SUSTAINABILITY OF IRRIGATION SCHEMES FOR SMALL-SCALE FARMERS: A CASE STUDY OF IRRIGATION SCHEME AT BULEYA MALIMA, GWEMBE VALLEY, ZAMBIA

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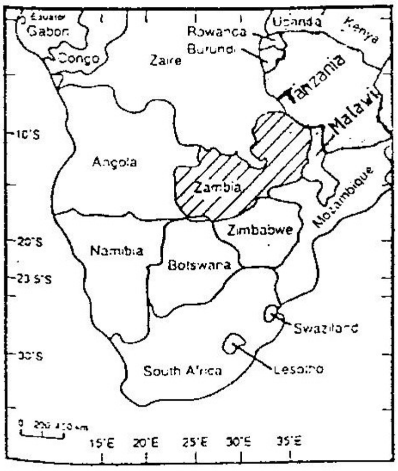
Abstract

A study to determine factors influencing sustainability of smallholder irrigation schemes was carried out at Buleya Malima, Southern Province, Zambia. These factors included technical and socio-economic factors. It was found out that the technical factors were 26.5, 64.5 and 9.2 percent for application efficiency, tailwater ratio and deep percolation, respectively, indicating that farmers wasted water mainly through tailwater runoff. From socio-economic point of view, the study indicated that the scheme lacked (i) farmer participation in designing and planning operation of the scheme (ii) managerial ability and innovativeness to form their own viable organisations and (iii) formal training in technical operations of irrigation, infrastructure and new agricultural practices. Due to these shortcomings, sustainability of irrigated agriculture at Buleya Malima could be hampered.

Introduction

Rainfall is erratic and low in many parts of Zambia. However, the Zambian government's policy on agriculture is to reduce food imports by developing irrigation schemes. This policy is based on smallholder irrigation schemes. The government in conjunction with donor agencies established a number of small-scale irrigation schemes throughout the country, with the hope that these communities would adopt the practices in the long run. These schemes were to use simple methods and required small capital investment[1].

Irrigated agriculture in Zambia has not recorded success. However, the government has continued to commission new irrigation schemes. The advent of Kariba dam in 1958 for hydro-electric power generation called for the creation of more irrigation schemes to resettle displaced people. This dam was built across Zambezi



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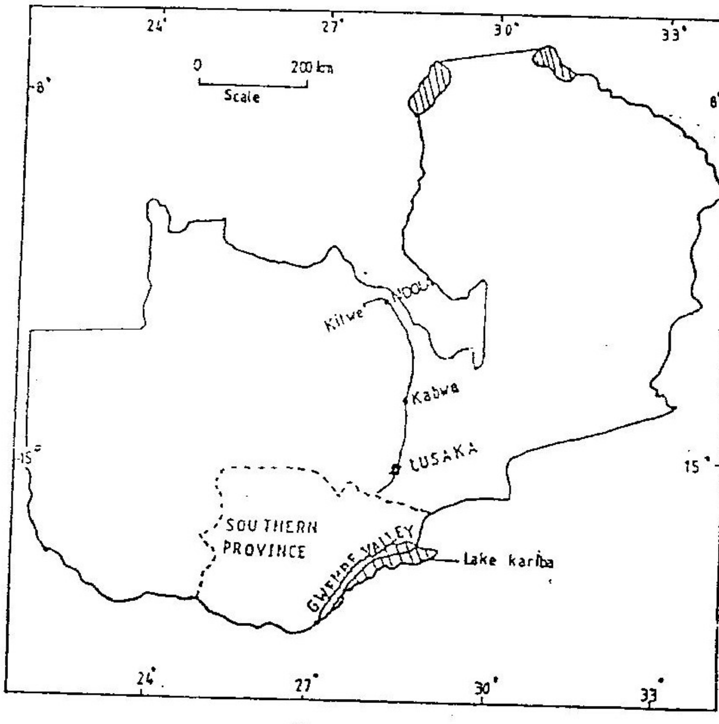

(b)

Fig. 1 (a) Position of Zambia in Southern Africa, and (b) Gwembe in Zambia

river between 1955-58 to generate electricity. It raised water level upstream thus flooding 536 400 ha of the Gwembe valley (Fig. 1), where 34 000 people lived [2,3]

. Consequently, the Zambian government with the help of donor agencies created irrigation schemes to settle people from the flooded area. These people were inexperienced in intensive farming systems of irrigation as they practised recession cultivation on the drawdown of the Zambezi river[1]. This made the adoption of irrigated agriculture difficult. Also, the established schemes were not efficient due to the inequity in distributing water within the scheme (poor water management). Farmers have never felt at home in their new settlements because these schemes were imposed on them.

Three schemes were established on the shores of the lake: Chiyabi, Siatwinda and Buleya Malima. These schemes have continued to run smoothly as long as there was government funding. The trend has been such that, once the government funds were removed on certan services (eg. free water services, subsidised agricultural inputs), the operations of these schemes were affected. This has been shown by the poor performance of these schemes after the government funding was removed [4]. Buleya Malima was selected for the study.

There has been no rigorous investigation on the part of the government to determine why smallholder schemes were not sustainable. A correct procedure of establishing new schemes (considering both technical and soci-economic aspects) has to be sort. There is also a need to take measures towards improving the performance of the existing schemes.

Vermillion[5] noted that it was easier to design and construct irrigation schemes than to operate and manage them, especially smallholder irrigation schemes. He observed that most small-scale irrigation schemes had not been successful due to poor farmer participation from planning stage, through design, construction, operation and maintenance. Even a well designed irrigation scheme would fail if farmer input was overlooked in the early stages.

Poor management has also been observed to be the main problem in managing smallholder irrigation schemes. Farmers have failed to manage water in these schemes due to lack of technical know-how. As a result the systems have been inefficient[6].

Evaluations of irrigation systems are therefore useful in helping farmers attain greater efficiency in irrigation. These evaluations would lead to better design criteria to suit the farmers' ability . Inefficiency in irrigation systems are common, particularly in developing countries. Cheong and Lim[7] found that farmers tended to apply more water per unit area than was needed, especially, if an abundant water supply was available. This led to several problems including reduced crop yields, increased operation costs, waterlogging and salinity.

In most cases technical problems coupled with the socio-economic problems (i.e. lack of farmer participation, lack of farmer training, poor organisational structure and management, and non-availability of agricultural inputs and credits) made it impossible for a small-scale farmer to achieve intended objectives. Hence, these problems undermined the chances of sustaining the scheme.

Consequently, the main objective of the study was to determine the technical, social, and economic factors influencing sustainability of small-scale irrigation at Buleya Malima irrigation scheme in Zambia. The specific objectives were: (i) to evaluate the scheme using technical and socio-economic parameters inherent in the scheme, (ii) to assess the current practices, and (ii) to make recommendations for improving the performance of the scheme and management practices.

Materials and Methods

Location and Description of Study Area

Buleya Malima irrigation scheme lies between 16° 51' and 17° S and 27° 42' and 27° 48' E in the Southern Province of Zambia (Fig. 2). It is situated in Mid-Gwembe valley , approximately 110 km upstream from Kariba dam. Its area is 103 km^2 in extent, bounded at its lower end by the shoreline of lake Kariba and by steeply rising hills of the Zambezi escarpment.

Climate

Zambia experiences long dry seasons (April to October) and short wet seasons (November to March). The rain season starts in mid November and ends in mid March. Total annual rainfall is about 677 mm.

July is the coldest month with temperatures falling to 10.8 °C, while October has the highest temperature reaching 35.2 °C. August-November coresponds to the period having the highest windspeed ranging from 3 to 5 km/h.

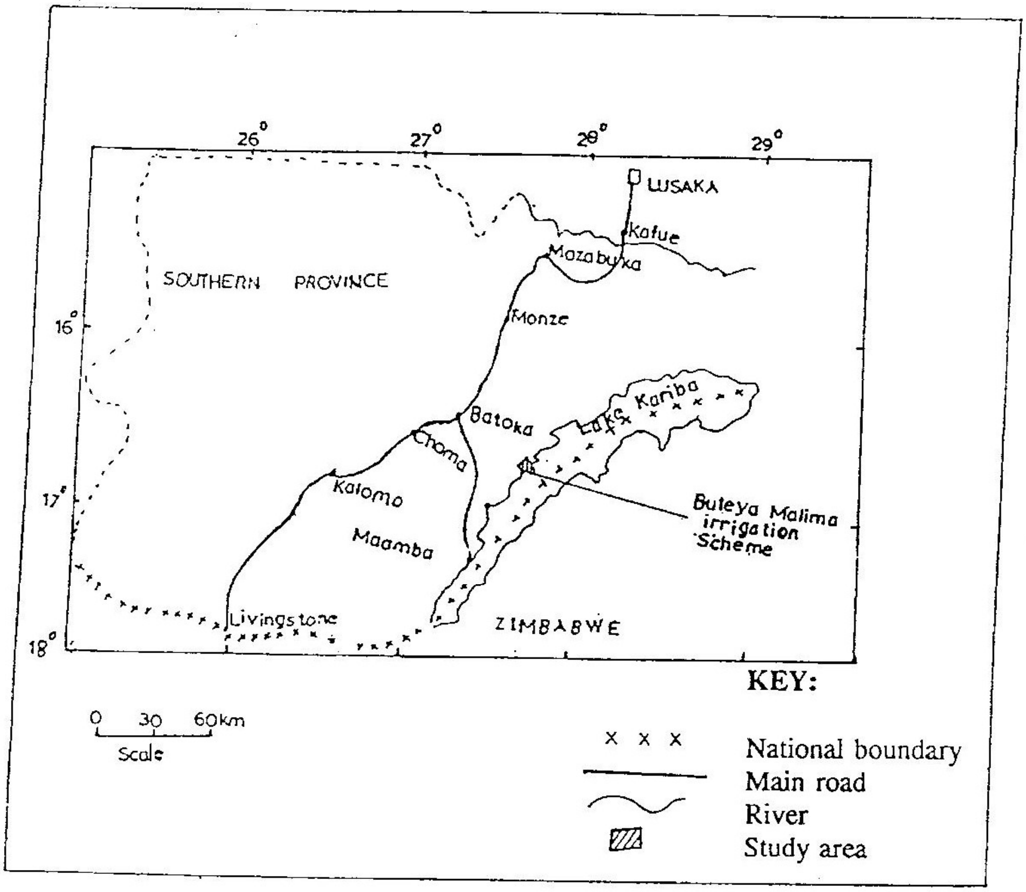

Fig. 2 Location of Buleya Malima irrigation scheme, Zambia.

Soils

Soils are nearly uniform being derived from colluvium deposits. Two types of soil occur in the area. The variations occurring between them are a result of the existence of calcareous layer at 150 cm over a limited area. The two soils have been described as 'Malima sandy loam' and 'Malima sandy loam' with calcareous substratum phase[8]. Malima sandy loam consists of deep, medium textured, well drained, and moderately permeable soil.

Land Use and Vegetation

Before the resettlement of people, Buleya Malima was sparsely populated. The available land use was based largely on ox-cultivation and considerable hecterages of land had been opened recently[9]. Sorghum was the most popular crop. Occasional crops such as finger millet, bulrush millet, maize and cotton were grown. However, maize was not very popular owing to the unreliable rainfall.

The area is free from tsetse fly and as such keeping cattle, goats and sheep was and is still a common practice. These animals are grazed communally by herding and kraaling overnight for protecting against wild animals[2].

The colluvial soils of Buleya Malima scheme support vegetation dominated by well-grown Cambretum imberbe and Sclerocary caffra. On the banks of the Nangombe river various acacias are found, notably Acacia albidia, and the winter thorn. On the irrigated land there used to be many young Acacia woodii[2].

Field Measurements

Data for assessing the sustainability of small-scale irrigation were measured or collected. Two types of data were collected: technical and socio-economic data.

Technical data

Water management problems which affect the efficient use of water were evaluated to determine the performance of furrow irrigation system using application efficiency, tailwater ratio, and deep percolation ratio.

Plots were randomly selected during the reconnassaince survey of the plots and furrows. Three representative furrow lines were selected; the middle one was taken as a test furrow while the outer two acted as buffers. Then the following measurements were made: (i) advance and recession, (ii) furrow discharge and runoff, (iii) soil moisture content, and furrow length and its cross-section. The standard measurements of these parameters as described by Merriem and Keller[10] were used in this study.

Socio-economic data

To minimise the magnitude of the limitation of questionnaire[11], the researchers employed a non-participant observer technique, unstructured interviews, and formal discussions with different key informants in the scheme. Following Boydy et al.[12], a sample (n) was chosen such that the sampling fraction (n/N) was at least equal or greater than 5 percent. Therefore, 20 farmers in the scheme were interviewed. These represented about 1/10 of the farmers having plots planted with maize in the growing season. These farmers were randomly selected.

Results and Discussion

Performance Indicators

The three performance indicators investigated in the study included: (i) application efficiency, (ii) tailwater ratio, and deep percolation ratio. Furthermore, the results of the questionaire, interviews and personal observations during the study on farmers' participation, education and extension, organisational structure and management, and agricultural inputs and credits are presented and discussed.

The average application (E_a) was very low (26.4 percent) compared to the recommended value of 75 percent for furrow irrigation [13]. This efficiency implied that nearly 70 percent of water applied was wasted from the field as tailwater runoff and/or deep percolation. It was observed that in many plots, furrow banks were not maintained leading to water movement across the ridges and contributing to more runoff. The measured steady stream size of 0.12 m^3/min seemed too large for the basic intake rate (0.00081 m^3/min) of the soils. This led to large quantities of water being lost as runoff, especially towards the end of each irrigation.

The overall mean of tailwater ratio (TWR) was 64.4 percent (Table 1) which was the main way of losing water in the plots. The low coefficient of variation (0.043) showed that the losses of water through tailwater runoff was uniform throught the scheme. The TWR of 64.4 percent was higher than the most widely recommended maximum limit of 20 percent for fallow irrigation[14]. This high tailwater loss could result into erosion of the fertile top soil in the long run. This was supported by complaints raised by the farmers that maize crop was not growing well without applying fertilizer. In some fields signs of land degradation were visible in the form of rills which could develop into gulleys if the situation was not controlled.

Table 1 Average performance for five sites.

Parameters	Mean	s.d	cv
Ea (%)	26.4	± 0.082	0.003
TWR (%)	64.4	± 2.6	0.043
DPR (%)	9.2	± 2.8	0.031

The estimated mean deep percolation ratio (DPR) of 9.2 percent (Table 1) was within the acceptable range of 0 to 25 percent. The low DPR could be contributed by surface crusting that was observed in furrows. This encouraged water to advance with less infiltration occuring.

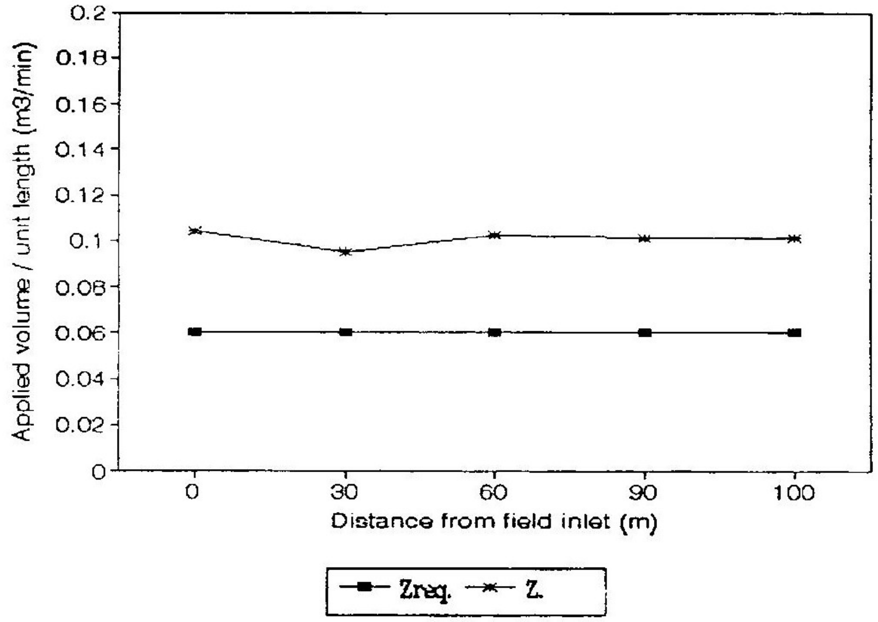

Fig. 3 Measured and required infiltrated depths along furrows

Fig. 3 shows the infiltrated depth of water at specific points along the furrow compared with the required depth of irrigation. It could be ascertained graphically that the farmers applied more water than required. However, under this situation, it seemed the deep percolation losses could not cause alarm because the ratio (9.2) was within the acceptable range. Therefore, the scheme could still be sustained at these levels of water losses by deep percolation.

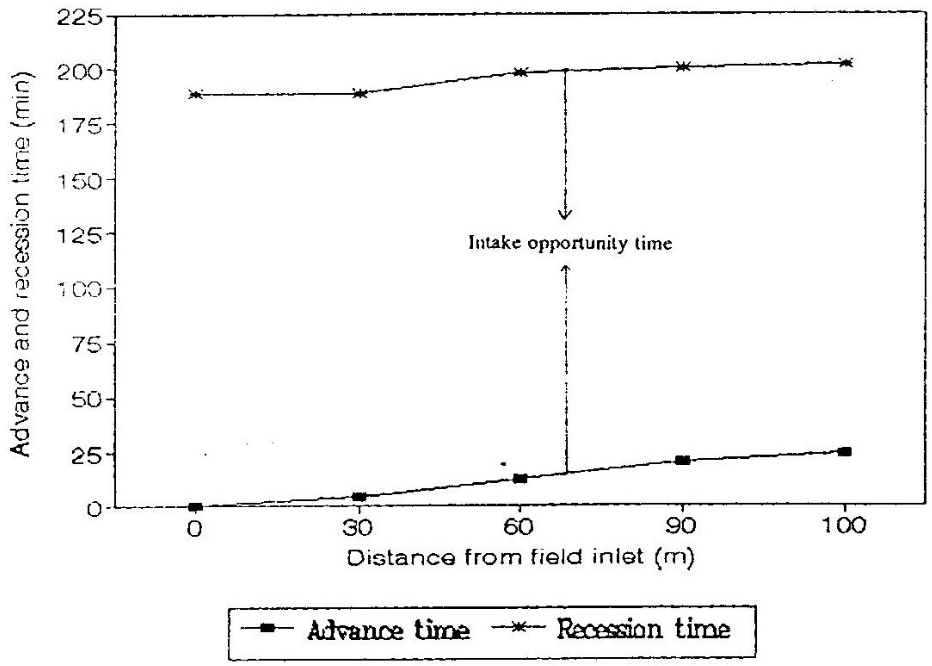

Fig. 4 Advance and recession and intake opportunity time.

Fig. 4 shows that the advance rate was slow in the furrows. This could be attributed to the low gradient (0.0075). Under such conditions one would have expected high deep percolation ratio, but this was not the case. The factors that seemed to have contributed to the high tailwater runoff would be the time of cutoff which was usually delayed (240 minutes) and also the large stream size into the furrows.

To reduce the high losses through tailwater runoff, several cutbacks during the irrigation were needed. This would reduce the amount of water lost and improve the application efficiency.

Participation of farmers in planning and decision-making

Ninety percent of the farmers interviewed indicated that the whole idea of establishing a scheme came from the government and the rest had the view that the idea was from both the farmers and the government. However, given the background of how Buleya Malima came into being (see introduction), one tends to believe what the majority had said. Therefore, in a nutshell it could be said that the scheme was organised by the government starting from feasibility study, securing funds, design, construction and also operating and maintaining the scheme. But this is no longer possible because of lack of funds.

Farmers' participation from the initial stages of the scheme is crucial in farmer-managed schemes. It is believed that this approach would have positive impact, as farmers would see the scheme as their property necessary to increase food security and income. Also, farmers need to be acquainted with the system's operation and maintenance if it is to run smoothly[16].

Design is usually conceived and implemented as a discrete task, rather than a gradual incremental process, and yet it sets long-term management parameters. Design carried out without the participation of the farmers usually presents a problem to them when the structures of irrigation are left under their responsibility. As a result they usually stop functioning quickly. To ensure their long-term utility there should be a collaboration between the engineers and the farmers so that alternative criteria and possibly operating norms, can be integrated into the design process[5].

Farmer participation in early stages of scheme development would assist in building farmers' capabilities and promoting a sense of self reliance and ownership. This would ensure sustainability of farmer-managed schemes[16]. Also, 65 percent of the farmers indicated that decisions were made by the scheme management (government officials). Usually where decisions are made by the majority of the farmers, the chances that such decision will be respected are high. In this regard, real commitment to the scheme activities by the majority of the farmers to meet the objectives they set is expected.

It has been further observed that participation of farmers in decision-making is promoted by the formation of farmers' associations. It is through these associations that farmers would participate in decision-making. To ensure the sustainability of schemes, these associations should be given most of the responsibilities regarding the affairs of the farmers. At Buleya Malima irrigation scheme, it was observed that farmers' associations were there just by name. They were not given the mandate and recognition they deserved by the management. This created a situation whereby those farmers who got frustrated by the way the scheme was being run, just moved out of the scheme on their own; because these associations could not assist them in any way. This undermined the sustainability of the scheme.

Extension Services to Farmers

Ninety percent of the interviewed farmers at least practised some of the agricultural technologies recommended by the extension workers. However, of the interviewed farmers, it became clear that the most popular activity was weeding (50 percent). The other activities such as proper fertilizer application, use of pesticides, and proper water application, were very unpopular as indicated by 10, 5, and 10 percent, respectively. This was mainly due to inadequate extension services coupled with lack of practical demonstrations. It seemed also that farmers mostly adopted those practices which appeared simple technologically such as timely planting and control of weeds. This created a situation whereby farmers' agricultural practices remained outdated. However, irrigation is a modern technology and as such to sustain it, modern agricultural practices are required[17] . Therefore, the failure to transfer modern agricultural practices by extension workers to the farmers would undermine the sustainability of irrigation schemes.

Agricultural Inputs and Credits

Twenty percent of interviewed farmers had access to inorganic fertilizers namely compound D and Urea while 35 percent of them had access to pesticides and 40 percent used improved seeds. A very small percentage of farmers interviewed (10 percent) had accesss to credit facilities. Farmers complained of high prices for fertilizers and pesticides. Others complained of non-availability of most agricultural inputs and credits at the time when they were needed. Agricultural inputs should be made available to the farmers at the right time, so that farmers have ample time to plan for their next irrigation season. The delay of these services tends to frustrate farmers, thus, again undermining the sustainability of the activities in the scheme.

Also, it was revealed that individual farmers had no access to credit facilities from commercial lending institutions (i.e. commercial banks). Furthermore, the security requirements by these banks were not easy to meet (eg. requirement of a title deed for the land). Apparently, farmers never owned individual lands. The Zambian government should be blamed for this since it has no clear policies regarding credit facilities in irrigation schemes. Most of the loans to farmers came from the management of the scheme which were usually too little to satisfy farmers' needs.

If farmers had access to lending institutions, they would be more self-reliant and be able to buy most of the agricultural inputs at the right time. But at Buleya Malima irrigation scheme, most farmers had problems of securing loans. This frustrated farmers making some decide to opt for non-intensive rainfed agriculture.

Conclusions and recommendations

Conclusions

The following conclusions were drawn from the study:

i. Loss of water through runoff was significant. This was shown by an overall tailwater runoff loss of 64.4 percent.
ii. The application efficiency was too low (26.4 percent). This was affected more by tailwater runoff (64.4 percent) than by deep percolation (9.2 percent).
iii. Farmers rarely participated in the initial stages of scheme design. This made it impossible for the farmers to operate and maintain the irrigation structures.
iv. Management of the scheme was a 'TOP-BOTTOM' rather than 'BOTTOM-UP' which did not encourage farmers' participation in decision-making, discussions and group activities in order to run the scheme smoothly and to use improved agricultural practices.
v. Availability of resources to support production; loans and other agro-support services were lacking. Thus, farmers were entirely relying on the government.

Recommendations

The following recommendations were made to improve sustainability of the scheme:

i. Water losses during irrigation should be reduced through instituting water charges, forming water users' associations, and installing water measuring and controlling structures in the scheme.

ii. Farmers should be given adequate training in all aspects related to proper operation and maintenance of irrigation system.

iii. Participation of farmers in decision-making from the project identification through, operation and maintenance of the scheme should be started to ensure sustainability of the project.

iv. Loans and other agro-support services should be made available to farmers at the right time.

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