An assessment of the multiple uses of small dams, water usage and productivity in the Limpopo Basin.

BY

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An Undergraduate Research Project Submitted in Partial Fulfilment of the Requirements of the Degree of Bachelor of Science Honours in Agricultural Engineering

May 2005

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Acknowledgements
First and foremost, I would like to express my sincere gratitude to my supervisor Dr Senzanje for the generous support and guidance he gave me throughout the year whist working on this research. I'm also grateful to Mr. S. Ncube, for the tolerance, encouragement and support during data collection in Filabusi. Appreciation is also expressed to my family, friends, colleagues and the university staff for informed constructive criticism and moral support whist working on this project.

Abstract

Zimbabwe has a long history of dam construction dating back to the 1920s. The dams range from small reservoirs to large dams used to supply water for urban mining and industrial areas and large-scale irrigation. Small reservoirs have been built in the former large-scale commercial farming areas and communal areas with the aim of improving the people's livelihood through their multiple uses. Despite the long history of small dam usage, there has not been a comprehensive study on the multiple uses focusing on the volume of water withdrawn and water use efficiency in a bid to establish their usefulness. This research therefore focuses at volume quantification on consumptive uses of the small dams and water productivity. However utilisation of the small dam is a function of how it is managed and the influence of various institutions and organisations related to the community.

Methods used to gather information included questionnaire survey on small dam users, interviews with various organisation and institutions, observation and secondary data. Small dams were found to be very important in the communities' well being as they are put to a number of uses, which are livestock watering, domestic use, irrigation, fishing, brickmaking, and collection of *Cypress spp.* reeds used for roofing. Livestock consumes the bulk of the water, the least being brickmaking. Water productivity as well as the economic value is generally the same per use when comparing with the dams, due to close location of the dams. On all dams, traditional leaders and the community are pivotal in management of the small dams. However, more interaction between various organisations and the community is called for as well as awareness on dam utilisation and catchment conservation.

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CHAPTER 1

Introduction

Ever since the 1920s, the government of Zimbabwe has directly and indirectly facilitated the construction of small dams (reservoirs), to date over ten thousand small dams have been constructed in communal areas and the then large-scale commercial farming areas (Senzanje and Chimbari, 2002; Sugunan, 1997). Small dams are water storage structures whose capacity is less than 1million m^3 with a maximum height above a cleared foundation level is 8m (Kabell, 1986). They impound the sporadic, partial and temporal precipitation from a given catchment, which is then used for various purposes.

Small dams are multipurpose structures, whose uses include, irrigation, livestock watering, brickmaking, domestic and recreation (Sugunan, 1997, Keller et al., undated). In view of the vast range of uses, small dams were developed to uplift people's living standards especially in communal areas where frequent dry spells are experienced, livelihood centred on agricultural production, there are high population figures and with least infrastructural development (Zirebwa and Twomlow, 1999).

However, management, ownership and location of small dams influence the number and types of uses on small dams. In the former large-scale commercial farming areas, the farmer was given water rights, which gave him/her the power to manage and use the small dams in a way he/she so pleases, in communal areas a different approach was used. Development Committees (VIDCO) and Ward Development Committees (WADCO) managed the small dams with the help from traditional leaders (Mohamed-Katerere and Chenje, 2002). With the passing of the 1998 Water Act and 1998 Traditional Leaders Act, all water is state water and local stakeholders have been given the mandate to plan, organise and control activities surrounding usage of small dams in their areas.

It is imperative to note that the capacity of most small dams is variable both within seasons and between seasons because of rainfall availability, evaporation, seepage and

siltation. Some cannot carry water from one season to another (Manzungu, 2002; Keller et al., undated). On the other hand the extent and scale at which each particular use is carried out depends on several factors which include, quantity and quality of the water, productivity, accessibility, distance to the dam, availability of alternative sources of water, and availability of, e.g., capital and labour and community's background (Dinar et al, 1995). Decision making in regarding management and utilisation of small reservoirs is therefore complex as it needs to take into cognisance all the above factors and that structures be put in place to consider all these in planning and development so as to realise benefits from the multiple uses derived from small dams.

1.1 Justification

Despite the wide coverage accorded large dams in reports and research, little information is available on small dams, they are thought to be less harmful and hence have received less attention. However, communities that host small dams have risks imposed on them and pay unwarranted and unacceptable costs of the benefits derivable from the small dams (Ogbeide et al, 2003). Therefore the need to study the relationship between small dams and their host communities is thus overdue and most relevant.

In the construction of small dams the capacity of the dam should be matched with the demand of the multiple uses. In most instances a trade off is made between the demands of some uses usually livestock and domestic, and factors which include topographical features of the catchment and available resources. This consequently has a bearing on the number of uses and volumes of water that can be withdrawn. Therefore there is a need to determine the amount of water that is utilised by each use and how it relates to the supply at any instant.

Small dams especially in the pre-independence era were built with little or no community participation (Zirebwa and Twomlow, 1999). This effectively means the multipurpose nature of small dams was taken for granted and no comprehensive studies were carried out to ascertain whether the reservoirs would meet the intended benefits. Moreover, a number of changes have taken place over the years which tends to distort the earlier

picture at construction, these include increase in population, increase in land degradation and the sub-division of former large scale commercial farms into A1 and A2 plots (where a greater percentage of small dams are concentrated). In light of the above, a review is therefore needed to establish whether small dams are meeting the communities' needs throughout the year by analysing volume and water use efficiency.

Of the water that is withdrawn, how efficiently is it used and what is the outcome? Two parameters can be useful in trying to answer the question, water productivity and economic value. Water productivity is the yield (output) of a particular use per unit volume of water used whilst economic value is the monetary value of the yield per unit volume of water used. These are an indication of water use efficiency and are useful in small dams development planning, but have not been studied in the context of small dams.

The usefulness of a property is to a large extent dependant on how it is governed or controlled. Apart from the community and traditional leadership, there are a number of organisations and institutions that are involved in the management and utilisation of small dams (Zirebwa and Twomlow, 1999). It is therefore important to establish the roles that these institutions are playing and their influence in the utilisation of small dams. This will then serve as a basis for stakeholder coordination and participation in developmental planning and conflict resolution and ultimately realising full benefits of the multiple uses of small dams.

This research was therefore aimed at investigating the multipurpose nature of small dams. It involved quantifying volume of water that goes towards the multiple uses, water productivity and its economic value for each use. The interrelationship between various organisations, institutions and the community in the management and utilisation of the dams was also investigated. Four small dams in the Limpopo River Basin, Insiza District, Godhlwayo communal area were chosen for the study.

1.2 Objectives

In order to find the answers to the problems raised above regarding the multipurpose nature of small dams (reservoirs) in communal areas of Zimbabwe, the following objectives were put forward.

1.2.1 Main objective

- To assess the various uses of small dams, water usage and its productivity.

1.2.2 Specific objectives

- To determine the range of uses of the small dams and the extent to which they are carried out.
- To quantify the volume of water utilised consumptive uses and determine the water productivity for some uses.
- To evaluate the economic value of water for some uses.
- To establish the linkages between institutions and organisations involved in the utilisation and management of the dam.

1.3 Hypothesis

The following hypothesis is posed for the main objective of the study; small dams are multipurpose structures whose uses have varying water demand and productivity.

Hypotheses for some specific objectives are as follows:

- Small dams have similar uses.
- There is a significant difference in volumes of water used by various uses of small dams.

CHAPTER 2

Literature Review

2.1 Background and Development

Zimbabwe is a semi-arid country with a unimodal rainfall season, which generally runs from mid November to early April averaging 650mm per annum (Senzanje and Chimbari, 2002). Protracted dry spells disrupt the rainy season especially in the southern parts of the country with serious repercussions on the river network system, as most rivers are not perennial and consequently agricultural production. Moyo (1995) noted before the 2000 Land reform, an estimated 90% of the rural population lived low rainfall areas. These areas were largely overgrazed with mostly infertile sandy to sandy-loam soils creating conditions unfavourable for agricultural production, the backbone of livelihood security (Zvarevashe and Ellis-Jones, 2000).

It is against this backdrop that an extensive network of dams has been constructed throughout the country dating back to the 1920s (Senzanje and Chimbari, 2002). These range from small reservoirs to large dams supplying water to urban, industrial and mining areas and large-scale irrigation. Small dams were mainly developed in the former large-scale commercial farms and communal areas constituting 61 % and 39 % respectively of the total number of small dams. In relation to regional countries, 86 % of the small reservoirs in Southern Africa (excluding South Africa) are found in Zimbabwe, which constitutes only 6.8 % of the geographical area in the region (Sugunan, 1997). The bulk of the dams were built after the devastating drought of 1982 to 1984.

Small dams are an essential part of developmental activities as they can serve multiple uses, which include smallholder irrigation, livestock watering, domestic use, recreation and brickmaking (Keller et al., undated; Sugunan, 1997). Apart from being operationally efficient, i.e., most are located close to the point of use and abstraction of water relatively cheap and easy, small dams can also increase biodiversity providing a sanctuary for

wildlife and birds (Zvarevashe and Ellis-Jones, 2000). Small dams also have been found to respond rapidly to precipitation runoff thereby harnessing the sporadic, spatial and temporal rainfall found in their catchments (Keller et al., undated). Given the above advantages, small dams were seen as a viable option for communal areas development.

2.2 Technical Aspects of small dams

A small dam is an excavated water storage structures whose capacity is less than one million cubic metres and whose height above a cleared foundation level is below eight metres. Dams in Zimbabwe are classified as small, medium, and large or major on consideration of maximum height above cleared foundation level and gross capacity (Kabell, 1986) as shown in table 2.1 below.

Table 2.1: Classification of dams in Zimbabwe

Size	**Capacity (x$10^6 m^3$)**	**Height (m)**
Small	Below 1	Below 8
Medium	1-3	8-15
Large	3-20	15-30
Major	Above 20	Above 30

Source: Kabell, 1986.

The financial benefits from the cultivation of land and proceeds from other uses are rarely enough to allow for expensive, technologically advanced concrete structures to be built to impound water, whether on- or of-stream, and in most communal areas the alternative is normally a small earth dam (Stephens, 1991), these are built with locally available material and the bulk of the labour coming from the community. This is why most small dams in Zimbabwe have earth embankments.

The actual storage capacity of such a reservoir must ideally take into consideration the following factors, demand of water for the environment, consumptive multiple uses, e.g., livestock watering, irrigation, domestic use, and brickmaking. Losses due to evaporation and seepage need to be taken into account as well as dead storage for the small reservoir to be viable. However in most instances uncontrollable features like the topographical

conditions at the dam site and catchment size set the dam capacity (Nelson, 1985). This is however seen as unfortunate and having a huge impact on the dams' ability to satisfy the intended uses within a particular community. Consequently, this then calls for the need to quantify volume of water that goes towards the multiple uses to see how it matches with supply through out the year. Another worrying factor considered in the construction highlighted by HR Wallingford (2004) is the usage of the ratio of the volume of stored water to the earthwork required to justify constructing a dam (in economic terms) depends on the value of stored water compared to the dam construction costs. The ratio should be above 8, if it is below 5 the dam should be rejected. The above gives an indication that the capacity of the dam depends on the budget allocation not necessarily driven by the multiple uses.

In assessing the multiple uses of small dams, there are some uses which are more of technical benefits rather than socio-economic hence becoming obscured in the view of an ordinary person. One such use that has gone unnoticed is the ability of small dams to act as silt traps for large dams downstream. This function has been compromised as more catchments are opened up to agricultural activities (Senzanje and Chimbari, 2002). However, this function causes a reduction in capacity due to sediment build up thereby impacting on the small dams' ability to serve the multiple uses. Recharging of aquifers is another use, small reservoirs in some countries, e.g., India are referred to as 'percolation tanks', they lose water through seepage which will then find its way to ground water reservoirs (Keller et al., undated). Small dams can also provide control against floods as the floodwater escaping downstream is moderated so as to be compatible with the flood carrying capacity of the river channel downstream (Nelson, 1985).

Weirs are another version of small dams; they are much smaller in size (height 2-6m), smaller catchment size and are made of concrete. They usually work as diversion structures i.e. to raise water level in a river to a height were gravity flow for water supply or for irrigation and can be utilised for livestock (Stephens, 1991). In cases when built across rivers, they are doubled up as crossing points and also work as silt traps for small dams.

Physical problems that can arise from small dams are in two forms; structural and non-structural defects (Sharma and Sharma, 2002; Stephens, 1991) Structural defects are associated with poor design and construction, e.g., slumping and sliding of the downstream face, partial slope failure, foundation slope movements, eroded spillway and wave action. Non-structural defects result in the dam not meeting its capabilities and usually this leads to a reduction in available water storage, e.g., dam basin fails to fill up (may be too large for the catchment) or dam silts up which is usually a long-term problem. In all these defects, volume of water is decreased leading to the dam not satisfying the intended multiple uses.

Water quality can determine success or failure of use of a small dam. Water may be of limited usefulness as it may be fit for irrigation or stock purposes but not for human consumption. Very saline water used for an irrigation scheme needs to be applied in greater volumes to ensure adequate leaching (Nelson, 1985). Given the above complexities on the technical side of small dams, one way to evaluate the usefulness of small dams is by taking an audit of the volume of water that goes towards the multiple uses.

2.3 Environmental Aspects of small dams

It is imperative to note that water is essential to maintaining the function of ecosystems and associated flora and fauna, which humans depend on directly and indirectly (Ellis-Jones et al, 1999). Small dams are water bodies and therefore exhibit this feature. They can improve biodiversity providing a sanctuary for wildlife and birds. This is the reason why in the Water Act of 1998 recognises the environment as a user of water (ZINWA, 2002). Rosegrant et al. (2002) also pointed that the environment demands water for ecosystem sustenance and for regulating pollution.

Sharma and Sharma (2002) further emphasises the need to understand the interrelationship between the water reservoir and natural ecosystems of the region with a

view not only to preserve the existing environments but also to further improve its quality. Long-term use of small dams has clearly proved that in a variety of climatic zones, the reservoirs form the basis of stable ecosystems matched with natural environment. Despite this knowledge of importance of water to the environment, there is no specific amount of water needed, Rosegrant et al. (2002) only mentions that water should not fall below a certain threshold.

Soil loss due to erosion of croplands in communal areas can be as high as 43t/ha per annum (WRMS, undated). Most of the soil finds its way to the small dams. HR Wallingford (2004) gives estimates of the loss of storage in large dams due to sedimentation ranging between 0,5% and 1% per annum. It has been found that annual siltation rates increase as the dams become smaller. This is attributed to "sediment delivery" effects, which usually result in increasing catchment sediment yields per km^2 as catchment areas become smaller. Small dams usually have smaller ratios of storage capacity to annual inflow than larger dams; this also has a major impact on siltation rates. A decrease in storage volume therefore means less water available for the multiple uses.

Small dams are more susceptible to degradation by pollution than large dams and many have lost their environmental and socio-economic benefits as a result of unsustainable development around them. They have reduced capacity to flush pollution from estuary (Sharma and Sharma, 2002; Dinar et al, 1995). Agricultural run-off may carry sediment, salts, nutrients, organic loads, pesticides and pathogens to the receiving reservoir. In effect the multiple uses of small dams is threatened by this change in water quality.

Negative impacts of small dams also include their being a source of water borne diseases such as malaria, bilharzia (schistosomiasis), cholera, dysentery and diarrhoea (Chavula, 2000). In a bid to lessen the health hazards associated with small dams the government through the ministry of Health used to undertake regular molluscicide and larviciding (to control malaria) and has also carried out awareness campaigns in water and sanitation (Senzanje and Chimbari, 2002). On the contrary, according to a study on small dams

constructed recently in Zimbabwe, Grosse (1993) dismisses the claims that small dams increased schistosomiasis prevalence.

2.4 Socio-economic aspects

In the Water Act of 1998, water use is classified as either primary or commercial. Primary is the reasonable use of water for sustenance of life i.e. for basic household needs not exceeding 5000m^3 and no permit is necessary. Any other use is commercial (ZINWA, 2002). However, Lumbroso (2003) distinguished water use into three types, withdrawals or abstractions, consumptive use and non-consumptive use. Withdrawal refers to water that is taken from the dam and after use returned, e.g., water used for cooling in industrial processes. Consumptive use starts with withdrawal but without any returns, it is no longer available because it has been transpired, evaporated, incorporated into products or consumed by living species. Non-consumptive use refers to in situ use of a water body e.g. recreation, fishery or effluent disposal. In all the definitions given above, small dams exhibit these in the form of small holder irrigation, fish farming, brick making and domestic water purposes, livestock watering, drainage sumps, ground water recharge, flood protection and conservation storage (Stephens, 1991; Ellis-Jones, 1999).

To highlight the importance of the social aspect of the small dams, Ellis-Jones et al. (1999) defined the social catchment as the area from which the different user groups as regards to the small dam multiple uses are drawn and who utilize the resource within the geographical area of the catchment. Two main user groups are identified, regular users who use the resource continuously on a daily, weekly or monthly basis. Seasonal users on the other hand tended to use the resource at key periods during the year or for emergency use, e.g., in drought conditions. In the classification of user groups the category was influenced by distance from the small dam, importance in life, accessibility and time of the year best suited for the activity.

In as much as small dams having a social bearing on communities' activities, they are important economically. Zvarevashe and Ellis-Jones (2000) described the capability of a small dam to be a productive water point, which is simply a water point that provides

water surplus to domestic needs that can be used for economically productive purposes. It can form part of a strategy to alleviate poverty and improve quality of life for communities. In light of this, when carefully exploited, the multiple uses can go a long way in uplifting people's livelihood especially in rural areas for instance, according to a study done in Mauritania, small dams helped to reverse the rural exodus: twenty years after the new strategy on small dams was launched 200,000 people lived in the small dams area, compared to only 50,000 in 1981 (Coulibaly, 2000).

Most small dams in communal areas were primarily developed for domestic and livestock watering (Senzanje and Chimbari, 2002). Livestock was prioritised as for instance cattle provide inputs in the form of draught power for ploughing and transport, manure, milk, meat, rituals and is viewed as a symbol of wealth. Donkeys provide draught power, whilst small stock like goats and sheep are most important in local economy through mobilizing cash for school fees and other expenditures and provision of meat (Cousins, 1989).

Irrigation of small private gardens and community gardens is one other important benefit derived from utilization of small dams. Socio-economic status of communities has improved as a result of selling of the produce. The nutritional status has also improved due to the availability of vegetables and fruits throughout the year (Ogbeide et al, 2003). Some non-governmental organisations have developed some gardens targeting HIV/AIDS affected people, orphans and under privileged members of the society. Small dams are also used for domestic uses, which include washing, bathing, cleaning and cooking (Lumbroso, 2003).

Fishing is another major benefit of small dams. Marmulla (2003) compared yield on a per unit area basis of amount of fish harvested in well managed small, medium and large reservoirs in Africa being 329; 80-90 and 27-65 kg/ha/year respectively. This has been attributed to smaller impoundments having greater surface area to volume ratio than larger impoundments. In effect, small dams have a great potential to be a lucrative source of protein from fish and money in communal areas.

Small dams are also a source of recreational activities these include swimming, boating, quiet contemplation and for some a refuge from stress. However, the above use has been viewed as of little relevance in most rural set ups (Dinar et al, 1995; Young, 1996). In Nepal, small dams have been considered as one of the most promising source of power as they have been developed and tested as low cost small hydro power stations since the mid 1970s (Sharma, 2003).

2.4.1 Water Use Efficiency

Water use efficiency can be measured using two performance indicators, water productivity and water economic value. Water productivity is defined in a number of ways and most refer to crop water productivity but can be applied to other water uses. Molden et al. (2003) defined water productivity as the amount of crop yield per unit volume of water used. Rosegrant et al. (2002) noted that water productivity varies from region to region and field to field depending on many factors such as crop and climate pattern, irrigation technology and field water management, land, infrastructure and inputs. Water productivity is a measure of how efficiently water is used and can be used in assessing the marginal value of for instance marginal value of supplementary irrigation (Lumbroso, 2003). Sander et al. (undated) used the same definition to evaluate livestock water productivity and expressed it as water depleted or diverted by livestock and for producing livestock products.

Whilst water productivity gives water efficiency in terms of yield, economic value of water indicates water use in terms of financial benefits of the input, which is mainly a function of marketing structure and field and water management (Lumbroso, 2003). It varies from place to place. Knowledge of the two performance indicators is useful for development planning in communal areas in the view of small dams utilisation where livelihood is dependent on agricultural production.

2.5 Management and Institutional Analysis

Chavula (200) defines water resources management as a people's control over water as it passes through its natural cycle, with balanced attention to maximizing economic, social and environmental benefits. This process entails the implementation of seven related activities namely assessment, planning, development, allocation, conservation, protection and monitoring. This definition can as well be applied to small dams management but a question is posed, how are they managed and what are the roles of the various stakeholder? Answering this question will go a long way in assisting communities in developing catchment management plans (Zirebwa and Twomlow, 1999), conflict resolution, institutional coordination (WRMS, undated) and ultimately realisation of the full benefits of the multiple uses of small dams. Zvarevashe and Ellis-Jones (2000) called for institution and social strengthening, as it is a vital ingredient to the long-term well being of rural communities in project development.

The passing of the 1998 Traditional Leaders Act has seen traditional leaders chiefs, headmen, and village heads functions and roles being defined and amongst them, protection of public property and to ensure compliance with natural resources management laws (Mohamed-Katerere and Chenje, 2002). Committees at village and ward levels headed by the traditional leadership will play the pivotal role in the management of the small dams. However, since customs vary from one area to the other, it should be noted rules emanating from different communities might also vary.

The government of Zimbabwe through various ministries has created various departments to work with communities at different capacities. Zimbabwe National Water Authority (ZINWA) has been given the mandate by the government through its parent ministry to oversee development and use of all water in Zimbabwe (Manzungu, 2002). In this regard, Zimbabwe has been divided onto seven catchment based on the major river systems (ZINWA, 2002). A catchment council is in charge of water affairs in its respective catchment and it consists of elected representatives of the various water users within the catchment. Its main functions include regulation and supervision of water use, conflict resolution amongst users and granting permits for water use. Catchments have

also been divided into sub-catchments having their respective councils. The councils report to the catchment councils, their duties include participation in catchment planning and protection, monitor water flows and use in accordance with allocation and collect levies.

Rural District Councils are mandated to provide, conserve and control water resources at district level. They also establish district development committees at village and ward level in the form of village development committees, ward development committees and neibourhood development committees (Mahomed-Katerere and Chenje, 2002). Other government departments such the Agricultural Research and Extension Services (AREX), District Development Fund, Department of Natural Resources, veterinary and health are available at ward level also have an influence in dam management but are mainly focused on their respective services in the community. There has also been an influx of NGOs in the water sector in particular small dams. Their support is in form of finance and technical expertise (Ellis-Jones, 1999).

It can therefore be seen that there are a number of organisations involved in the management and utilisation of the small dams. These operate at different levels and capacities and at times targeting specific uses of the small dams thus the need for assessment of the roles played and problems faced in faced in their operations.

Small dams utilisation has thus been found to a function of technical, environmental, socio-economic and management aspects. The above-mentioned aspects in one way or another tend to have a bearing positive or negative on volume of water abstracted by each consumptive use. Therefore a study of the multiple uses with these factors in mind will go a long way in making sure that the small dams serve as many people as possible in a bid to improve people's way of living.

CHAPTER 3

Methodology

3.1 Introduction

The research was undertaken in the Limpopo River Basin on four dams. Data was collected by use of questionnaires, interviews, observation and use of secondary data. The investigation was aimed at identifying the multiple uses of small dams; quantifying the volume of water used by the various uses, determining the water productivity of the various uses, and establishing the interrelationship of the community, institutions and organisations and the role they play in the management of the small dams.

3.2 Study Area

Four dams were selected for the investigation. All of them are located in the Mzingwane catchment, Insiza District, Godhlwayo communal area. These are, Avoca, Dewa, and Denje in Ward 12, Makoshe is in Ward 6. The area is in Agro-ecological region IV characterised by annual rainfall of 450-650mm, which is erratic, and frequent dry spells are experienced. Population of Avoca (Ward 12) where 3 dams Dewa, Denje and Avoca are located is 3175 and number of households being 597. Makoshe small dam is located in Ward 6 with 684 households and a population of 4005 (CSO, 2002). Main livelihood activities are livestock production and rain fed crop production. It is against this backdrop that over 856 small reservoirs (Sugunan, 1997) have been built in Insiza District to complement the low rainfall received and improve people's livelihood.

Limpopo River Basin stretches over four countries, Zimbabwe, Botswana, South Africa and Mozambique. Figure 3.1 below shows the map for the Limpopo Basin.

Figure 3.1 Map of Limpopo River Basin.

Zimbabwe is divided into seven catchments based on seven major river systems. Mzingwane catchment is shown below in figure 3.2. Avoca, the study area is approximately in the middle of Filabusi and Mataga.

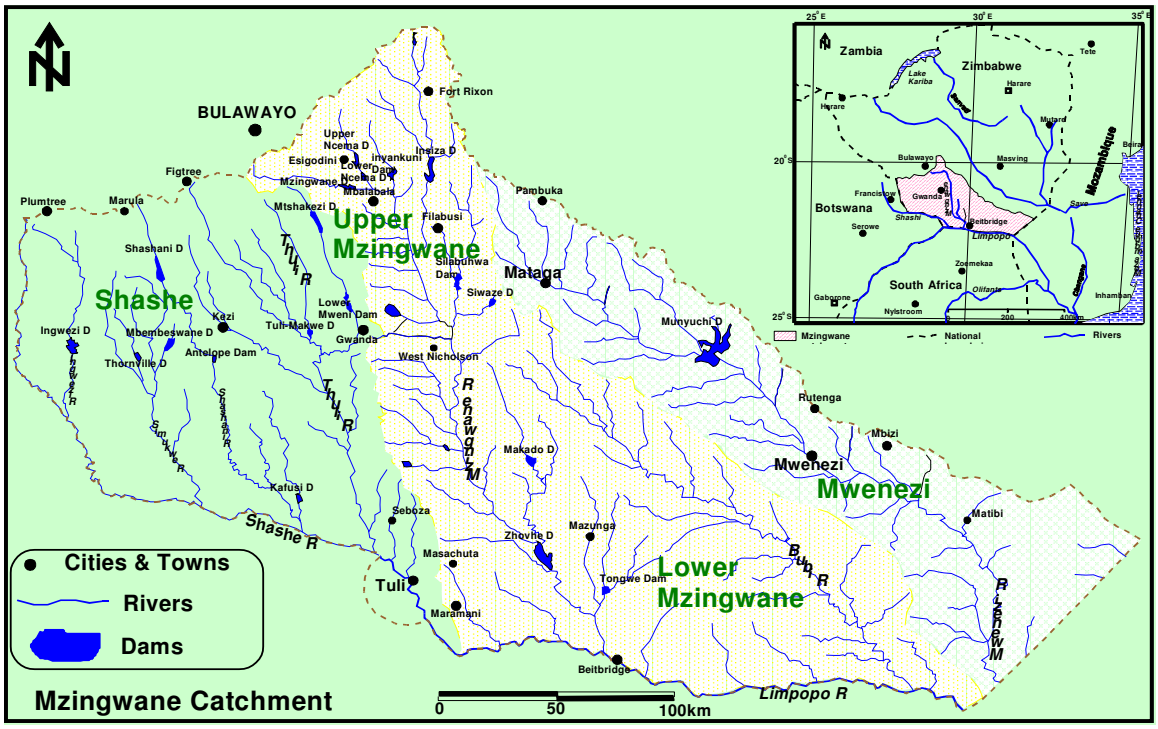


Figure 3.2: Map of Mzingwane Catchment

Table 3.1. below shows the characteristics of the small dams that were used in the research.

Table 3.1. Characteristics of the small dams studied

Name of Dam	Grid Reference	Catchment Size (km^2)	Mean annual runoff	Capacity ($x10^3$ m^3)	Type of Dam	Year Built
Dewa	QG620000	4.0	152000	60	Earth	1954
Denje	QH681990	9.5	332500	na	Earth	1955
Avoca	QH623923	4.0	152000	60	Earth	1947
Makoshe	QG587770	na	na	926	Earth	1998

na = not available

Source: District Development Fund.

3.3 Questionnaire Design

A questionnaire was designed for the small dams' users. It had both structured questions and open ended (unstructured). Structured questions are those which require the respondent to choose from a given options, this enabled the study to capture qualitative and quantitative data. The questionnaire was designed to be as short as possible whilst at the same time capturing relevant information. The following information was to be established:

Personal details

- Age
- Sex
- Number of years living in the area
- Number of people in the household

General information about the small dam and its geographical catchment

- When and who constructed the dam
- Major reasons for construction

- Current uses
- How it is managed
- Organisations and institutions attached to the dam
- Problems encountered in utilisation of the small dam
- Alternative sources of water and their location
- Distance between dam and where the water is used

Multiple uses (domestic, irrigation, livestock, fishing, brickmaking, recreation)

- Quantifying volume of water used for each use
- Yield
- Amount of money realised from each use
- When and how the uses are carried out
- Who is responsible for carrying out the different activities

3.4 Pre-test

Pre-testing of the questionnaire was done during the reconnaissance visit to assess potential problems in its administration such as phrasing, length of the questionnaire, omission of some details, and irrelevant questions. It was seen that some parts needed rephrasing and that it had left some vital information for instance availability and location of alternative watering points, necessary changes were then made.

3.5 Sampling

With the help from some community members and AREX officials, spheres of influence for each dam were established. The village and kraals were listed. It was imperative at least each kraal was included in the study to have a clear view of the utilisation of the dam by everyone in the sphere. Simple random sampling was used to choose households by use of random numbers. The household that corresponded to that number was selected. This was done to ensure that every household had an equal chance of being selected.

3.6 Data collection

3.6.1 Questionnaire Administration

The questionnaire was administered orally to the users in Ndebele and answers written in English. Each questionnaire lasted for about thirty minutes. Effort was made to get views from various age groups and both sexes. Fifteen respondents were interviewed for small dams Avoca, Denje and Makoshe whilst 14 were interviewed in Dewa. These figures constituted 7.5%; 6%; 10% and 7% of the households served by the small dams respectively, the main constraints for getting a larger sample being time for the study and resources. The questionnaire is given in appendix 1.

3.6.2 Interviews

Oral interviews were conducted using pre-prepared checklist with representatives from various organisations and government departments listed below, these were to identify the uses of the small dams, establishing specific roles and services they offer to the community and problems they encounter in their service provision. Were possible, some secondary data was obtained which was used in analysis.

- Agricultural Research and Extension Services (AREX), a government department that offers extension services to farmers mainly in cropping and livestock practices.
- Veterinary Services Department, a government department that offers vet services and operates dip tanks countrywide.
- District Development Fund (DDF), a government department that deals with construction and maintenance of public infrastructure, small dams and boreholes included.
- Rural District council (RDC),
- Department of Natural Resources (DNR),
- Zimbabwe National Water Authority (ZINWA),
- Environmental Health Department,
- Zimbabwe projects Trust (ZPT),
- Village heads.

3.6.3 Secondary Data and Observation

Secondary data were available was used in the analysis, this included population figures from the 2002 census results by Central statistical Office, livestock population figures from December 2004 census by Department of Veterinary Services and livestock per capita water consumption from literature, and information on small dams studied. Observation of the activities occurring around the small dams was undertaken to verify some of the responses given.

3.7 Data Analysis

All the information obtained from the questionnaires was recorded on a Microsoft Excel spreadsheet and statistical analysis was done using Statistical Package and Service Solution (SPSS). One-way analysis of variance was used to compare the mean volumes of water consumption per household for the following consumptive uses, livestock, irrigation, domestic and brickmaking. This was done on each of the four dams to ascertain if there is a significant difference between the volumes of water abstracted at level of significance $P < 0.05$.

3.7.1 Multiple uses

The multiple uses for the small dams were obtained from questionnaire responses and interviews with stakeholders. In the questionnaire the respondents were asked to identify the uses of the dam and also to give a score between 0 and 5 to show its importance, 0 being of least importance whilst 5 being very important.

3.7.2 Quantifying volume of water used

Below are the consumptive uses that were investigated and the method used to evaluate volume of water used:

- Livestock: Livestock records are given on dip tank basis, these dip tanks are located close to small dams. The average number of livestock species per household per dip tank were obtained and multiplied by the total number of

households served by the dam. Numbers of each type of livestock were then multiplied by the per capita water consumption rates given in table 4.1.

- Irrigation: for small gardens and nutritional gardens, respondents were asked to give the number of buckets (20 litre) of water used per irrigation and number of irrigation per season. An average value was then calculated per garden and then multiplied by the number of gardens.
- Drip irrigation: Each farmer has seventeen 100m laterals with emitter spacing of 40cm. Each emitter has a discharge of 2 l/s. The system operation provides for a single farmer for every four hours thereby serving six farmers a day throughout the day.
- Domestic: An average household daily consumption was obtained and multiplied by the percentage number of respondents and number of households served by the dam.
- Brick making: An average value of number of bricks and volume was calculated for each dam then multiplied by the number of brick moulders per dam

3.7.3 Water Productivity

Water Productivity is measured in kg/m^3. Irrigation water productivity was given as the yield in kg of a particular type of crop divided by the volume of water used for the crop in the season in m^3. Brickmaking water productivity was obtained from the average weight of bricks moulded per dam divided by the volume of water used to mould the bricks. Livestock water productivity was expressed as the average weight of each particular livestock species divided by the volume of water used.

3.7.4 Economic value

The economic value of water is a measure of economic water use efficiency in $Z\$/m^3$; it is the monetary value of the yield per unit volume of water used. This was obtained from the market value of the output for the use divided by volume calculated above.

3.7.5 Management and Institutional Analysis

In the questionnaire, respondents were asked to give a rating out of 4 of the most common institutions and organisations involved in the utilisation and management of the small dams. The rating gives the respondent's view of the influence the particular institution has in the management and utilisation of the small dam. The rating of 4 depict very influential and 0, least influential. Venn Diagrams were then used to visualise the influence of the institution using the average rating from all respondents. The more important an institution the closer it was to the centre of the Venn diagram.

CHAPTER 4

Results

4.1 Dam Profiles

4.1.1 Dewa Small Dam

All respondents (100%) indicated that the dam was developed mainly for livestock watering and domestic use since rivers are not perennial, the area is prone to droughts and the nearest dam was 5km away. Villages served by the dam are Dewa and part of Mathamisa. The dam serves about 150 households constituting. Of the interviewed respondents, 58% and 42% were male and female respectively. Their ages ranged from 20 to 52 years with the mean age being 36.9 years.

The current uses are livestock watering, irrigation, domestic use, fishing, brick making and recreation. Types of livestock that access the dam on a daily basis are cattle, goats, sheep and donkeys whose population are 694; 540; 360 and 215 respectively. Irrigation is confined to small gardens and a recently established one-hectare nutritional garden. This project is an initiative of Zimbabwe Project Trust targeting HIV/AIDS victims, elderly and the less privileged members of the community. In the small gardens, buckets are used to carry water to the field. Mainly vegetable crops are grown for household consumption throughout the year and a little of the produce for selling.

Domestic use of water comprises drinking, washing, bathing and cleaning. Fifty seven percent of the respondents use the dam water on a daily basis, a borehole downstream is used for getting drinking and cooking. Average volume used per day is 126 litres. Buckets are mainly use to fetch water to the homestead; concrete structures were built on the other side of the dam wall, which are used for washing.

Fishing is also carried out throughout the year but thrives in summer when temperatures are high. The most common method of fishing is by using lines; nets are used by licensed cooperatives. Types of fish mainly caught are breams and babbles. Average

catch per day per fisherman is 0.5kg and up to 10kg for net users and an average price of Z$11500 per kg. Brickmaking is mainly carried out in the winter when there is little work to be done in the fields as it is labour intensive. Winter is also favoured because high temperatures cause cracking of the bricks. Average volume of water used to mould thousand bricks is 209 litres and average price for a thousand bricks is Z$95000. However no significant recreation is taking place at the small dam apart from fishing and scenic viewing, no swimming is allowed. Reeds *cypress spp*. are used for roofing houses but their availability is threatened by cattle which feed on them.

Village heads and the community through appointed people from each kraal are responsible for the management of the small dam. Most respondents (86%) identified siltation as posing the greatest threat to the utilisation of the dam. competition is rife particularly in the dry season and in drought years. The fence surrounding the dam has since been stolen. Figure 4.1 is a sketch map of Dewa Dam. It shows the general layout of the dam and its catchment.

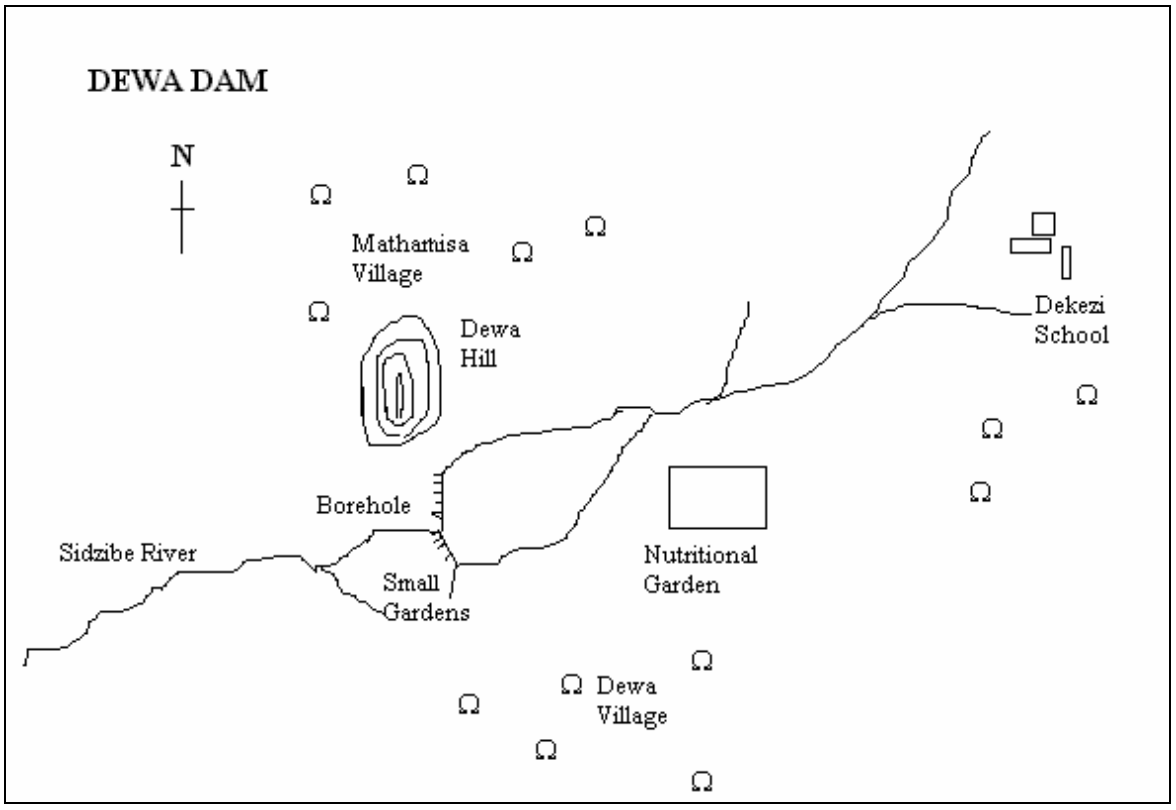


Figure 4.1 Sketch map of Dewa Dam.

4.1.2 Denje Small Dam

Villages served by the dam are Phumelela, Bophasqine, part of Bambanani and some smallholder farmers constituting about 250 households. Male and female respondents constituted 54% and 46% respectively whose average age was 38.7 years. All respondents indicated that the main reasons for construction of the small dam was for livestock watering and domestic use. Some further indicated that development in the area was centred on the dam as the school and the shops were located close to the dam and that even people from as far as Mberengwa at some point used the dam.

Current uses are livestock watering on almost a daily basis and a dip tank is located near the dam site. The livestock species are cattle, goats, sheep, and donkeys whose population are 1555; 693; 660 and 623 respectively. Irrigation is restricted to small gardens whose and a one-hectare nutritional garden with 40 beneficiaries. Vegetables are mainly grown for household consumption and for sale throughout the year with a decrease in the rainy season when most people concentrate on grain production. Water is carried to the garden by buckets.

The dam is also used for domestic purposes. Forty six percent of the respondents indicated the use of the small dam for domestic purpose with an average volume per household is 138 litres per day. Other sources of water are a borehole located about a kilometre from the dam, streams and shallow wells.

Fishing is also available; a fishing cooperative is the main participant though it has not been operational of late due to non-availability of fishing equipment. Types of fish caught include various species of breams and babble. Average daily catch for individuals is 1.78 kg which is mainly for household consumption, average price per kg is Z$9600. Brickmaking is on the decline due to dwindling firewood resources. It is normally done in winter, with an annual average of 2667 bricks per individual and average volume of 213 litres per 1000 bricks. There is no significant recreation taking place.

Management of the dams activities is mainly done by the village heads and monitoring by appointed people from the community. Siltation has been sited by most people (73%) as the greatest threat to the viability of the small dam. Some prohibited activities such as dumping garbage in water, washing and bathing in the dam were raised. Some pointed that no proper management is taking place as some trees are growing on the dam wall, the nutritional garden being located very close to the dam and free access by livestock and people. Figure 4.2 is a sketch of Denje Dam, drawn not to scale. It shows the major activities surrounding the dam and location of villages.

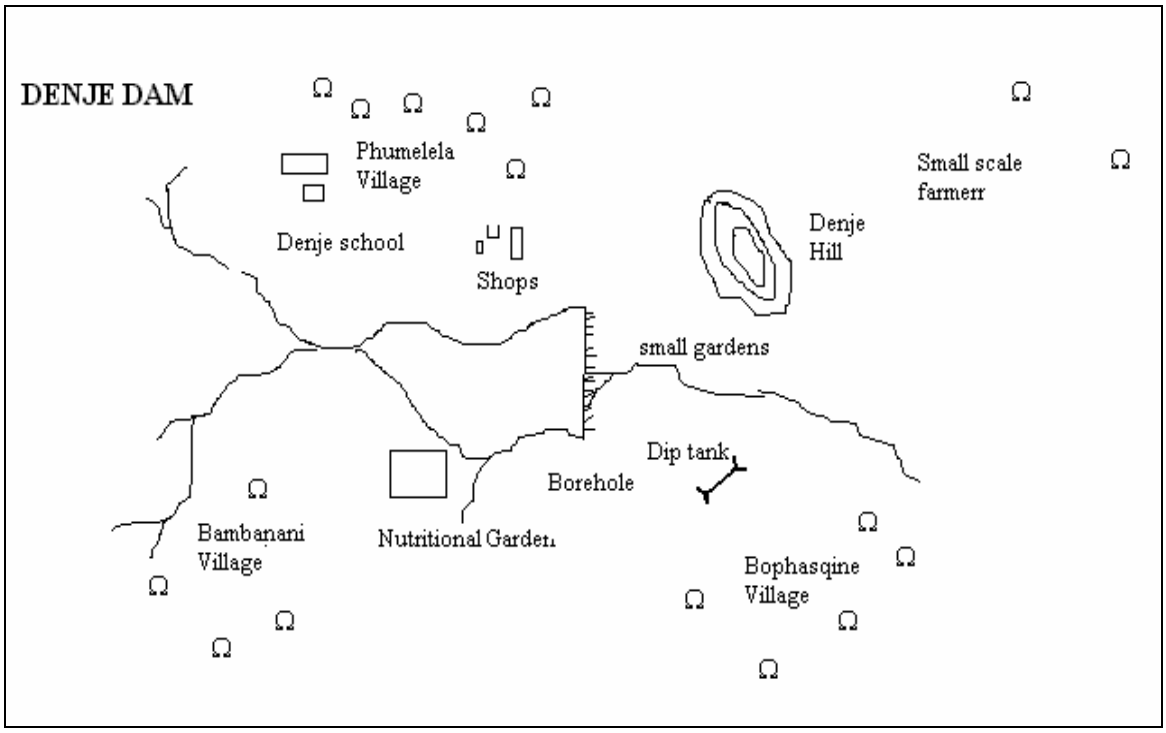


Figure 4.2 Sketch map of Denje Dam.

4.1.3 Avoca Small Dam

The small dam is located about 700m behind Avoca Business Centre. The dam was developed mainly for domestic use and livestock as evidenced by water chlorination tanks on the other side of the dam wall and drinking troughs. Of the respondents 67% were male and 33% female with an average age of 41.9 years Some people claim that the small dam influenced the growth of the business centre, which boasts of a Post Office,

Grain Marketing Board depot, cattle selling pens, DDF and AREX offices and many shops. Villages served by the dam are Ukhutula, part of Phakhama and part of Bambanani constituting about 200 households. However the dam cannot meet the demand for water by the business centre so a large dam Siwaze was built to provide it with piped water, but it serves as a back up when the pumps at Siwaze fails.

Current uses of the dam are livestock watering, dip tank, irrigation, domestic, fishing and brickmaking. Livestock species that access the dam daily are cattle, goats, sheep and donkeys whose population are 925; 720; 422 and 197 respectively. Irrigation is for the small gardens used for growing vegetables. Buckets are used to fetch water to the gardens.

Domestic use consumes a daily average of 104.7 litres per household. Fifty three percent of the respondents indicated the use of the dam for livestock. Fishing like the other dams is mainly done in summer, the average daily catch being 0.67 kg per person. Use of nets is prohibited, so no cooperative operates at this dam. Village heads are discouraging brickmaking as it causes deforestation and effectively siltation of the dam. However 1000 bricks cost an average of $96667 and an average of 8667 bricks per individual. The dam dries up late in the dry season and in drought years.

Management of the dam is by the village heads and the community, there is little input from other institutions and organisations. The main problem is that the dam dries up late in the year because of the high siltation, causing competition especially during this period. Figure 4.3 below is a sketch map of Avoca Dam drawn not to scale. It shows the general layout of activities surrounding the dam.

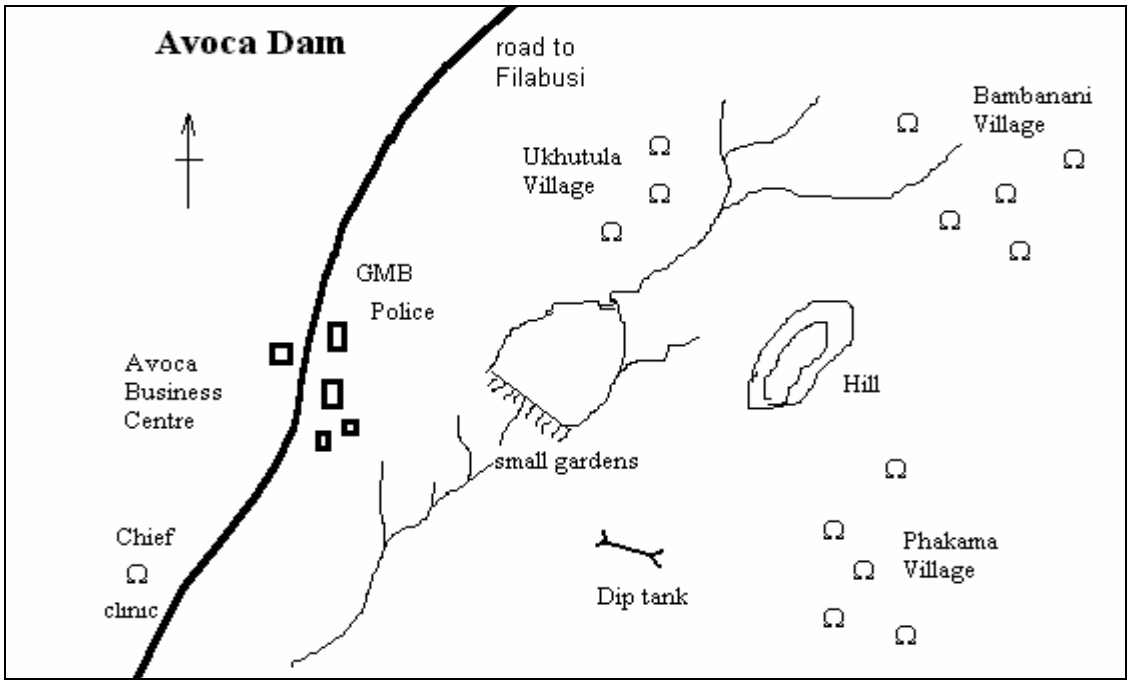


Figure 4.3 Sketch map of Avoca Dam.

4.1.4 Makoshe Small Dam

District Development Fund (DDF) with funding from Oak Foundation built Makoshe dam in 1998. It was developed for irrigation, livestock and domestic purposes. Villages served by the dam are Bambanani-Makoshe and Mbawulo consisting of about 150 households. Most people relied on streams and shallow wells for water, which are seasonal and at times could, not meet the demand. The construction of the dam saw the solving of a long standing water problem and came with the following uses, irrigation, domestic, livestock watering fishing, brickmaking and reeds can be collected for roofing houses. Livestock species are cattle, goats, sheep and donkeys whose population are 644; 852; 320 and 197 respectively.

Irrigation is in three forms, for small gardens, nutritional garden and drip. The nutritional garden is not operational due to some misunderstandings between beneficiaries. Drip is for an 18-hectare plot for forty beneficiaries who were involved in the construction of the dam. Currently, 8 ha are being utilised for the production of maize, soyabeans, wheat, sweet potatoes and a variety of vegetables for household use and selling. Farmers take turns in the watering of their 0.2 ha portions.

The dam is also utilised for domestic purposes, an average household consumption of 116.5 litres per day. Fishing is also carried out with an average individual catch of 0.25 kg per day and an average price of Z$10500 per kg. Brickmaking is done mainly in winter. An average of 5000 bricks are moulded per person and with the average price per 1000 bricks being Z$72500 and volume per 1000 bricks being 198 litres.

The drip irrigation committee, the village heads and the community play a leading role in the management of the dam. The Oak Foundation helps with some technical advice and the Rural District Council trains the committee on management aspects of the dam. Problems encountered in the utilisation of the dam include siltation and a lot of suspended material that causes clogging of drip system filters, stolen fence. The drip irrigation system is being operated without the filtration system because the filters were being clogged after a few days. Figure 4.2 is a sketch map of Avoca Dam, drawn not to scale. It shows the general layout of the dam and activities surrounding it.

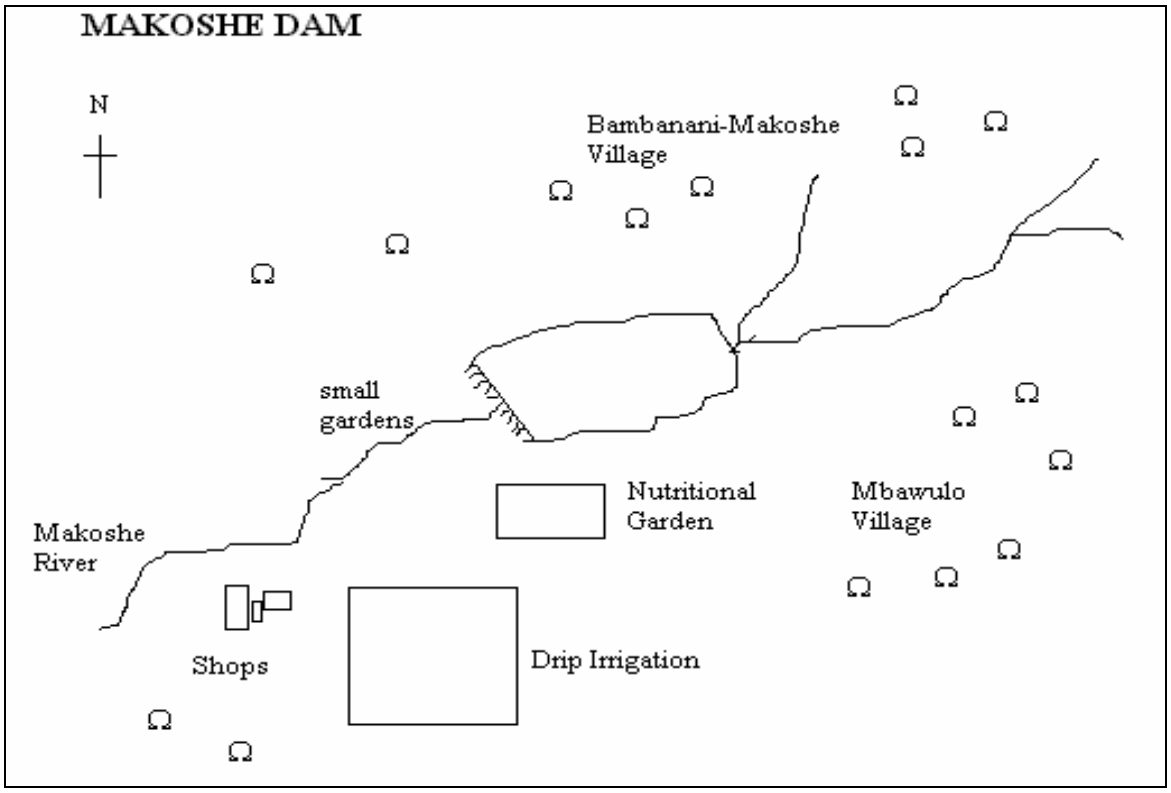


Figure 4.4. Sketch map of Makoshe Dam.

4.2 Small Dams' Uses

Figure 4.5 shows the uses for each dam and gives the rating as viewed by the respondents surveyed. Some of the uses are not present at some dams as evidenced by absence of the bar representing the dam.

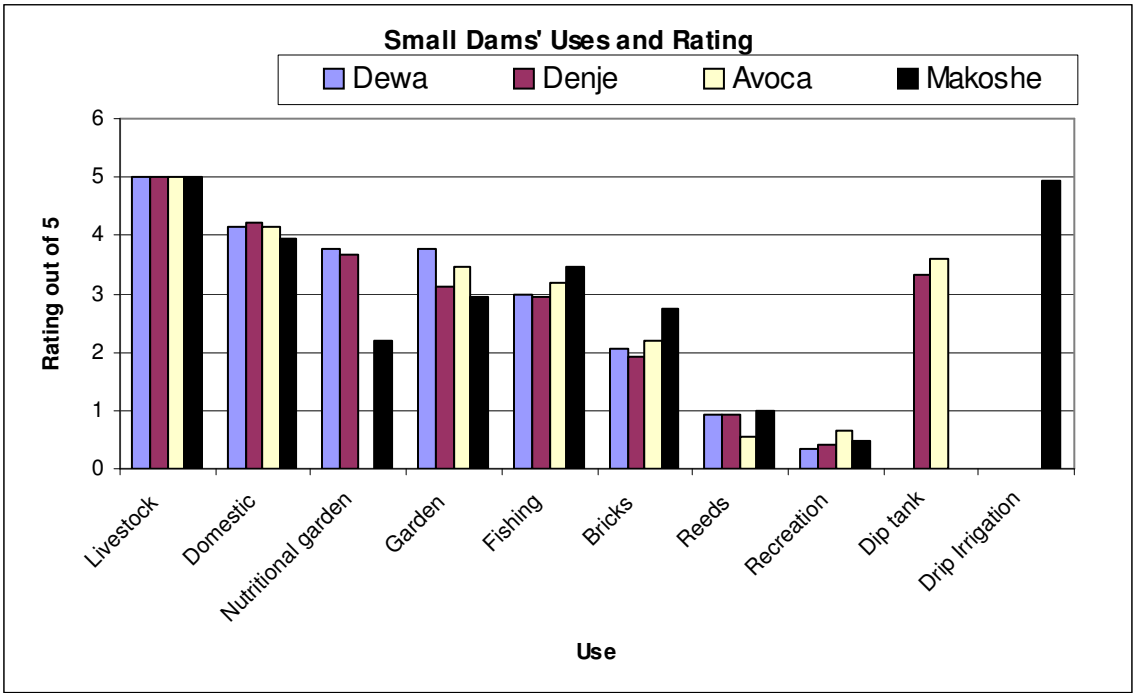


Figure 4.5. Small dams' uses and their ratings.

The average distances travelled by people from the household to the small dam for each use is given on a dam basis are given in figure 4.6.

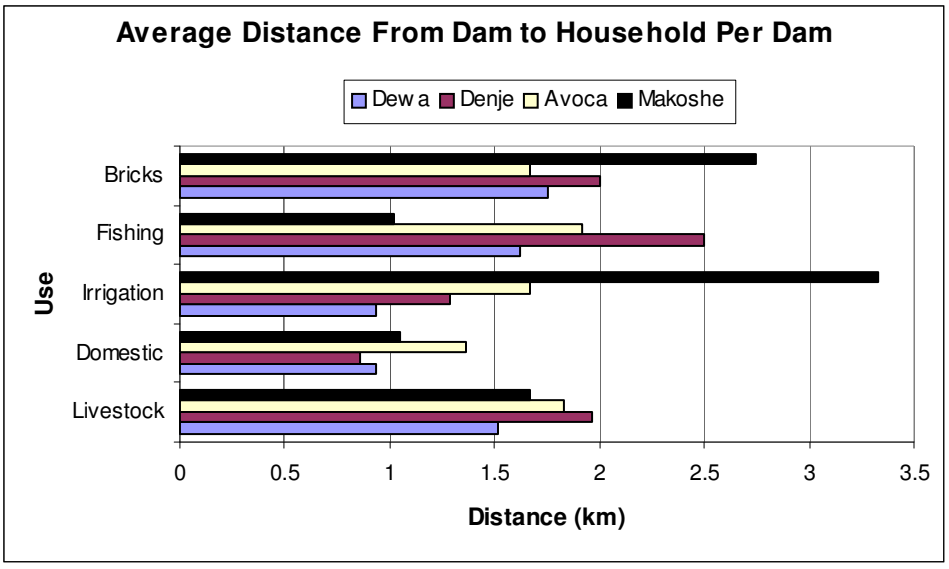


Figure 4.6. Average distance from household to the dam for the uses.

4.3 Volume of water used

Average live weights and per capita daily water consumption values for various types of livestock used in the calculations is given in table 4.1 below.

Table 4.1. Average live weights and per capita daily consumption rates.

	Cattle	Goats	Sheep	Donkeys
Average live weight (kg)	350[a]	45[b]	45[b]	210[c]
Daily consumption rate (l)	50[b]	11.5[b]	11.5[b]	22.17[d]

Source: a = Mbanje et al (1997), b= Pond et al. (1995) c = Pearson et al. (1999)
d = Aganga et al. (2000)

Volume of water used by consumptive uses per annum for each per dam is given in figure 4.7**.** Volume for irrigation was split into small gardens, nutritional garden and drip irrigation.

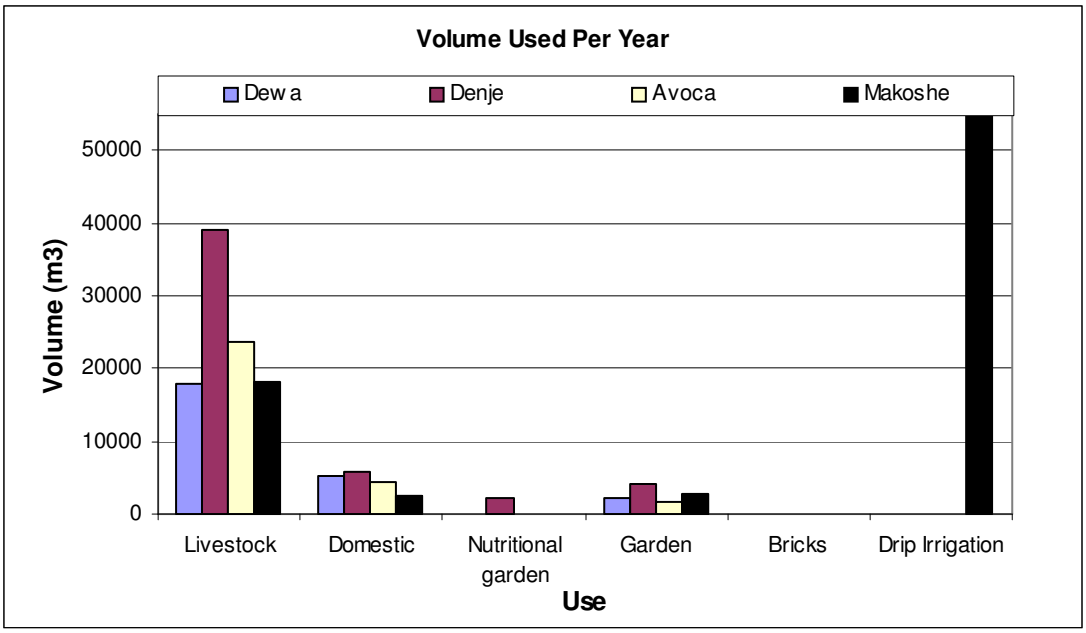


Figure 4.7. Volume of water used per annum

Statistical analysis

Statistical analysis to compare average volumes of water consumed per use on each dam was done using one-way ANOVA at a level of significance $P<0.05$. The results are presented in table 4.2. Multiple comparisons of the volumes of water between the uses were done using LSD, the results as well as the ANOVA tables are in appendices 2 to 5. Tables 4.2 shows the statistical results of average volumes of water used per household.

Table 4.2. Average household water consumption per use per dam ($m^3 \pm$ se*)

Use	Dewa	Denje	Avoca	Makoshe
Livestock	144.5 (± 21.7)	174.4 (±27.5)	199.7 (±34.5)	171.5 (±23.3)
Irrigation	108.6 (±11.9)	91.3 (±18.8)	111.9 (±12.8)	855.6 (±312)
Domestic	46.0 (±3.3)	50.4 (±3.5)	38.1 (±7.7)	42.4 (± 5.1)
Brickmaking	2.5 (±1.2)	0.6 (±0.08)	2.8 (±1.5)	1.2 (±0.3)

* = Standard error

4.3 Water Productivity

Table 4.3. below shows water productivity values in kg / m^3 of the various crops grown under irrigation using water from the small dams. Gaps in the table were because of either the crop is not grown or the respondents could not give information on the yields and volume.

Table 4.3. Crop water productivity in kg/m^3 of irrigation water per dam.

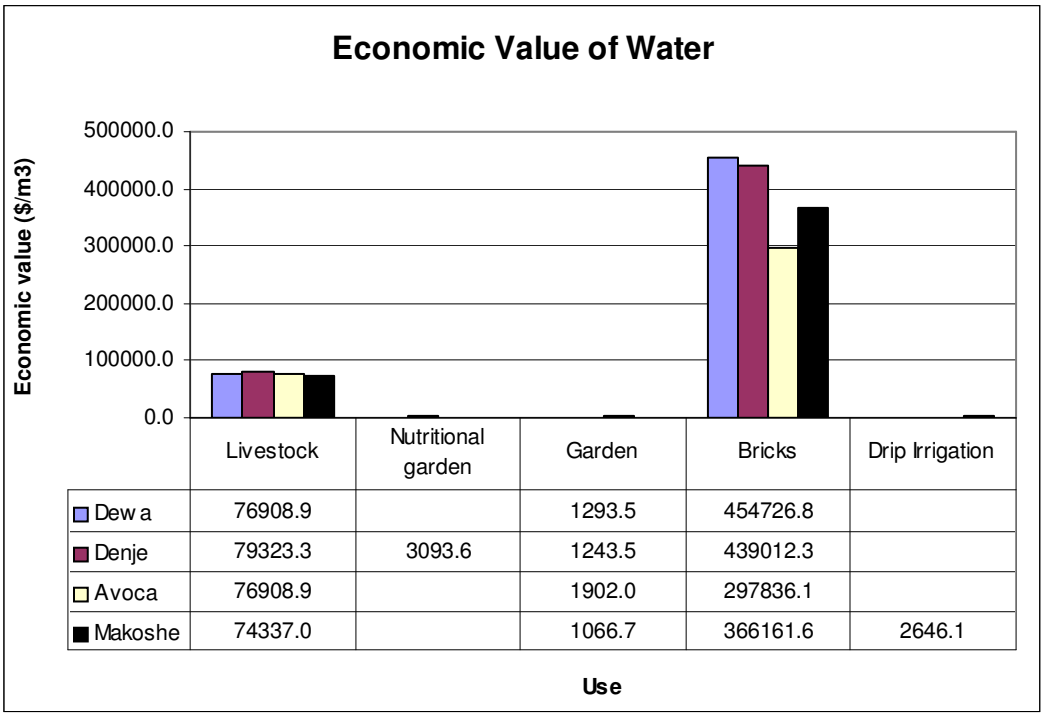
	DEWA	**AVOCA**	**DENJE**		**MAKOSHE**	
	Small Garden	Small Garden	Small Garden	Nut Garden	Small Garden	Drip System
Leaf vegetable	0.508	0.513	0.234	0.322	0.533	0.025
Tomato	6.250	6.250	9.722	4.498		
Onion				1.042		
Cabbage			22.222	10.278		0.311
Maize						0.028
Wheat						0.014
Sweet potato						0.187

Since similar per capita water consumption for the various types of livestock used to calculate annual volume of water consumed for all the dams as well as average live weight, livestock water productivity for all the dams was similar averaging 16.64 kg/m^3. Specific water productivity for the different types of livestock were as follows; cattle 19.18kg/m^3, donkeys 25.95 kg/m^3 and both sheep and goats 10.72 kg/m^3.

Brickmaking water productivity results for the small dams were almost similar except for Avoca whose value is 4621.5kg/ m^3. Dewa, Denje and Makoshe brickmaking water productivity values are 7179.9kg/ m^3, 7055.56kg/ m^3 and 7575.76kg/m^3 respectively.

4.4 Economic Value of Water

Economic value of water results of the uses do not vary much per use when comparing similar uses on dams. Figure 4.8 shows the economic value of water for some selected uses.



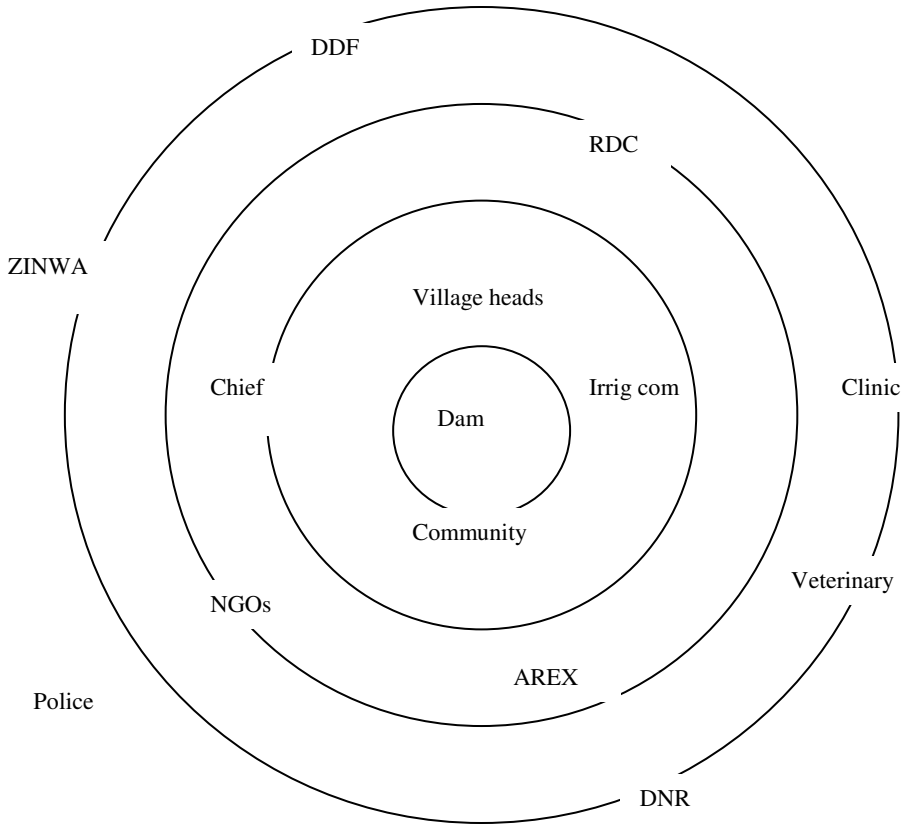
	Livestock	Nutritional garden	Garden	Bricks	Drip Irrigation
Dew a	76908.9		1293.5	454726.8	
Denje	79323.3	3093.6	1243.5	439012.3	
Avoca	76908.9		1902.0	297836.1	
Makoshe	74337.0		1066.7	366161.6	2646.1

Figure 4.8. Economic value of water for some of the small dam uses

4.5 Management and Institutional Issues

4.5.1 Venn diagram

Figure 4.9 shows the overall Venn diagram for all the small dams combined. It gives a general picture of how the dams are managed which are in a more or less similar set up. Some of the organisations were not given a rating but were mentioned in some instances, this led to their inclusion in the Venn diagram.



* = Irrigation committee

Figure 4.9. Venn diagram on management of small dams

4.5.2 Organisations and Institutions

Rural District council (RDC)

Their main thrust is on catchment management and conservation hence small dams management. The RDC is pivotal in the establishment of dam committees and facilitates the training of the committee members mainly focusing or recently built small dams. It also promotes coordination and corporation between the committee and the community.

An anomaly was noticed in which the recently established dams built as a result of the community's request were well received at the implementation stage but as time went on operations come to a halt, committees dissolved and rampant mismanagement is experienced. But the old ones seem to have survived by strict management practices. In utilisation of the dam the communities are faced with maintenance problems, stolen

fences and rampant soil erosion upstream. The RDC sited that lack of funds hinders their operations.

District Development Fund (DDF)

Main functions include, construction of small dams, their maintenance, i.e., rehabilitation, fencing the dam wall, planting vertiver grass and dam silt removal. DDF also keeps a database for the small dams and carry out awareness campaigns on how to maintain small dams. The database is however incomplete as some of the information is missing and it recognises three main uses, livestock, domestic and irrigation. It also cited negligence on the part of the community as the main problem that is being faced in the utilisation of the small dams. Inadequate funds, shortage of transport and staff shortage have negatively affected DDF in carrying out its duties.

Environmental Health Department (Avoca Clinic)

Environmental health is a department in the ministry of Health that is responsible for carrying out surveys and enlightening the communities on water and sanitation issues, regular testing of water especially from boreholes, monitoring and record keeping of environmental health problems and interacting with various organisations in developmental projects within the communities. Problems by communities in the utilisation of the small dams include schistosomiasis in the dry season and diarrhoeal diseases in the rain season; these have been attributed to free access to the small dams by both livestock and people.

Department of Natural Resources (DNR)

The main thrust of this department is on environmental management, i.e., conservation works for the whole catchment in soil, water and vegetation in a bid to curb soil erosion, water pollution and deforestation. DNR also carries out awareness programmes through workshops, distribution of posters and pamphlets and conservation competitions. It also works hand in hand with organisations that intend to and are running projects associated with small dams. It however does not do any siltation studies on small dams. Inadequate funds and shortage of transport are the major setbacks in their operations.

Zimbabwe Projects Trust (ZPT)

ZPT is a non-governmental organisation involved in a number of projects in Matabeleland South. These include construction and rehabilitation of boreholes and establishment of nutritional gardens that use water from the small dams. Nutritional gardens are mainly targeted at enhancing nutritional status of HIV/AIDS victims, elderly and less privileged members of the communities. In the establishment and operations of these, ZPT works in conjunction with the traditional leadership, and various government departments. It however sited non-availability of proper management structure as the main problem affecting utilisation of small dams.

Agricultural Research and Extension Services (AREX)

AREX is a department under the Ministry of Agriculture and Rural Resources. Its main thrust is in assisting farmers with agronomic advice and conducting lessons on conservation and maintenance of small dams. This is done through workshops with farmers and regular meetings with the community. AREX is usually involved in most developmental projects pertaining to small dams undertaken by the government and NGOs. Problems faced by the communities in the utilisation of small dams include siltation resulting in most dams drying up late in the dry season. Shortage of transport and being short staffed is hindering their service to the community.

Veterinary Services Department

This is a government department that is responsible for giving farmers advice in livestock farming, ensuring livestock has enough watering points, operating dip tanks, record keeping of livestock numbers and owners, and monitoring animal health status. It however expressed concern over the rate at which the dams are silting partly as a result of overgrazing in the area leading to stiff competition in the dry season and in drought years and some dams unable to meet the next rain season. Most dams had their fences stolen causing free access by animals, which then contaminate the water for other uses.

Zimbabwe National Water Authority (ZINWA)

Overall management of all water resources is under the auspices of ZINWA. Zimbabwe was divided into seven catchments based on seven major rivers. Catchment councils were then set up comprising water stakeholders within the catchments. The catchment councils report to ZINWA, which then provides technical assistance to the communities. ZINWA keeps records of all the water bodies, at the moment it is still in the process of recording all small dams in the country. Their focus currently is on dams that are used for commercial purposes leaving out most small dams in the communal areas. It however acknowledged the deplorable state of most small dams citing lack of funding to carry out most activities.

Traditional Leadership

Traditional leaders play a pivotal role in the management of the small dams. This structure of chief, headman, village heads is a custom in most communal areas and has been practised for a number of years as a result it commands a lot of respect from the community hence it has been effective in the management of small dams. Traditional leaders are involved in the planning of small dams' activities, these include, development, conservation, maintenance, monitoring through appointed people, enforcing bylaws and conflict resolution. All developmental projects by various organisations and institutions in relation to the small dams get approval from the traditional leaders.

CHAPTER 5

Discussion

5.1 Uses

Uses common to all dams are livestock watering, irrigation, fishing, brickmaking, and collection of reeds *(Cypress spp.)* used for roofing. These uses are similar but vary in form from one dam to the other. The trend in the rating of importance of use from livestock, domestic, irrigation, fishing, brickmaking, collection of reeds and recreation is the same on all four small dams. This may be attributed to similarities in the social set up as three of the dams Dewa, Denje and Avoca are in the same ward and Makoshe dam about 30km away. Zirebwa and Twomlow (1999) identified the same uses in the communal areas of Masvingo Province. Therefore are typical of small dams in communal areas.

Livestock is given the highest rating of 5 and domestic 4 showing the importance of livestock in the communal areas particularly southern areas of Zimbabwe supporting the reason why most communal small dams were developed for livestock (Senzanje and Chimbari, 2002). Domestic use was given high showing the importance of water for household use but the water is mainly restricted to washing and bathing as it is dirty to be used for cooking and drinking. Other sources of water are used for the latter activities.

Irrigation however varies from one dam to the other in the form of small gardens common to all dams; nutritional gardens found at Denje and Makoshe dams and drip irrigation at Makoshe. Irrigation is also given a fairly high rating, as it is important for family income as well as contributing to the nutritional status of the household showing that communal way of living is agro-based. It is for the same reasons why the government of Malawi embarked on a programme to use small dams for irrigation development (Chavula, 2000). Fishing is widely carried out to provide a cheap source of protein. One important feature is that fishing is not labour intensive; every member of the family from children to the elderly is able to fish contributing to the family's income and livelihood.

Brickmaking is given a low rating of about 2 due to a number of reasons, in Avoca for instance; village heads are discouraging it as it causes siltation of the dam due to deforestation and some moulding sites are located very close to the dam. Zvarevashe and Ellis-Jones (2000) also pointed to brickmaking as one of the cause of siltation in small dams. It is also labour intensive and only done in winter when conditions are favourable. Collection of reeds is not very important on all dams partly because they do not contribute to family income and that in most dams they are low in quantity as cattle also feed on them. On all dams, no significant recreation is taking place. Swimming is discouraged on all dams and the areas are not well developed to attract visitors.

Distance has an influence on the uses; from figure.4.2 the average distance for people using the small dams for domestic use is 1 km and that for irrigation 1.3 km showing that people very close to the dam normally carry out these uses. However due to the presence of a drip irrigation system at Makoshe dam, come from as far as 3km away. For livestock the average distance is greater than 1.5 km showing the importance of small dams to livestock as people can travel long distances in search of water.

5.2 Volume of water used

From the statistical analysis, all dams showed significant variations ($p<0.05$) in the volumes of water utilised for the uses, livestock watering, irrigation, domestic and brickmaking. Livestock consume the greatest amount of water for the small dams ranging from 18000m^3 to about 40000m^3 except for Makoshe, which has a drip irrigation system. The high value shows why the livestock was given the highest rating of importance and most small dams being developed primarily for livestock watering. Irrigation and domestic use consumes almost similar amounts of water within the range of 15633m^3 to 5794m^3 (excluding Makoshe). A comparison of the two uses using LSD multiple comparisons ($p<0.05$) at household level, there is no significant difference between the volumes consumed on the dams Dewa, Denje and Avoca. This can be attributed to the same method of water conveyance and in both cases women are normally involved and roughly the same distance is travelled.

5.3 Water productivity

Leaf vegetables were the most common vegetables grown under irrigation on all dams. Water productivity for leaf vegetables on all small gardens ranged from 0.2 to 0.5 kg/m^3. This is typical of similar irrigation practices, i.e., using buckets and in the same area as these dams are located within 30 km of each other. Water productivity for tomatoes ranges from 4.498 to 9.722 kg/m^3, which is low compared to the range given in FAO (2002) of 10-12kg/m^3, this may be attributed to agronomic practices. Extremely low water productivity for the drip system is a cause for concern as drip irrigation is the most efficient method. Water productivity is based on two variables, yield of produce, which is a function agronomic practice, and volume of water applied which depends on the efficiency of irrigation method. Therefore one or both variables is responsible for the low water productivity, a careful look at the two will give a clearer picture of the causes of such a low value. Low water productivity of the drip irrigation may be explained by the inefficiency of the system as the system does not have a filtration system so the emitters may be heavily clogged and it is also because of the water management practices as the irrigation interval is set by rotation as opposed to crop water requirements.

Livestock water productivity was the same on all dams, because same average per capita consumption rates of water for each type of livestock was used for all the dams and that average live weight were also assumed to be similar on all the dams. Brickmakng

5.4 Economic value of water

A comparison of economic value of water for each particular use shows that the values show a similar trend because the dams are located in the same area hence the marking structure and market values are similar. Despite using the lowest amount of water, brickmaking economic value of water is the highest on all the dams averaging $380 000. This figure may to a large extend be misleading for one embark on brickmaking as a business as it is being discouraged and that in communal areas most people prefer to make the bricks themselves. Though drip irrigation uses most water of Makoshe dam, there is not much money being earned from every unit of water used. This is and

indication of inefficiency of the drip system, agronomic practices and marketing system. Of importance in light of the small dam to serve multiple uses is inefficiency of the drip system as this deprives other users some water.

5.5 Management and Institutional Issues

Venn diagrams of the four small dams show great similarity in how they are managed. Located very close to the dams are the community and traditional leaders and for Makoshe the drip irrigation committee. This is typical of communal small dams where the dams are seen as community property with everyone having equal access (Zirebwa and Twomlow, 2000). Chiefs are located slightly outside the first ring because he is distant from the community and only attends to critical issues passed to him by the village heads.

The next ring comprises of the AREX, RDC and NGOs. AREX officers are in constant interaction with the community, for instance in all the irrigation projects, the communities look up to them for some advice on agronomic practices. NGOs on the other hand fund most of the projects and get approval from the local government representatives the RDC. The above shows a close-knit relationship amongst the organisations.

The other groups then follow which are veterinary, clinic and DDF. From the interviews, they seem not to be doing much because of resource constrains, as they are required to cover the whole district while operating on meager budget allocation. Zimbabwe National Water Authority is virtually unknown by most people maybe because it was recently established and still in the process of adjusting and getting small dams into the system.

CHAPTER 6

Conclusions

Small dams are multipurpose structures whose uses have varying water consumption, water productivity and water economic value figures. From the research, the following uses were established in order of importance, livestock watering, domestic use, irrigation, fishing, brickmaking, reeds *Cypress spp*. collection and recreation. These uses have been found to be similar on all dams but vary in form from one dam to the other thereby proving the hypothesis correct.

Volumes of water that is consumed by livestock, irrigation, domestic and brickmaking varied significantly on all the four small dams proving the hypotheses that volumes of water used have significant differences correct. The general trend in volume of water utilised was that livestock consumes the bulk of the water followed by domestic and irrigation whist brickmaking uses the least. Different water productivities and economic values were realised for the uses but had a similar trend on the uses for all the dams, both parameters were in descending order, brickmaking, livestock and finally irrigation.

There are a number institutions and organisations mainly government departments that are involved in the utilisation and management of small dams in different capacities. Of these, traditional leadership and the community at large were found to be pivotal in the management of the dam with some organisation giving technical and financial assistance in various activities surrounding the small dams.

Recommendations

One greatest threat to the multipurpose nature of small dams is rampant siltation on most dams as some of the dams dry up late in the season. Frequent siltation evaluation and awareness on ways to reduce soil erosion should be carried out and measures taken to curb soil erosion in the catchments. This may be done through more interaction between the community and organisations such as the AREX and DNR. There is also a need for further research in siltation of small dams.

Water abstraction is mainly done using buckets for irrigation, domestic and brickmaking, which is laborious as a result the small dams are not fully utilised. Usage of technology such as drip irrigation will see more people benefiting from the small dams and more water being put into productive use. However for these to be of benefit they need proper maintenance and frequent evaluation.

In this research much focus was on the demand side of water for various uses but there is a need to look at the supply side that is the amount of water available for use at nay instant. The supply side can then be matched with the demand side and appropriate measures taken to ensure that maximum benefits are derived from small dams.

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APPENDIX

Appendix 1: Survey Questionnaire

GENERAL

1. **Respondent's details**
   Name …….. Sex …….Age…….
   How long has he/she been living in the area?…….years
   Distance from household to dam…….km
2. **What is the name of the dam**……Ward……District……..
3. **When was the dam built?** .....
4. **Who constructed the dam**? .....
   .....
   .....
5. **What were the major reasons for building the dam?** *Give a brief history of how these have changed over the years*……..
   .....
   .....
   .....
   .....
   .....
   .....
   .....
   .....
6. **What are the uses of the dam?** *(Give a rating of its <u>importance</u> in terms of cash generation and other needs e.g. food, medicine, construction, aesthetic value by assigning a figure 0 to5; 0 being the least important and 5 being the most important in that order)*
   .....
   .....
   .....
   .....
   .....
   .....
   .....
   .....
   .....
   .....
   .....
   .....
7. **What has the impact of the dam in your life, socially, economically, environmentally** etc? Very critical, moderate, little importance *(tick the appropriate and explain)*
   .....
   .....
   .....
   .....
   .....
   .....
8. **How is the dam managed**? i.e. development, planning, conflict resolution, conservation, water allocation, monitoring and assessment

……
……
……
……
……

9. **Which organizations or institutions are responsible or contribute to the day-to-day management of the small dam?** *(Give a rating of its <u>importance</u> by assigning a figure 0 to4; 0 being the least important and 5 being the most important in that order)*
   ……
   ……
   ……
   ……
   ……

10. **What problems do you encounter in using the small dam?** *e.g. competition, water quality etc*……
……
……
……
……
……

B. DOMESTIC

1. **What is the number of people in your household?** ……...

2. **How often do you use water from the small dam for household use?**

Everyday……..
Seasonally ……
Other (specify)……...

3. **What method do you use to supply water from the dam to the household?**
   ……
4. **What is the number of buckets of water used for the following on a daily basis from the small dam in the period specified in 2.?**

Drinking……...
Bathing……...
Washing……...
Cleaning……
Other (specify) ……...

5. **What other sources of water do you use besides the small dam?**
   ……...……
6. **How far is the source mentioned above from the household**?……..…m
7. **What problems do you encounter in using water from the dam for domestic use?**
   ……
   ……
   ……
   ……

BRICKMAKING

1. **At what scale are you operating?** *(Tick the appropriate)*

Own use……..…..
Business……...
Other (specify)…….

2. **What method of water supply do you use also indicate the SIZES and NUMBER?** *e.g. five 20 litre buckets*

Buckets ……
Drums……..
Other (specify)…….

3. **How many bricks do you mould in a year?**

……

4. **How are the bricks MARKETED and also indicate QUANTITIES sold in a year?**

Own use .....
Institutions e.g. churches, schools etc .....
Individuals .....
Other (specify) .....

5. **What is the price per 1000 bricks molded?**……...

F. FISH FARMING

1. **At what scale do you operate?** *(Tick the appropriate)*

Individual…….
Institution e.g. church……...
Cooperative……..….
Other (specify)…….

2. **What time of the year do you operate?**

Throughout the year…….
Winter (specify months)……
Summer (specify months)……
Other (specify)…….

3. **How much fish in kgs is produced per day in the period indicated above?**

……..

4. **How is the produce MARKETED, indicate the QUANTITY sold?**

Own consumption……
Local traders…….
Local market……

Institutions……...
Other (specify)…….

5. **What is the average PRICE per kg**?.....
6. **What problems do you encounter when using the dam for fishing?**
   .....
   .....
   .....
   .....
   .....
   .....

G. RECREATION

1. **What activities are carried out in and around the small dam***?(tick the appropriate)*
   Swimming……...
   Picnic……...
   Fishing……
   Canoeing…….
   Functions e.g. weddings, gatherings……...
   Other (specify)……

2. **How often do you carry out the activity** (in a day/ week/ month/ year/ other (specify)
   (*write the activity and the corresponding time*)
   .....
   .....
   .....
   .....
3. **How much money do you pay for the activity(s) listed above, if any and to whom do you pay?**
   .....
   .....
   .....
   .....

NB: Other dam uses not included should be written in the blank sides of the sheets, effort should be made quantify the volume of water used, quantity and market of the produce and monetary value.

Appendix 2 : Dewa Dam Statistical Results.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	82822.243	3	27607.414	10.023	.000
Within Groups	63353.704	23	2754.509		
Total	146175.947	26			

Multiple Comparisons
Dependent Variable: VOLUME
LSD

		Mean Difference (I-J)	Std. Error	Sig.
(I) USE	(J) USE			
Livestock 1	2	35.89156667	33.87789873	.300
	3	98.52440000	23.95529193	.000
	4	142.01765000	30.30131380	.000
Irrigation 2	1	-35.89156667	33.87789873	.300
	3	62.63283333	35.53143995	.091
	4	106.12608333	40.08487036	.014
Domestic 3	1	-98.52440000	23.95529193	.000
	2	-62.63283333	35.53143995	.091
	4	43.49325000	32.13939670	.189
Brickmaking 4	1	-142.01765000	30.30131380	.000
	2	-106.12608333	40.08487036	.014
	3	-43.49325000	32.13939670	.189

* The mean difference is significant at the .05 level.

Appendix 3. Denje Dam Statistical Results

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	116801.750	3	38933.917	7.520	.001
Within Groups	129426.270	25	5177.051		
Total	246228.020	28			

Multiple Comparisons
Dependent Variable: VOLUME
LSD

		Mean Difference (I-J)	Std. Error	Sig.
(I) USE	(J) USE			
Livestock 1	2	83.14026154	35.51163860	.027
	3	124.00969011	33.73148917	.001
	4	173.82359487	46.08598784	.001
Irrigation 2	1	-83.14026154	35.51163860	.027
	3	40.86942857	40.03024462	.317
	4	90.68333333	50.87755299	.087
Domestic 3	1	-124.00969011	33.73148917	.001
	2	-40.86942857	40.03024462	.317
	4	49.81390476	49.65140767	.325
Brickmaking 4	1	-173.82359487	46.08598784	.001
	2	-90.68333333	50.87755299	.087
	3	-49.81390476	49.65140767	.325

* The mean difference is significant at the .05 level.

Appendix 4. Avoca Dam Statistical Results

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	156335.930	3	52111.977	9.331	.000
Within Groups	111695.693	20	5584.785		
Total	268031.623	23			

Multiple Comparisons

Dependent Variable: VOLUME

LSD

		Mean Difference (I-J)	Std. Error	Sig.
(I) USE	(J) USE			
Livestock 1	2	87.81487167	49.19424100	.089
	3	161.60945500	35.44822345	.000
	4	196.93487167	49.19424100	.001
Irrigation 2	1	-87.81487167	49.19424100	.089
	3	73.79458333	50.59340831	.160
	4	109.12000000	61.01794626	.089
Domestic 3	1	-161.60945500	35.44822345	.000
	2	-73.79458333	50.59340831	.160
	4	35.32541667	50.59340831	.493
Brickmaking 4	1	-196.93487167	49.19424100	.001
	2	-109.12000000	61.01794626	.089
	3	-35.32541667	50.59340831	.493

* The mean difference is significant at the .05 level.

Appendix 5.Makoshe Dam Statistical Results

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2412688.156	3	804229.385	9.130	.000
Within Groups	2025918.973	23	88083.434		
Total	4438607.128	26			

Multiple Comparisons

Dependent Variable: VOLUME

LSD

		Mean Difference (I-J)	Std. Error	Sig.
(I) USE	(J) USE			
Livestock 1	2	-684.01547500	157.97776062	.000
	3	129.12119167	148.39426673	.393
	4	170.37452500	171.35093969	.330
Irrigation 2	1	684.01547500	157.97776062	.000
	3	813.13666667	179.71438169	.000
	4	854.39000000	199.09180073	.000
Domestic 3	1	-129.12119167	148.39426673	.393
	2	-813.13666667	179.71438169	.000
	4	41.25333333	191.57617457	.831
Brickmaking 4	1	-170.37452500	171.35093969	.330
	2	-854.39000000	199.09180073	.000
	3	-41.25333333	191.57617457	.831

* The mean difference is significant at the .05 level.