems (boreholes) that are semi-functional for domestic water. Such systems were installed either by the Rural Water Supply Branch or Japanese International Corporation Agency in cooperation with the local government (Sukati, 2004). Unfortunately in these communities, the water is very salty, such that its use for consumption purposes is almost impossible and its usage for irrigation would trigger salinization. Therefore, water savings through WDM could solve the problem of water scarcity and salinity.

Objectives

The objectives of the study were to:

1. Identify and locate communities along the IYSIS canal and around the irrigated areas;
2. Map community boundaries, homesteads, fields, and open areas that can possibly be supplied by the canal through the gravity flow method; and
3. Establish possible water abstraction points and conveyor routes from the canal to the communities and open areas.

LITERATURE REVIEW

Re-Distributing Water to Surrounding Rural Communities

Swaziland's economy is agro-based. However, the agricultural productivity, among other factors is influenced by access and use of irrigation water. Agriculture is the consumer of fresh water resources, accounting for almost 97 percent of withdrawal in the country (Mwendera et al., 2002). Of this, 90 percent is used in growing sugarcane which is the main cash crop. The country is split between largely rain-fed subsistence production by smallholders, and cash cropping on large private estates. Small holders constitute about 70% of the population and occupy 75% of the crop land, but their productivity is low, accounting for only 11% of total agricultural output. Poor availability of water for irrigation is a major constraint to smallholder production, and in years of low rainfall, harvests plummet and further aggravate the food crisis (WaterWiki.net, 2009) There is mounting pressure for food self sufficiency. The incident of poverty is high, particularly in rural areas. There is a need to improve equity by making more water available to small scale farmers. In the water sector, the government's goal is to provide access, conserve, develop, and manage water resources in such a way that irrigation, domestic, and industrial needs are met in the most efficient and equitable manner.

The irrigation water systems in the rural parts of Swaziland have in most cases been designed for small scale sugar cane production organized under cooperatives. In these communities, irrigation water is directed only to the distant sugarcane fields, not to the homesteads. As a result, individual household plots around the homesteads cannot benefit from the irrigation water. Thus rain-fed crop production on individual household plots continues to fail due to drought.

Directing Water Saved Through WDM to Fields around Homes

A study by Peter, Simelane, and Matondo (2007), revealed that there was a very high demand for productive water uses in Vikizijula community, which is supplied by a single domestic water safe supply system. The majority of the households (89%) were demanding water for productive activities, such as growing vegetables (67%) and other crops, most of which was maize (18%). Among the factors indicated to limit the pursuance of other productive activities were insufficient water (67%) and restrictions on the use of the domestic water supplied (22%).

In Mangweni community, the study showed that there is a canal used for irrigating sugarcane. However, a majority of the households could not use the irrigation canal for any domestic purpose, because they were located far from it. Furthermore, the water was only pumped to the sugarcane fields without any provision for household domestic uses. The study further revealed that in rural communities without water supply schemes, a majority of those who relied on the river water source had to walk great distances to fetch water, only to collect small quantities (20-40 liters per day).

In communities like Mangweni where irrigation projects were not directed at the household level and to their fields around the homes, the household's productive needs were not met adequately. Sugar cane fields were operated on a cooperative basis located far from the homes. Households were still cultivating their individual fields around their homes, but could not benefit from the irrigation system. Thus, while Mangweni had an irrigation water project, it was not able to adequately address individual household demands for productive activities, in particular the much needed irrigation of their household plots near their homes where they were growing food crops such as maize, fruit trees, and vegetables (Peter, Simelane, & Matondo, 2007).

The Need for the Gravity Flow Method

According to Peter, Simelane, & Matondo (2007), some respondents complained of "illegal" pumping and use of water by individuals to irrigate maize. The illegal use of the cooperative's engine reduced profits since it contributed to high costs for electricity and maintenance, thus inability to pay service loans. Therefore, this study is advocating the distribution of water which is likely to be saved through WDM to poor rural communities for both consumptive and productive purposes. The anticipated productive activities are likely to be subsistence production of food crops, such as maize, vegetables and fruits for domestic consumption and a surplus, which may be sold. The most likely crop to be grown and irrigated, based on previous studies, is maize. Maize, although important for food and food security of households, does not yield high financial revenue to meet the increased water bill charges incurred during production. To reduce the cost of water, employing the gravity flow method seems to be the best alternative to electric pumps.

Furthermore, some respondents complained that their domestic water projects collapsed partly due to lack of strict control of "illegal" use of water for watering maize, fruits, and vegetables by some individuals. Tyler (2007) noted that lack of adequate water supply for human consumption was identified in the Millennium Development Goals (MDGs) as a key factor in the prevalence of poverty, and is a target for poverty reduction. Water also figures prominently in terms of social inequity. It is popularly claimed that historically the human experience of social inequality (and economic surplus) first arose with the development of irrigated agriculture (Tyler, 2007).

Tyler (2007) avers that poverty alleviation measures have to create opportunities, security, and empower the poor. Promoting opportunity for the poor means not only employment creation, but also access to inputs (or assets) such as credit, education, infrastructure, sanitation, and natural resources. Enhancing security means reducing the vulnerability of the poor to adversity by reducing risk or strengthening coping mechanisms. This includes risk related to climatic fluctuations, extreme weather events, as well as, illness or disability. Rights to predictable supplies of water, either for irrigation or domestic consumption, are important in reducing such risks. Empowerment means that the institutions of collective action and governance are accountable to the poor, and that accountability can be upheld by legal and political action. Empowerment also means increasing the responsiveness of public delivery of essential services and infrastructure to the needs of the poor. Swaziland in general and the study area in particular are located in a drought prone area. During drought periods (which has been the case for many years now), households are more exposed to food insecurity and poverty due to crop failure. Provision of water for both consumptive and productive activities at the household level will be very important in creating production opportunities for poor households. This will ensure a reduction in drought related risks stemming from unreliable rain fed agriculture, while on the other hand increasing the responsiveness of public delivery of essential services and infrastructure to the needs of the poor.

METHODOLOGY

The Study Area

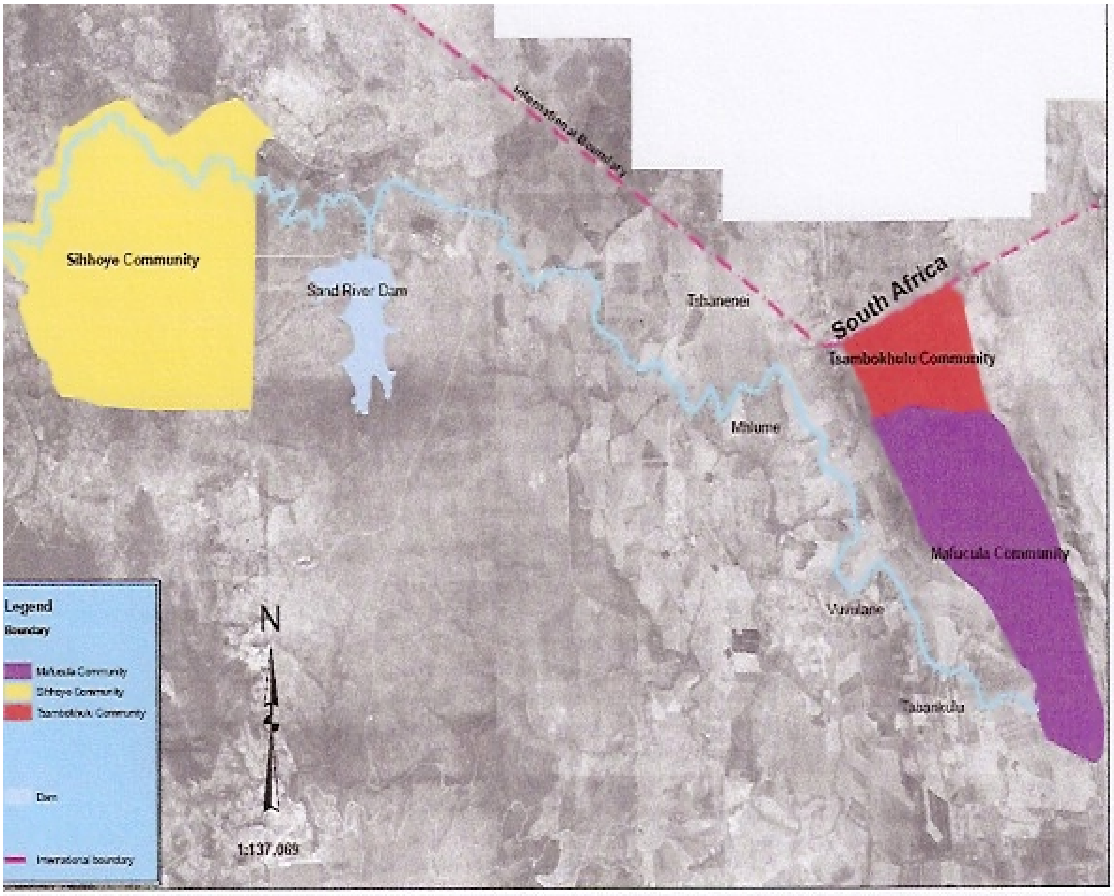
The study area is a stretch of land starting from the source of the IYSIS canal at the Komati River situated at Sihhoye area, all the way to the international boundary of Swaziland around the Mananga area and the Lubombo escarpment, down to the Maphiveni area. In-between these locations there are Tshaneni, Mhlume, Tabankulu, and Vuvulane irrigated farms that mainly practice commercial sugarcane farming. Sihhoye community is found on the north eastern margin of the country in the Hhohho region. It is bounded by the IYSIS canal on the western and northern sides, and on the eastern side by the regional boundary demarcating the Hhohho and Lubombo regions.

Sihhoye area is located between $25^0$56’S to $26^0$00’S and $31^0$34’E to $31^0$40’E. Next to Sihhoye community there is Sand River Dam which recharges the canal during low flows. The dam is located at $25^0$59’S and $31^0$42’E. Tshaneni area lies at $26^0$00’S and $31^0$45’E, Mhlume estates lies at $26^0$02’S and $31^0$49’E, and Vuvulane irrigated farms lies at 26^0 04’S and $31^0$52’E. Mananga can be found at $25^0$56’S and $31^0$45’E, and Maphiveni lies at $26^0$08’S and $31^0$59’E. These areas are shown below in Figure 1.

Methods

The study used spatial data. A Global Positioning System (GPS) was used to capture and update physical location of homesteads and their fields, possible abstraction points and canal routes, as well as, boundaries of the communities. Other data was sourced from Seamless Image Database (SID) files, topographic and orthophotographic maps. The data was analyzed using Geographical Information System (GIS) where the analysis was based on Microstation and ArcMap 9.0 software. The results were presented in map form, which indicate that a major part of the study area is Title Deed Land (private owned, thus not communal) except for Sihhoye, Mafucula and Tsambokhulu communities (Figure 1).

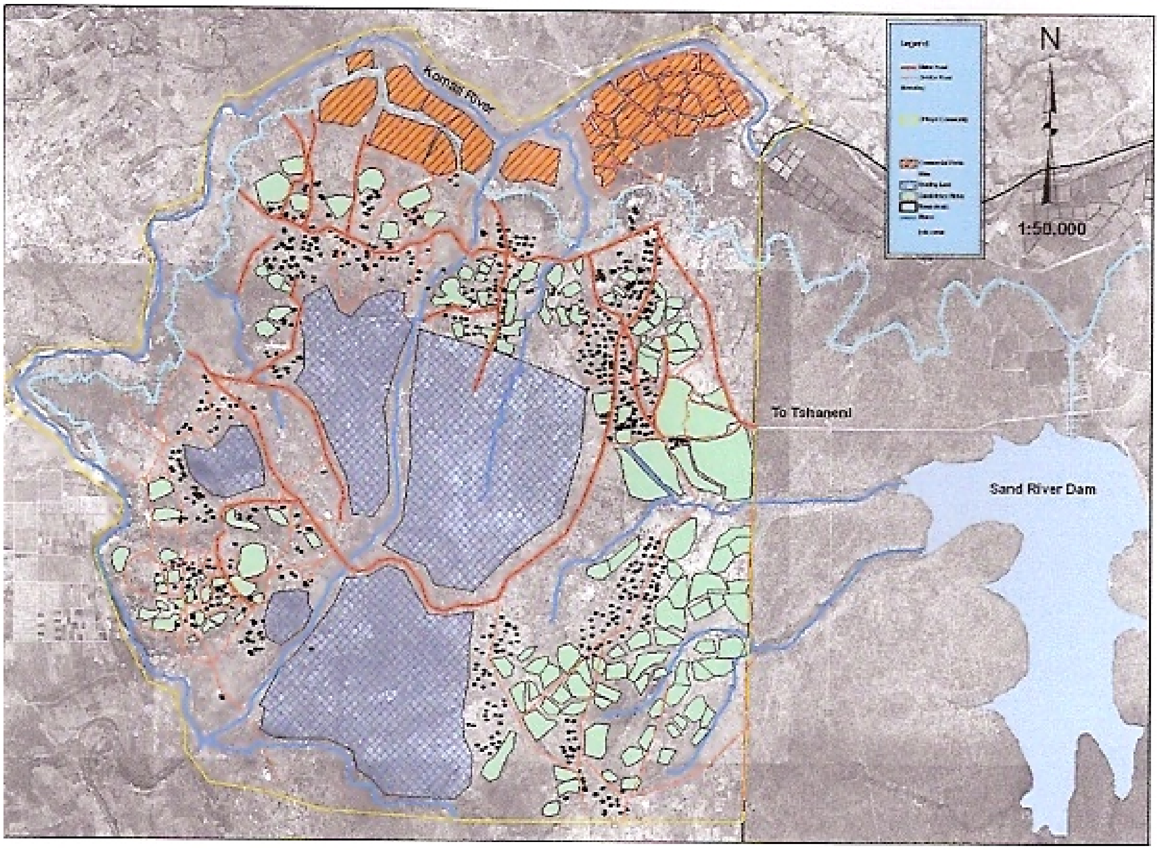
Figure 1: A Map of the Study Area Showing Sihhoye, Mafucula, and Tsambokhulu



Sources: Orthophoto maps (1999) and Field survey (2008)

After locating the communities, more details were mapped and formulated into shape files which recorded the land uses and infrastructure in these communities. More information sought included the homesteads, fields, open areas, grazing lands, the IYSIS canal route, rivers, and roads of the communities (Figures 2, 3, and 4). All three communities are still living primitively with hardly any technological advances due to poverty. The homesteads entirely depend on subsistence agriculture. Land owned was mainly for crop production which has since been abandoned by some homesteads as a result of unreliable rainfall. Therefore, the importance of irrigation cannot be over-emphasized to get land back to production.

Figure 2: Sihhoye Community; Main Land Uses and Infrastructure



Sources: Orthophoto maps (1999) and Field survey (2008)

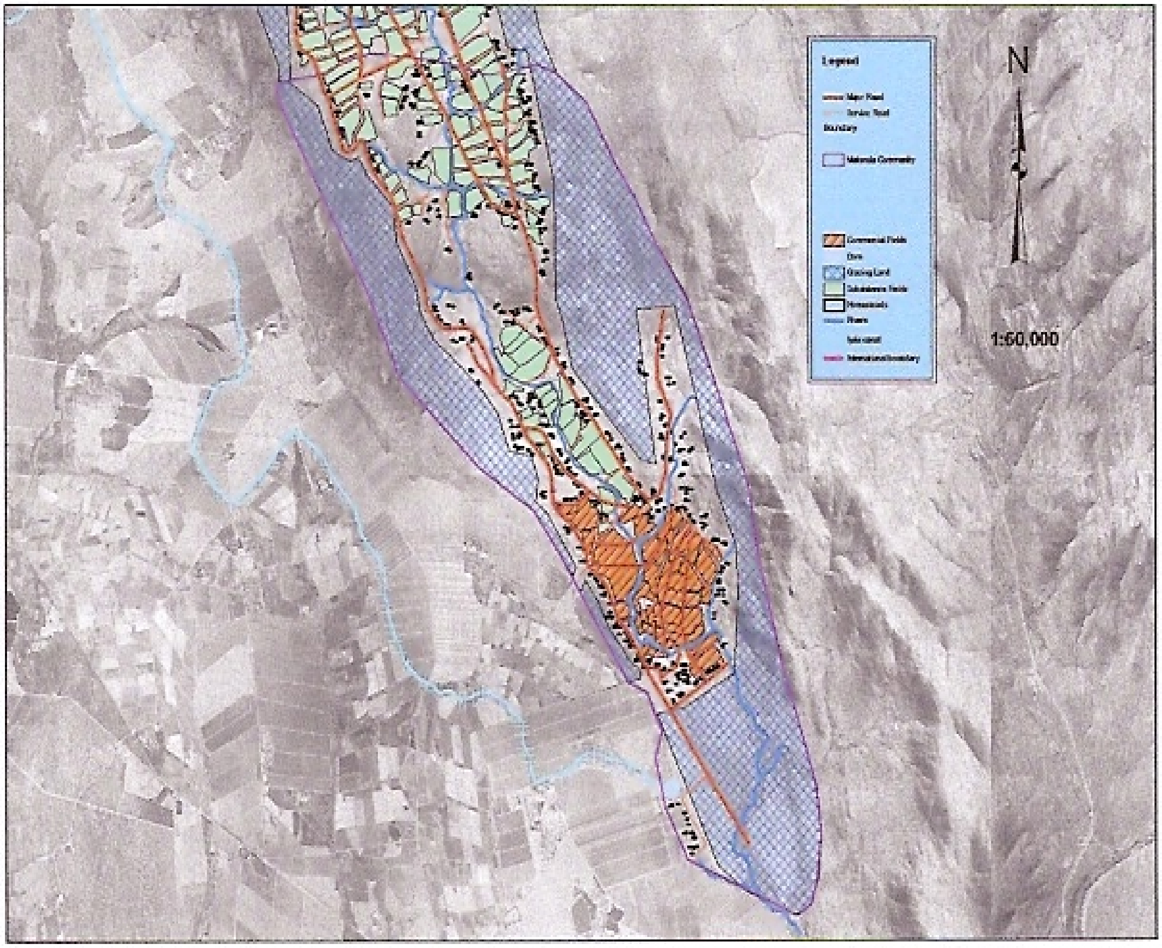
Sihhoye Community

This is the community where the source of the IYSIS canal is located. Sihhoye community is made up of 670 homesteads which are mainly clustered along roads and some around the ephemeral streams of the area (Figure 2, above).

Mafucula Community

This community is made up of 266 homesteads (Figure 3, below). The southern part of Mafucula community has been provided with water from the IYSIS canal for both domestic use and agriculturally, but strictly for irrigation of sugarcane. On the other hand, the northern part of the community depends on hand pump systems which were installed by the local government in cooperation with the Japanese International Corporation Agency.

Figure 3: Mafucula Community; Main Land Uses and Infrastructure



Sources: Orthophoto maps (1999) and Field survey (2007)

Tsambokhulu Community

Tsambokhulu community is made up of 128 homesteads (Figure 4, below). The sole source of water for this community is hand pump systems installed by the local government in cooperation with Japanese International Corporation Agency. The river draining the area is ephemeral.

Figure 4: Tsambokhulu Community; Main Land Uses and Infrastructure

Sources: Orthophoto maps (1999) and Field survey (2007)

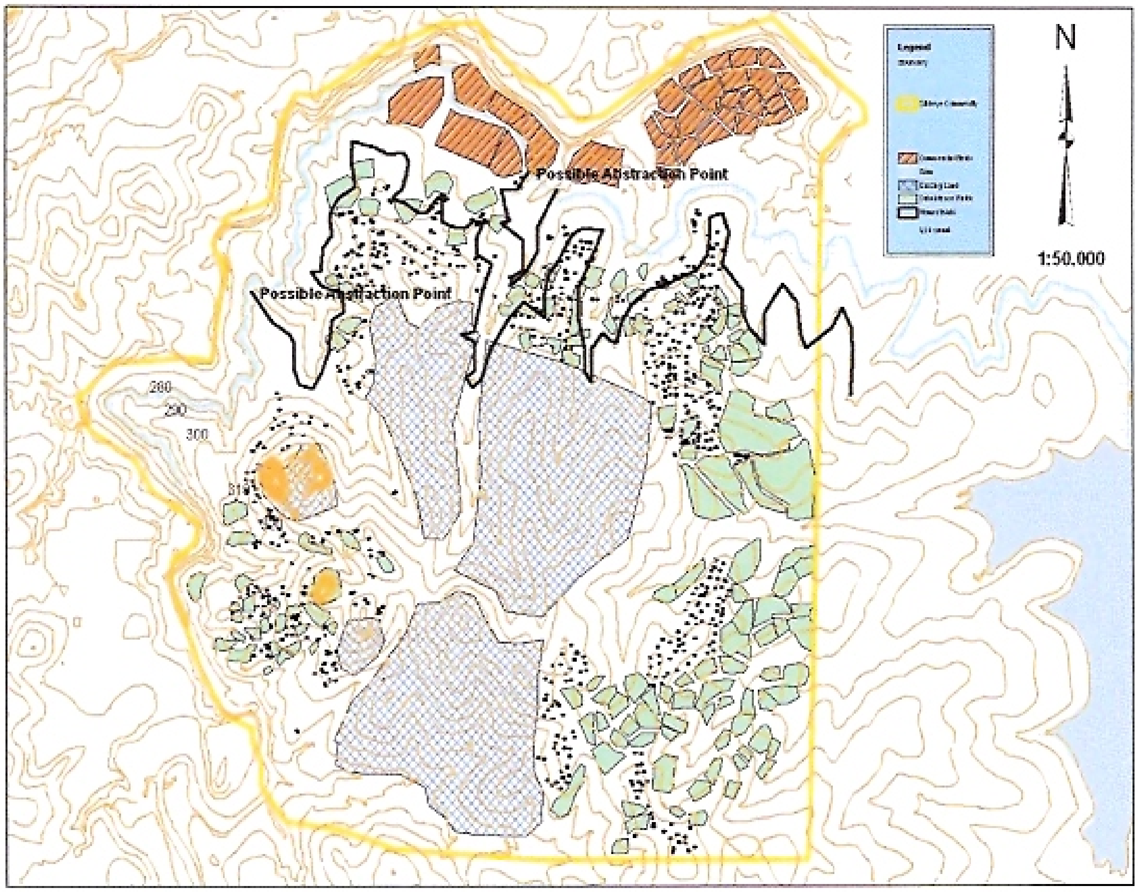
Possible Abstraction Points and Conveyor Routes to Communities

To establish possible abstraction points and water conveyor routes from the IYSIS canal to the community, contour shape files were overlaid on the community shape files. Then possible abstraction points and conveyor routes were mainly determined by looking at the contour system against homesteads, open areas, and most importantly, the canal route. Worth noting is the amount of water that can be diverted was not looked into, but the discussion attempts to highlight that there are communities that could benefit from possible water savings if WDM is implemented.

Sihhoye Community

Upon overlaying the contours on the land use map, it was noted that the canal traverses around the 300m contour at Sihhoye community. Therefore, homesteads that lie on and below the 300m altitude were considered as possible beneficiaries from the possible water savings through WDM along the IYSIS canal. At Sihhoye, two main possible abstraction points were determined from the canal to the community (Figure 5, below). Each possible conveyor route can further break down into sub-routes as it traverses the homesteads below the 300m contour.

Figure 5: Sihhoye Community; Overlay of Contours, Possible Abstraction Points and Conveyor Routes



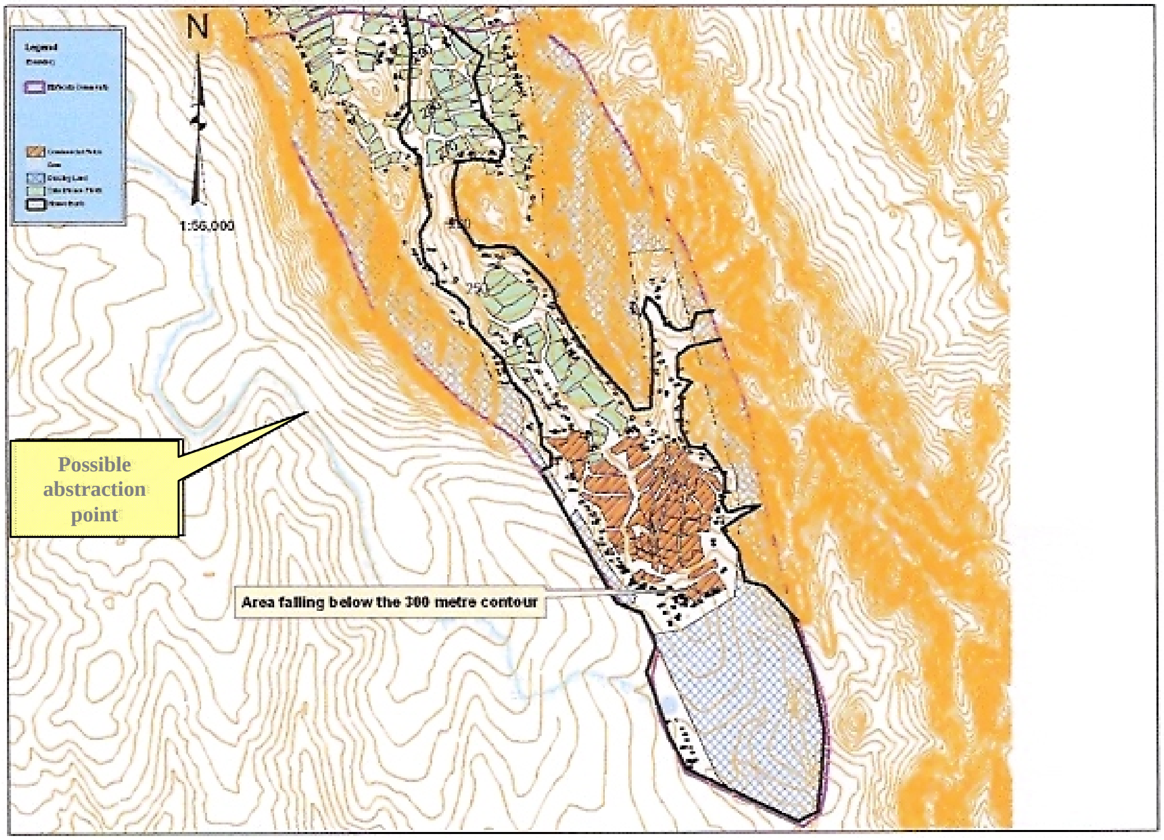
Sources: Orthophoto maps (1999) and Field survey (2007)

Moreover, considering that the source of the canal is at Sihhoye and that it also forms the western and northern boundary of the community, the average distance from the canal to the community is negligible. However, due to the terrain of the area, most homesteads of Sihhoye community fall above the 300m contour. For instance, 90 percent (603 of 670) of these homesteads lie above the 300m contour line, hence impossible to supply them with water through the gravity flow method. This means only 10 percent (67) of the homesteads can be provided with water by gravity flow method.

Mafucula Community

Upon overlaying the contours on the Mafucula community, the possible abstraction point and conveyor route were derived using the same method employed at Sihhoye. The 300m contour line also traverses through Mafucula community, a relatively flat community in terms of slope (Figure 6, below). Part of Mafucula has been supplied with irrigation water strictly for sugarcane irrigation through a small reservoir constructed at the end of the IYSIS canal. Implementation of WDM and redistribution of water savings will ensure that 75 percent (199 of 266) of the homesteads in the community are supplied with water.

Figure 6: Mafucula Community; Overlay of Contours, Possible Abstraction Points and Conveyor Routes



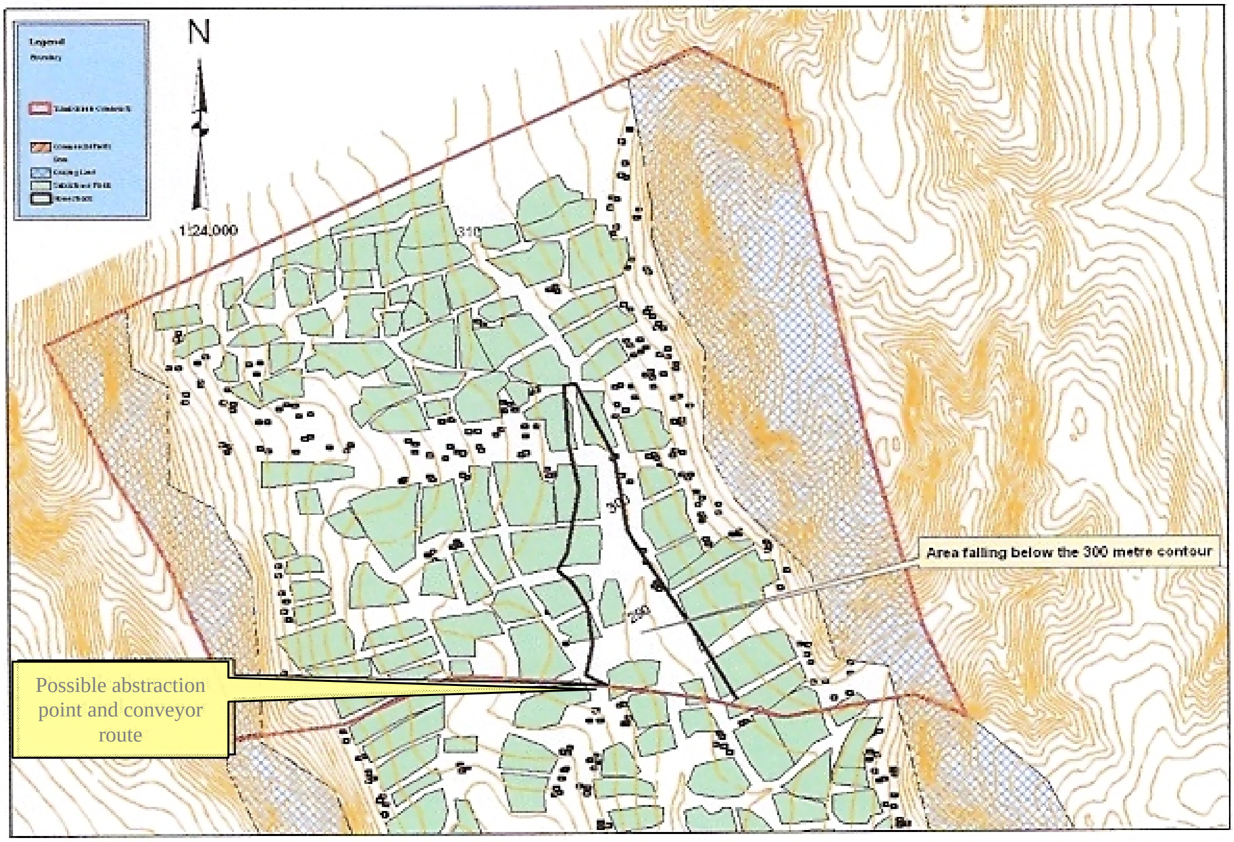
Sources: Orthophoto maps (1999) and Field survey (2007)

However, about 50 percent of the homesteads that cannot benefit from the canal through the gravity flow method along the 300m contour are within a negligible distance from the possible conveyor route so they could fetch water using vehicles or draught power. It is worth noting that the community of Mafucula has the most permitting topography for the application of the gravity flow method since the homesteads are located on the gentle undulating terrain.

Tsambokhulu Community

Tsambokhulu is the furthest community (9 km) from the IYSIS canal, but water could be drawn through gravity flow method from the route that will be coming from Mafucula. Of the 128 homesteads in Tsambokhulu, implementation of WDM can ensure that a meager 7 percent (9) of the homesteads benefit from the redistribution of water savings from the IYSIS canal by the simple gravity flow method (Figure 7, below). Most homesteads in the community are at the foot of the escarpment, with the center of the community used for cultivation. This is why the gravity flow method would have a minimal impact on this community for the provision of domestic water.

Figure 7: Tsambokhulu Community; Overlay of Contours, Possible Abstraction Points and Conveyor Routes



Sources: Orthophoto maps (1999) and Field survey (2007)

CONCLUSION

It is concluded that not all communities in Swaziland require heavy construction infrastructure and sophisticated technology to supply possible water savings ascertained through WDM. Therefore, some communities can benefit from implementation of WDM through redistributing water using the gravity flow method, especially where the topography permits. Hence, it can be safely concluded that implementation of WDM in Swaziland has a potential to relieve some communities' stress of water scarcity. With water available, communities could afford to advance and diversify their agricultural production, thus alleviating and eventually eradicating poverty.

RECOMMENDATIONS

This paper recommends that further studies should:

1. Consider other low cost technologies that could complement the gravity flow method, especially where terrain is a challenge,
2. Measure the distances from possible abstraction points to the communities, and
3. Consider determining the amount of water that can be diverted from the IYSIS canal and the quantity needed by each community.

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