Trajectory from Government-Managed to Farmer-Managed Smallholder Irrigation and its Effects on Productivity, Operation and Maintenance: An Analysis of Mamina Smallholder Irrigation Scheme in Zimbabwe

A mini-thesis submitted in partial fulfilment of the requirements for the degree of Master of Philosophy (Poverty, Land and Agrarian Studies)

INNOCENT SHAYAMANO

Student Number 3212181

Institute for Poverty, Land and Agrarian Studies (PLAAS)

Faculty of Economic and Management Sciences (EMS)

University of the Western Cape (UWC)

Supervisor: Dr. Barbara Tapela

Co-supervisor: Prof Moenieba Isaacs

March 2017

Trajectory from Government-Managed to Farmer-Managed Smallholder Irrigation and its Effects on Productivity, Operation and Maintenance: An Analysis of Mamina Smallholder Irrigation Scheme in Zimbabwe

Innocent Shayamano

KEY WORDS:

Zimbabwe

Smallholder farmers

Irrigation management transfer

Operation and maintenance

Productivity

Food security

Common pool resources

Land tenure

Self governing institutions

Collective action

ACKNOWLEDGEMENTS

I want to thank my former supervisor Dr Barbara N. Tapela for her support and contribution towards the foundation of the thesis. I want to acknowledge my co-supervisor Prof Moenieba Isaacs for her support in making the production of this mini-thesis a success. She came in at a time when the thesis had hit turbulent times but she managed to calm the waters. She gave the recipe which led to the finalisation of the thesis. I also want to extend my gratitude to Ms Ursula Arends for making sure the mini-thesis met every standard required for examinations. It is also a pleasure to thank Ms Carla Henry for her good administration work. She was always there when called upon to assist with all the administration work related to the thesis. My lovely family was also instrumental in the accomplishment of the studies as they always gave me the support. Moudy Mukunyadzi, my wife, thank you so much. I also want to thank my workmates for the support and encouragement.

ABSTRACT

Trajectory from Government-Managed to Farmer-Managed Smallholder Irrigation and its Effects on Productivity, Operation and Maintenance: An Analysis of Mamina Smallholder Irrigation Scheme in Zimbabwe

Government's decision to devolve irrigation management to farmers was partly influenced by international policy imperatives, which were propounded mainly by institutions associated with the Consultative Group for International Agricultural Research (CGIAR) and the inability by the government to continue funding operation and maintenance costs. The central question of the study is to understand the effects of Irrigation Management Transfer (IMT) on productivity, operation and maintenance in the Mamina Irrigation Scheme. Interviews with various primary and secondary stakeholders that included the irrigators, local political leadership and locally-based agriculture extension officers were carried out. The interviews were aimed at getting an insight on land tenure, participation and representation of women, water and electricity supply system and pricing, effects of irrigation management arrangements on equity and productivity, understanding the irrigators' food security status, operation and maintenance arrangement after Irrigation Management Transfer (IMT).

Findings of this study suggest that the existing governance arrangements have partly led to low crop productivity, increased water and electricity bill arrears, poor water distribution, change to uneconomic plot sizes, unsustainable increase in the number of irrigators, failure to organise for operation and maintenance. The key factors influencing the poor performance include poor collaboration, pumping system that utilised more electricity, inability of the irrigators to replace leaky pipes, failure of the irrigators to contribute towards electricity and water bills, failure of the irrigators to contribute towards operation and maintenance.

The study identified nine challenges that affected the success of IMT. The challenges that lay at the heart of Mamina irrigation scheme were mainly caused by the poor irrigation technology design, pricing structure of electricity, water permit system, inequalities in water distribution, low gender participation and representation, non-availability of formal markets for certain crops, food insecurity, plot alloction and land disputes. Poverty analysis has shown that the irrigators' ability to escape from poverty or food insecurity is critically dependent upon their access to assets. Different assets are required to achieve different livelihood outcomes. The cycle of accumulation of utility bill arrears continued even after devolution because the same defective irrigation infrastructure was transferred to the irrigators. In the case of Mamina irrigation scheme, modernisation of the scheme was required to achieve different livelihood outcomes, but because this did not happen the recurrent utility bill arrears, low productivity and food insecurity continued to be a very serious challenge even after IMT.

DECLARATION

I declare that *Trajectory from Government-Managed to Farmer-Managed Smallholder Irrigation and its Effects on Productivity, Operation and Maintenance: An Analysis of Mamina Smallholder Irrigation Scheme in Zimbabwe* is my work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full name: Innocent Shayamano Date: 08/08/2017

Signed……………………………………

LIST OF ABBREVIATIONS

AGRITEX	(Department of) Agricultural Technical and Extension Services
ARDA	Agricultural and Rural Development Authority
CAADP	Comprehensive Africa Agriculture Development Programme
CBP	Colombia Basin Project
CGIAR	Consultative Group for International Agricultural Research
CPR	Common Pool Resources
DANIDA	Danish International Development Agency
DEVAG	Department of Agricultural Development
ESAP	Economic Structural Adjustment Programme
FAO	Food and Agriculture Organization
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
IMT	Irrigation Management Transfer
NEPAD	New Partnership for Africa's Development
SADC	Southern African Development Community
SIDA	Swedish International Development Cooperation Agency
TILCOR	Tribal Trust Lands Development Corporation
USBR	United States Bureau of Reclamation
WUA	Water User Association
WUCC	Water Users Cooperative Company
ZESA	Zimbabwe Electricity Supply Authority
ZINWA	Zimbabwe National Water Authority

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Irrigation scheme governance is a complex process as irrigation management and crop productivity are influenced at multiple scales by many actors and sectors. Irrigation and crop productivity can be affected at several levels – by policies at the macro level, by management at the meso level and by use of irrigators at the micro level. Policies affecting irrigation management and crop productivity interactions comprise many different areas, e.g. environment, water, agriculture and energy, and these might be overlapping or conflicting. These policies come from different political levels, e.g. national, regional and international and, finally, multiple actors are involved at the different levels.

Since the 1990s, the irrigation sector in Zimbabwe has faced several challenges that have led several established smallholder irrigation schemes to become non-operational, with some needing major rehabilitation. This has ignited several debates on the viability and contribution of smallholder irrigation development to economic development. These developments appear to be linked to government efforts to improve the conventional state-led irrigation management approach and restructure governance institutions by adopting Irrigation Management Transfer (IMT) as an alternative approach. The Mamina Irrigation Scheme faced several challenges before and after the introduction of IMT and chief among the challenges was the accumulation of huge electricity and water bill arrears. This problem has been there since the years government was responsible for the payment of electricity and water bills. The problem has continued even after the farmers had inherited the responsibility for paying electricity and water bills. The other problem was poor water distribution, as insufficient water for irrigation reached the tail end because of leaky pipes. Furthermore, the yield levels per hectare were very low, causing food insecurity to the irrigators.

FAO (1997a) claims that in the absence of measures to manage the use and sharing of water, some of the farmers ran their sprinklers continually for up to 48 hours in one position at peak demand instead of the 12 hours for which the scheme was designed. One perception was that the problem of wasteful water use was due to farmers not being responsible for paying the costs of electricity and water supply services, hence their lack of water care. This mini-thesis examines the irrigation water governance arrangements at Mamina irrigation scheme and identifies context relevant policymaking dynamics that could enable greater irrigation operation, maintenance and productivity. Ostrom et al (1990) consider governance as a dimension of jointly determined norms and rules designed to regulate individual and group behaviour.

Government's decision to devolve irrigation management to farmers was partly influenced by international policy imperatives, which were propounded mainly by institutions associated with the Consultative Group for International Agricultural Research (CGIAR). With specific respect to smallholder irrigators, international imperatives include the Food and Agriculture Organization's (FAO) emphasis on the 'small-scale farmer', the New Partnership for Africa's Development (NEPAD) and the Comprehensive Africa Agriculture Development Programme (CAADP), which advocates for the promotion of small-scale farmers. Despite a degree of resonance with international imperatives for IMT, Zimbabwe's experience with the devolution of irrigation management seems to have further exacerbated the decline of most of the smallholder irrigation schemes. A major concern for the proposed study will be the evaluation of the effects of IMT on productivity, operation and maintenance in a selected case study area.

This study specifically examines the trajectory from government-managed to farmer-managed smallholder irrigation in the case of Mamina Smallholder Irrigation Scheme, which exemplifies many similar irrigation schemes in rural Zimbabwe. The scheme is located in Mhondoro Ngezi District of Mashonaland West Province, approximately 130km to the south-west of Harare. The scheme started operating in 1994 and has an area of 216ha. Its membership consists of 154 plotholders, most (139) of whom occupy plots of 1.5ha each. A small proportion (15 plotholders) have plots of 0.5ha each. Since the transfer of irrigation management from government to farmers, day-to-day operations of the scheme have been managed by an Irrigation Management Committee (IMT), whose members are drawn from among the farmers. The historical trajectory from government-managed to farmer-managed smallholder irrigation in Mamina has not been characterised.

Following the implementation of irrigation management transfer in Mamina, food insecurity in the irrigation scheme was reportedly so severe that during the 1996/97 season farmers ended up approaching the government's Department of Social Welfare for food hand-outs. This is confirmed by findings of a compact study conducted by the Food and Agriculture Organization (FAO, 1997a). The FAO study examined 10 irrigation schemes, which included Mamina irrigation scheme, with the aim to assess the socio-economic impact of smallholder irrigation development in Zimbabwe. At the time of the study, Mamina irrigation scheme was performing badly under the 'government management' model. The FAO study revealed that smallholder farmers of Mamina had not been able to procure any assets using irrigation incomes. Study findings also showed that the decline in productivity was so appalling that farmers at the smallholder irrigation scheme were compelled to seek drought relief assistance from government during the 1996/97 season despite their access to irrigation scheme resources. Since the release of the FAO study findings, several debates have been raised about the viability of plot sizes, crop choices and diversification; effective irrigation scheme management model; role and effectiveness of Irrigation Management Committees (IMCs); and the capabilities of the farmers. These debates remain unresolved.

Combined with observations by the FAO (1997a) of a decline in irrigation scheme productivity and profitability, such debates raise questions about the rationale often put forward by proponents of IMT. For example, in his argument for IMT, Makadho (1994) asserts that water deliveries in terms of both amounts and timing are less reliable in government-managed irrigation schemes than in community-managed irrigation schemes. Makadho (1994) therefore argues that the role of farmers in the design, construction and management of smallholder irrigation schemes needs to be increased and the role of government reduced. In the case of Zimbabwe, and Mamina in particular, although government has embraced prescriptions for the devolution of irrigation scheme management to farmers, the extent to which the roles of government should be reduced and farmers' involvement increased remains unclear. Furthermore, the assertion that water management practices in farmer-managed schemes are more reliable than those in government-managed schemes has yet to be tested in Mamina. The institutional environments for successful IMT remain unexplored.

Views have been put forward that the Zimbabwean government's adoption of IMT was influenced by the shortage of government funds to subsidise irrigation operation and maintenance. For example, Bolding (2004) asserts that in 2000 government had very limited resources to operate and maintain irrigation projects for the farmers. Payments for operation costs incurred were in most cases delayed and power supply was often cut, resulting in irrigation schemes operating inefficiently in fits and starts. Bolding (2004) concludes that the government had no choice but to hand over the operation and maintenance of smallholder irrigation projects to the irrigators. Key questions for this study will be whether or not the Mamina irrigators were ready to assume management responsibilities at the point of IMT and whether or not the irrigation committee currently possesses the requisite financial empowerment, administrative capacity, farm enterprise management skills, technical know-how and legal powers to take over irrigation management. Since the sharing of smallholder irrigation infrastructure, by nature, creates a common pool resource (CPR) scenario that demands collective action among irrigators for productivity to be sustained Ostrom (1992), a related question will be to what extent the Mamina irrigation management committee has been able to achieve cooperation among irrigators with specific regard to equitable water distribution, efficient water use, resource mobilisation, productivity, crop production and marketing, operation and maintenance of irrigation structure and conflict resolution.

Alongside IMT, there has also been an emergence of 'new agricultures', which has involved the reorganisation of commercially-orientated agriculture sectors into complex agri-food systems and global value chains (Nilsson, 1997). These new institutional arrangements now determine what to produce, how to produce and when to produce. Smallholder irrigation farmers are expected to integrate into these new agri-food systems (Nilsson, 1997). There seems to be a plausible need to examine whether or not smallholders of Mamina can effectively compete in the globalised agri-food chains, given their existing socio-economic profiles and crop production and marketing practices. There is also a need to identify the physical constraints and opportunities relating to the operation and maintenance of irrigation infrastructure.

Towards charting future directions for smallholder irrigation development, the government of Zimbabwe has created an environment to harmonise irrigation activities through the formation of the Irrigation Working Group in 2010, with the hope of coming up with sustainable solutions. The Irrigation Working Group comprises of government departments, non-governmental organisations (NGOs), universities, the irrigation industry, farmers' associations and banks. Several studies spearheaded by various members of the Irrigation Working Group have been commissioned. It is hoped that these studies will bring out a viable model for smallholder irrigation development and management. In this context this project seeks to instigate further debate and provide recommendations to reinforce findings from the other ongoing studies.

The study will relate the findings with emerging issues from farms distributed under the land reform exercise of 2000. A key objective of Zimbabwe's land reform programme was to correct the inequalities in land ownership inherited after independence in 1980 through land redistribution and the development and implementation of three models namely, A2 large scale, A1 self-contained and A1 villagised farming. Some of the gazetted farms had irrigation infrastructure existing on them and this was shared/divided among the resettled farmers. Following land reform, many challenges emerged in the management and sharing of this infrastructure. By contrast, smallholder irrigation schemes, such as Mamina, have had a longer history of shared irrigation infrastructure and have more recently made the transition to farmer-managed schemes. Lessons learnt from the case of Mamina Smallholder Irrigation Schemes might have useful applications for similar contexts associated with the land reform programme.

Beyond the Zimbabwean policy discourse on smallholder irrigation development, an overarching concern for the study was to evaluate the effects of irrigation management transfer on productivity, operation and maintenance in the Mamina Irrigation Scheme. In this regard, the study engaged with the broader scholarly perspectives in rural development literature, which considers agriculture to be the best vehicle towards reducing rural poverty. Based on observations that in many developing countries, agriculture and related activities provide most of the employment in rural areas, proponents of such perspectives argue that agriculture contributes to poverty alleviation at rural, urban and national levels in four ways, namely, (a) reducing food prices; (b) employment creation; (c) increasing real wages and (d) improving farm incomes. In examining Zimbabwe's trajectory from government-managed to farmer-managed smallholder irrigation and its effects on productivity, operation and maintenance, the proposed study will essentially test the validity of economic efficiency-orientated views with respect to smallholders in the Mamina Irrigation Scheme.

1.2 PROBLEM STATEMENT

Since the establishment of the Mamina smallholder irrigation scheme in 1994, the scheme has faced several socio-economic and food security challenges. Historical evidence of smallholder irrigation schemes in Zimbabwe has shown a cycle of good performance in the initiation phases and a general decline in the latter stages of operation. On the international arena, proponents of Irrigation Management Transfer (IMT) have prescribed the devolution of management responsibility as a means to salvage small-scale irrigation schemes but the validity of assumptions underlying IMT is still up for debate. Given that IMT has coincided with the rise of a globalised agro-food system, further investigations are required to determine whether or not small-scale irrigators can withstand the pressures. Although some scholars argue that IMT has worked well in many irrigation schemes, Zimbabwe's experience with devolution of irrigation management seems to have further exacerbated the decline of most of the smallholder irrigation schemes and most continue to face a number of challenges.

In light of the foregoing factors, a major concern for the proposed study will be to evaluate the effects of IMT on productivity, operation and maintenance in the Mamina Irrigation Scheme. The study will draw on international 'best practices' to inform the discourse on directions the country could take, especially after the land reform exercise of 2000.

The problem for the proposed investigation is captured in the following central question:

- What have been the effects of irrigation management transfer on productivity, operation and maintenance in the Mamina Irrigation Scheme?

Towards addressing the central question above, specific research questions are as follows:

- To what extent can the Common Property Resources explain the type of rights, access, use and tenure of the irrigation scheme?
- What is the current physical condition, rules and regulations in the allocation and distribution of irrigation water in Mamina irrigation scheme and how does it differ from the past?

- What are the main constraints and opportunities of the shift from a state-led irrigation system to a farmer-led irrigation system, in relation to water and electricity allocation as well as the pricing system. ?
- What is the relationship between water allocation and productivity across location (head, middle and tail-end)?
- To what extent is gender an important factor in the allocation, and decision making structures on the Mamina irrigation scheme?
- What is the food security status of the sampled households?
- What are the strengths and weaknesses of IMT at Mamina irrigation scheme?

1.3 RESEARCH AIM AND OBJECTIVES

The aim of the study is to:

Determine the effects of irrigation management transfer on productivity, operation and maintenance in Mamina Irrigation Scheme.

The objectives of the study are to:

- Determine the rights and institutions that govern access to and use of the irrigation scheme.
- Examine the physical condition, the rules and regulations in the allocation and distribution of irrigation water in Mamina irrigation scheme.
- Determine the constraints and opportunities of the shift from a state-led irrigation system to a farmer-led irrigation system in relation to water and electricity allocation as well as the pricing system.
- Determine the relationship between water allocation and productivity across location (head, middle and tail-end) .
- Determine the extent gender is an important factor in the allocation, and decision making structures of Mamina irrigation scheme.
- Determine the food security status of the sampled households.
- Establish the strengths and weaknesses of Irrigation Management Transfer (IMT) at Mamina irrigation scheme.

1.4 SIGNIFICANCE OF THE STUDY

This study will generate useful insights for the way forward regarding some of Zimbabwe's land reform beneficiaries, who now occupy gazetted commercial agricultural land under the A2 large-scale, A1 self-contained and A1 villagised farming models and face challenges of having to share the irrigation infrastructure that exists on the redistributed land. The Mamina case has experienced both the government-managed and farmer-managed irrigation models, as well as endured the transition from the former to the latter. Such experiences might yield critical understandings for decisions on the direction irrigation development in Zimbabwe should take.

Based on observations that in many developing countries, agriculture and related activities provide most of the employment in rural areas, proponents of such perspectives argue that agriculture contributes to poverty alleviation at rural, urban and national levels in four ways, namely, (a) reducing food prices; (b) employment creation; (c) increasing real wages and (d) improving farm incomes. In examining Zimbabwe's trajectory from government-managed to farmer-managed smallholder irrigation and its effects on productivity, operation and maintenance, the proposed study will test the validity these perspectives in the case of the Mamina Irrigation Scheme.

1.5 ETHICS STATEMENT

The study was undertaken in accordance with generally accepted ethical guidelines for research on human subjects. The principles of informed consent, transparency, confidentiality, equity and respect were upheld at all times. The ethics principles, adopted from work done by Tapela et al (2009) are as follows:

Principle of respect: The engagement between communities and researchers should be based on mutual respect; respect for the other person, the background, culture and life choices of that person and the wider community or organisation(s) of which that person is part.

Principle of reciprocity, mutual benefit and equitable sharing: this principle warrants that extra attention be given to ensure that communities benefit from research.

Principle of process: The engagements between the researchers and communities should be based on a fair and equitable process of negotiation that foregrounds the principle of flexibility rather than rigidity.

Principle of full disclosure: Communities are entitled to be fully informed about the nature, scope and ultimate purpose of the proposed research. The research must be explained in such a way that it is understood by community members.

Principle of differential needs and objectives: Different people have different needs and researchers' needs and objectives are different than those of communities and community members. In the process of negotiation between researchers and communities these differential needs and objectives need to be fully disclosed and openly discussed with an aim of accommodating each other.

Principle of communication and due acknowledgement: Local communities are full partners in the research process; they should therefore be kept up to date about research plans, progress and outcomes. They have the right to receive the published outcomes of research and for these outcomes to be presented to them in a way that is appropriate and understandable. They also have the right to be duly and appropriately acknowledged for their shared knowledge and cooperation.

Principle of acknowledgement of different types of knowledge: The use of multiple knowledge systems should be encouraged, where different types of knowledge, such as formal (e.g. scientific knowledge) and informal (e.g. local or traditional or indigenous knowledge), are recognised for their strengths and weaknesses, and are granted equal status.

Prior to interviews, each respondent was informed about the purpose and nature of the study as well as their freedom to participate or not in the research. All interviews for the study were carried out strictly upon receipt of either verbal or written consent from respondents. For purposes of privacy of private persons, pseudonyms rather than actual names are used to safeguard the identities of respondents.

1.6 CONCLUSION

Government's decision to devolve irrigation management to farmers has partly been influenced by international policy imperatives, which are propounded mainly by institutions associated with the Consultative Group for International Agricultural Research (CGIAR). The concepts behind these imperatives are not clear and are fragmented. Government hastily implemented IMT to reduce the burden of payment of bills. There was no consideration of its effect on productivity, operation and maintenance. The study will put into context several issues which required to be resolved before IMT. For instance, the technology was defective, it required too much power to pump water into the system, but unfortunately officials went ahead to transfer a defective system despite reservations by the irrigators in receiving a defective system. However, the irrigators organised themselves to take up the challenge through putting in place self governing institutions. These will be reviewed in the proceeding chapters ahead. The central question of the study is to determine the effects of irrigation management transfer on productivity, operation and maintenance in the Mamina Irrigation Scheme. The study will propose and build a compact conceptual framework to study Common Pool Resources (CPR) under self governing institutions on irrigation schemes. The study will bring forth the challenges that bedevilled the Mamina irrigators before and after IMT and propose how the irrigators can escape some of the dilemmas they are into. Despite all the challenges, self governing institutions have proven to be resilient in the pool of several challenges.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Globalisation is transforming traditional institutions and communities faster than they are able to adapt or modernise. The term has come into common usage since the 1980s, reflecting technological advances that have made it easier and quicker to complete international transactions—both trade and financial flows. Globalisation refers to an extension beyond national borders of the same market forces that have operated for centuries at all levels of human economic activity—village markets, urban industries, or financial centres. Markets promote efficiency through competition and the division of labour—the specialisation that allows people and economies to focus on what they do best. Global markets offer greater opportunities for people to tap into more and larger markets around the world. It means that they can have access to more capital flows, technology, cheaper imports, and larger export markets. But markets do not necessarily ensure that the benefits of increased efficiency are shared by all.The trend towards globalisation deserves special attention. It is manifest in the growth of regional blocs that cooperate in such areas as trade and legal frameworks, in the power of intergovernmental bodies such as the World Trade Organization and in the spread of transnational corporations. Globalisation has profound implications for governance, the final impact of which we cannot yet determine. In the context of Mamina irrigation scheme, globalisation would provide options on new irrigation technologies that require less energy to pump irrigation water across the irrigation scheme. Some of the technologies that could be explored are the use of centre pivots with a pumping unit requiring less energy.This chapter has several objectives. First, it gives the context of the study and why it is important. It defines what it means by Common Pool Resouces (CPR) and then it provides the CPR conceptual framework which is built on self governance institutions, collective action problems, structure of devolution that is composed of the following: constitutional choice rules, collective choice rules and operational rules. This study's proposition is that land tenure in CPR self governing institutions on irrigation schemes should include the right to determine crop and method of cultivation, infrastructure use rights, the right to mobilise and manage finances and other resources, the right to select and supervise service providers, the right to support services, right of organisational self determination, right to membership in organisation, water rights, feasibility of exclusion, gender rights, productivity, food security and globalisation.

2.2 CONCEPTUAL FRAMEWORK

The conceptual framework for the study revolves around Common Property Resources and Institutions. This framework is discussed in detail in the following sections.

2.3 COMMON-POOL RESOURCE (CPR)

Ostrom et al (1990) describe a common-pool resource, as a natural or man-made resource from which it is difficult to exclude or limit users once the resource is provided, and one person's consumption of resource units makes those units unavailable to others. Exclusion occurs when potential users can be denied goods unless they meet certain criteria. A good is subtractive when one person's use of it prevents its use by others. CPR theory sees the individual as the unit of analysis and her rational choices under a set of constraints that must be explained or controlled (Bardhan and Ray, 2006). Calculation of individual preferences provides the logic supporting commons projects with the assumption that rational actors influenced by constraints of resource institutions (enforced rules) will make calculated decisions based on their own best interest (Ostrom et al 1990). Tang (1992) claims that operating and maintaining an irrigation system requires coordination among many farmers. Collective-action problems arise easily when each farmer has the incentive to use more water and invest in the system. This problem is exemplified by the situation at Mamina irrigation scheme whereby the irrigators at the tail-end receive low water supply as compared to their counterparts at the head and middle of the scheme. This has influenced the irrigators at the tail-end not to cooperate to invest in the maintenance of the irrigation scheme. This has spiralled into affecting water and electrity payment contributions. Tang (1992) argues that the solution requires institutional arrangements to provide a structure of rules that enable participants to sustain credible commitments and long-term productive relationships with one another.

Ostrom (1992), states that in any evolutionary process, there must be the generation of new alternatives, selection among new and old combinations of structural attributes, and retention of those combinations of attributes that are successful in a particular environment. This is possible if the historical as well as the system context are considered. The historical context should be depicted as the irrigation system size, type of management, tenure issues, irrigated holding size, conflicts, productivity, conflict resolution and challenges. Ball (2006) claims that governance studies must not choose too narrow a focus, but must *study policies in their context.* They must build on a sense of *time and history*. Even if a study focuses on present political changes, these are rooted in a pre-history which in itself was not uniform, but influenced by various internal dynamics.

2.4 SELF GOVERNANCE INSTITUTIONS

Ostrom et al (1990) consider governance as a dimension of jointly determined norms and rules designed to regulate individual and group behaviour. Tang (1992) argues that in a self governance institution the irrigators develop rules that assign rights and responsibilities among themselves. The rules are not government created. The irrigators are responsible for enforcing the rules they create and for resolving disputes among themselves. Governance is about finding a way to make 'decisions that reduce the level of unwanted outcomes and increase the level of desirable outcomes' (Ostrom, 1998:1). These outcomes in the case of resource governance include efficiency, equitability, sustainability of resource access, management and use. Governance involves the structures and processes of power and authority, cooperation and conflict, that govern decision making and dispute resolution concerning resource allocation and use, through the interaction of organisations and social institutions (Woodhouse, 1997:540).

The main source of influence about 'governance' was the publication in 1968 of Garret Hardin's metaphor 'the tragedy of the commons'. The debates generated then and since among theoreticians in these disciplines have been driven by disagreements about the relation between individual rational self-interest and group interest, in particular about the likelihood and conditions for 'collective action' (Peters, 2000). The resource systems we now refer to as common property regimes have become fodder for these theoretical battles that have no *necessary* connection with the resource systems themselves but, as these theoretical debates about institutional change were picked up by development theorists and organisations, application of the theories has greatly influenced the way resource systems are understood and directed (Peters, 2000).

In a recent article, Ostrom (2000) selects Mancur Olson's (1965) publication, *The logic of collective action* as the key examplar of the 'zero contribution thesis'which, in Olson's terms, is the proposition that 'unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interest' (1965:2, cited in Ostrom, 2000:137). Ostrom argues that there is now a large literature that contradicts this proposition as well as the policy conclusion that is drawn from it, namely, that collective action can occur only when 'externally enforced rules' assure it. Taking the management of common-pool resources as typical of collective action problems, Ostrom goes on to argue that empirical studies show that successful management is characterised by certain 'design principles', which she first laid out in 1990 in *Governing the commons.* These design principles, in turn, allow a specification of the 'configuration of rules' in common-pool resource institutions. Regarding applications of the concept of collective action, Ostrom, (1992) asserts that users and suppliers of irrigation systems must craft a variety of institutional arrangements to cope with the physical, economic, social, and cultural features of each system. The rules established for particular systems are based on *design principles* that users have developed in crafting their own irrigation institutions.

2.4.1 Design Principle 1: Clearly Defined Boundaries

Defining the boundaries of the irrigation system and of those authorised to use it can be considered a first step in organising for collective action; if either of these boundaries is unclear, no one knows what is being managed or for whom (Ostrom, 1992). Even those irrigators who have authorised access can abuse their privileges as farmers at the head-end of the system may take so much water that the flow at the tail-end may be unpredictable and inadequate for agricultural use. Tang (1992) found that the variety of rules used in irrigation was smaller than among inshore fisheries. The single most frequently used boundary rule, used in 32 of the 43 systems (74%), was that an irrigator must own land in the service area of an irrigation system (Tang, 1992:84-85).

From various studies of irrigation systems, Tang (1992:90-91) identifies three types of authority rules that are most frequently used. These are (a) a fixed time slot for each irrigator;[1] (b) a fixed order for a rotation system among irrigators, and (c) a fixed percentage of the total water available during a period of time. A variety of bases were used in these rules, such as amount of land held, amount of water needed to cultivate existing crops, number of shares held, location of field, or official discretion. (Tang, 1992).The most poorly performing systems and those with relatively high levels of conflict tend to be those that use no authority rules at all.

2.4.2 Design Principle 2: Proportional Equivalence between Benefits and Costs

Rules specifying the amount of water that irrigation is allocated are related to local conditions and to rules requiring labour, materials and/or money inputs. Adding well-tailored appropriation and provision rules to boundary rules help account for the sustenance of irrigation systems themselves (Ostrom, 1992). Self-organising irrigation systems use different rules to mobilise resources for construction or maintenance and to pay water guards. In long-enduring systems, those who receive the highest proportion of the water are also required to pay the highest proportion of the costs. (Ostrom, 1992).

2.4.3 Design Principle 3: Collective-Choice Arrangements

Most individuals affected by operational rules are included in the group that can modify these rules (Ostrom, 1992). Irrigation systems using this principle are better able to tailor rules to local circumstances, since the individuals who interact directly with one another and with the physical world can modify their rules over time to better fit them to the specific characteristics of their setting. (Ostrom, 1992).

2.4.4 Design Principle 4: Monitoring

Monitors, who actively audit physical conditions and irrigator behaviour, are accountable to the users and/or are the users themselves (Ostrom, 1992). In some systems, guards retain a portion of the fines. All formal guard positions are accountable to the users; thus, monitors

[1]In Tang's study, this type is practised in 19 out of the 37 farmer-managed schemes for which data was available, and in 10 out of 12 government-owned systems.

can easily be fired if they are discovered slacking off. A failure to deter rule breaking by one mechanism does not trigger a cascading process of rule infractions, since these other mechanisms are potentially available (Ostrom, 1992).

2.4.5 Design Principle 5: Graduated Sanctions

Users who violate operational rules are likely to receive graduated sanctions (depending on the seriousness and context of the offence) from other users, from officials accountable to these users, or both (Ostrom, 1992).The initial sanctions used in most systems are surprisingly low though it is frequently presumed in modem theoretical work that participants will not spend the time and monitor and sanction each other's performance, substantial evidence exists that irrigators do both in long-enduring user organisations (see Ostrom et al, 1990).

As long as individuals are confident that others are cooperating and joint benefits are being provided, they willingly contribute resources to achieve a collective benefit (Levi, 1995). In Levi's theory, enforcement is normally provided by an external ruler even though her theory does not preclude other enforcers.

The costs of monitoring are low in many long enduring irrigation systems as a result of the rules in use.

2.4.6 Design Principle 6: Conflict Resolution Mechanisms

Users and their officials have rapid access to low-cost local arenas to resolve conflict between users or between users and officials. Applying rules is rarely an unambiguous task as even such a simple rule as "each irrigator must send one individual for one day to help clean the irrigation canals before the rainy season begins" can be interpreted in various ways (Ostrom, 1992:80). Who is or is not an "individual" according to this rule? Does sending a child under ten or an adult over seventy years of age to do heavy physical works fulfil this requirement? Can someone working only four to six hours be said to have worked for one "day"? Does cleaning the canal immediately next to one's own farm qualify for meeting a community obligation? There are always ways to "interpret" the rule in order to claim compliance while actually subverting the intent (Ostrom, 1992). Even those who intend to follow the spirit of a rule can make errors. What happens if someone forgets about a labour day and does not appear? What happens if the only able-bodied worker is sick or unavoidably in another location? (Ostrom, 1992).

If individuals are to follow rules over a long period of time, some mechanism for discussing and resolving what is or is not a rule infraction is necessary. If some farm families are allowed to free ride by sending less valuable workers to a required labour day, others will feel like suckers if they send their strongest workers, who could be working to produce private goods rather than communal benefits. Over time, only children and old people will be sent to do work that requires strong adults and the system will break down. If honest individuals are unable to provide the required labour and the system does not allow them to make up for their lack of performance in an acceptable way, they will view the rules as being unfair, and conformance rates will decline (Ostrom, 1992).When individuals hold land at both ends of a system, conflict between head and tail farmers is less severe than when no cross-cutting interests soften group antagonisms (Coward, 1979). In many irrigation systems, conflict resolution mechanisms are informal and those who are selected as leaders are also the basic resolvers of conflict.

2.4.7 Design Principle 7: Minimal Recognition of Rights to Organise

The rights of users to devise their own institutions are not challenged by external governmental authorities. Many water-user groups may organize in a *de facto* manner but are not recognised by national governments as legitimate forms of organisation (Ostrom, 1992). Consequently, leaders of a water-user organisation cannot legally open a bank account in the name of the organisation or represent the interests of their members before administrative or judicial bodies (Ostrom, 1992). Decisions by user-group organisations may not be enforced by the police or by formal courts. Without official recognition of the right to organise, it is difficult to hold either user-group officials or members accountable for their actions (Ostrom, 1992). An effective irrigator organisation lacking formal recognition may crumble rapidly when its authority to make legitimate rules for its own members is unsupported and challenged by the formal government of a regime (Ostrom, 1992).

2.4.8 Design Principle 8: Nested Enterprises

Appropriation, provision, monitoring, enforcement, conflict resolution and governance activities are organised in multiple layers of nested enterprises. Large long-enduring irrigation systems are usually organised into many tiers of nested organisations. Work teams may be as small as four or five individuals. All irrigators using a particular branch of an irrigation system may form the basis for another level of organisation. A third layer may involve all farmers served by one pumping unit. A fourth layer may involve all systems served by the same river (Coward, 1979). By nesting layers of organisation within one another, irrigators can take advantage of many different scales of organisation. Small-scale work teams help prevent free riding because everyone monitors everyone else. Large-scale enterprises allow systems to take advantage of economies of scale when relevant and to aggregate capital for investment.

The design principles reflect one of the central propositions in institutional economics and political science which has proved most problematic in their influence over the field of 'governing natural resources': namely, the definition of institutions as sets of rules. Elinor Ostrom has encouraged researchers to draw on field-based empirical research on people managing resources which has been extremely significant. Central to an examination of governance is therefore an assessment of measures and procedures for setting the rules for the exercise of power and settling conflicts over such rules (Hyden, 1998). Furthermore, governance involves the implementation of these rules through a variety of institutional mechanisms such as policies, laws and organisational structures (both formal and informal).The Mamina irrigators developed their self governing institutions which regulated the operation and maintenance of the irrigation scheme. They maintained the governance structure of the Irrigation Management Committee to make decisions and run day to day activities of the irrigation scheme.

2.5 COLLECTIVE-ACTION PROBLEMS IN IRRIGATION SYSTEMS

Ostrom (1996) claims that common–pool resources have two independent attributes namely, the feasibility of excludability (or control access) and subtractability (or rivalry). In excludability the physical nature of the resource is such that controlling access by potential users may be costly and, in the extreme, virtually impossible. In subtractability each user is capable of subtracting from the welfare of other users. Subtractability (or rivalry) is the source of the potential divergence between individual and collective rationality. Berkes et al (1989:91) define common-property resources as a class of resources for which exclusion is difficult and joint use involves subtractability.

In order to facilitate analysis, it is important to define four categories of property rights within which common property rights are held: Open access, private property, communal property and state property. Open access is the absence of well-defined property rights. Access to the resource is unregulated and is free and open for everyone (Feeny et al, 1990). Private property is the right to exclude others from using the resource and regulate the use of the resource are vested in an individual (or group of individuals such as a corporation) (Feeny et al, 1990). In communal property, the resource is held by an identifiable community of interdependent users. These users exclude outsiders while regulating use by members of the local community. Within the community, rights to the resource are unlikely to be either exclusive or transferable; they are often rights of equal access and use. Finally, Feeny et al (1990) define state property, or state governance, rights to the resource are vested exclusively in government which in turn makes decisions concerning access to the resource and level and nature of exploitation. At Mamina irrigation scheme the irrigation infrastructure were held as communal property while the irrigation plots were held privately. This is an example of two property regimes.

2.6 STRUCTURING OF DEVOLUTION TO PROMOTE COLLECTIVE ACTION

Collective action is both decision-making and the behaviour invoked by a common pool resource. It is collective because it represents the shared interests of a defined group of resources. Regarding applications of the concept of collective action, Ostrom (1992) asserts that users and suppliers of irrigation systems must craft a variety of institutional arrangements to cope with the physical, economic, social, and cultural features of each system. The rules established for particular systems are based on design principles that users have developed in crafting their own irrigation institutions. System technology which has originally been designed for management by agencies and technical people often needs to be revised to be compatible with local management capacities and water rights (Vermillion, 1994; Diemer and Slabbers, 1992). Following Meinzen-Dick and Knox (1999), devolution is the transfer of rights and obligations over resources to resource user groups. Johnson et al (1995), claim that devolution was largely driven by government fiscal shortages and inability to raise sufficient revenues from collection of water charges. Collective action is the coordinated behaviour of groups towards a common interest or purpose. There is a significant knowledge gap about actual results of IMT especially which strategies work and what are necessary pre-requisites. This thesis focuses on the basic institutional elements which are included in devolution. Included are essential set of elements (rights, responsibility and power) which should be included in irrigation management devolution.

2.7 CONSTITUTIONAL-CHOICE RULES

These rules determine who is eligible to participate in the system and what specific rules will be used to craft the set of collective-choice rules, which in turn affect the set of operational rules (Kiser and Ostrom 1982). This involves the design and establishment of the group or association, wherein its mission and basic structure of authority and decision making are determined and adopted. Mamina irrigation scheme struggled with inefficiencies in the irrigation system resulting in low pressure and inequitable allocation of water.The problem was due to three major leakages in the mainline, pressure chambers that are filled with water and broken down pressure gauges whose gate valves need attention. This affected the tail-end users as they were not receiving enough water for irrigation. Constitutional choice rules should consider key obligations that should be attached to property rights as financing, construction and maintenance of infrastructure, modernisation of irrigation infrustructure, financing costs of service provision and following rules regarding use or protection of resources. Property rights (the "building blocks" of land tenure) have received increased attention as policy instruments that affect access to food, yet the links suggested any such instruments have been the subject of little empirical research Maxwell (1998). The following are the bundle of rights proposed for Mamina irrigation scheme:

2.7.1 Land Tenure Rights

Land tenure is the system of rights and institutions that govern access to and use of the land and other resources Maxwell (1998). Rihoy (1999) states that tenure is one of the principal factors determining the way in which resources are managed and used, and the manner in which the benefits are distributed. It is usually defined in terms of a 'bundle of rights' (Bruce et al, 1993). Adams et al (1999) state that the term "land rights" may encompass rights to occupy a homestead and make permanent improvements, rights to cultivate, rights to bury the dead, and to have access for gathering natural resources such as wood. It also includes rights to transact, give, mortgage, lease, etc. areas of exclusive use, rights to exclude others, listed rights, and rights to enforcement of legal and administrative provisions in order to protect the rights holder. A review of the Irrigable Area Regulation of 1970 by Manzungu (1999) established that every plot holder was issued with three permits that were renewed every year; a permit to reside, another to graze stock and yet another to cultivate. The issuing of permits was a powerful instrument for securing the compliance of farmers.

2.7.2 Right to Determine Crop and Method of Cultivation

Vermillion (1994) claims that individual water users, sometimes are constrained by group imperatives, have the right to select which crops they will plant and how they will cultivate. He further assets that it is essential if farmers are to have the potential to optimize productivity based on local knowledge. With the advent of improved technologies farmers can optimize the productivity based on improved technologies blended with local knowledge. This permits considerable flexibility and responsiveness to market conditions by farmers in choosing crops and cropping patterns (Vermillion, 2001).

2.7.3 Infrastructure Use Rights

The set of rights should include the right to operate, repair, modify or eliminate structures (Vermillion, 1994). Vermillion (1994) implores that without this right, the association is unable or unwilling to invest in long term maintenance and repair as they are likely to consider the infrastructure as the property of the government. Where clarity is lacking about the terms and conditions for future rehabilitation and system improvements, especially regarding financing obligations, farmers are unlikely to raise a capital replacement fund (Vermillion and Garces-Restrepo, 1994). The terms and conditions for future rehabilitation and system improvements are not clear for the Mamina irrigators especially regarding the financial obligations. A systematic description should be drawn up of key maintenance processes, including a breakdown of the resources required (labour, material and equipment). The maintenance requirements for a coming year are assessed on the basis of a status survey, which involves an inventory of damage to the system. It is necessary to select suitable norms for adequate maintenance and define what maintenance is to achieve. Most literature notes that when Water User Associations contract to a set of commitments, the irrigation agency itself does not commit to any performance standards. Where there is a clear policy that farmers must finance rehabilitation it appears more likely that they will raise a capital replacement fund once they know that they are responsible for the long term sustainability of the system (Svendsen and Vermillion, 1994). Frederiksen (1994) asserts that systems designated for handing over should have reasonable operational-water which should reach the tail areas in the command. Frederiksen (1994) claims that experience shows that no society is interested in taking over a system which is leaking beyond reasonable limits or is non-functioning. The experience in Maharashtra shows that there is reluctance to take over such systems (Frederiksen, 1994). The Mamina irrigators initially resisted the takeover citing poor irrigation design which yielded higher electricity bills and that the irrigators lacked the capacity to maintain the imported pumping technology.

The physical elements and basic operating rules of the irrigation system also form a relevant part of the transfer context (Vermillion, 2001). The system should have adequate conveyance capacity to deliver required amounts of water throughout the system. The Mamina irrigation system lacked the conveyance capacity to deliver required amounts of water throughout the system as the tail-end was deprived of enough water. The system's physical facilities should be upgraded as a part of the transfer agreements and received by the irrigators in good working order. In a number of countries in Asia, total system operation and maintenance costs are shared, with government funding and managing the upper levels of the system, whilst farmers fund and manage the in-field infrastructure.

2.7.4 Right to Mobilise and Manage Finances and Other Resources

Vermillion (1994) claims that the association should have power to impose service fees, plan and implement budgets, require labour or other inputs from members, provide training, recruit and release staff. According to Rukuni et al (2006), irrigation is expensive and therefore the profitability of production is critical in justifying both short-term and long term viability of an enterprise. Hence, strong management is needed to enhance efficiency, cost recovery and be able to sustain the whole system. Indeed, development costs for small-scale irrigable schemes continued to rise due to several factors (Rukuni et al, 2006). The costs of developing a hectare of land were estimated to be between US$2,000 to US$3,000 for engineering works, which were unaffordable since Zimbabwe was faced with an acute shortage of foreign currency and this has affected the costs of raw materials procured from outside the country (Rukuni et al, 2006). The cost of irrigation development has continued to rise, the costs range between US$5000-US$7000. A Southern African Development Community (SADC) report in 1992 reported that most new smallholder irrigation schemes in the Southern African region would not cover the cost of development and operation and were therefore uneconomic. Mupawose (1984) questioned the economic viability of smallholder irrigation schemes in Zimbabwe and pointed out that certain smallholder schemes had failed and were under-utilised due to poor management, lack of inputs and irrigation experience by farmers. However, FAO (2000) concluded that cost recovery from poor farmers for operation and maintenance of irrigation systems was controversial, and subsidising these services and providing irrigation water far below cost were financially unsustainable.

Tapela (2012) claims that users will only pay water fees if the organisation managing their irrigation system delivers water reliably and ensures the long-term productivity of the system. Studies on the introduction of IMT elsewhere in the SADC region, however, raised questions about the prospects of IMT, particularly for smallholders. Denison and Manona (2007) concluded that infrastructure development alone was unlikely to succeed, rather, comprehensive strategies which consider all the activities that make up irrigation enterprise, such as markets, finance, inputs, institution-building and crop production information are needed for success.

2.7.5 Right to Select and Supervise Service Providers

Where members of the association are unable or unwilling to directly implement operation and maintenance OandM service by themselves, the association may appoint third parties (such as contractors) to implement the required services. The association has the right to set the terms of such contracts and supervise service providers.

2.7.6 Right to Support Services

Subject to government policies or agreed conditions, the association has the right of access to support services it needs in order to function properly. This may include access to credit, banking services, subsidies, conflict resolution support and other legal services, marketing assistance, and training. Where organisational and management skills are lacking an emphasis on training farmers and management staff may be essential to introduce viable local management (Sagardoy 1994; Plusquellec 1989). The legitimacy and enforceability of these contracts is an important feature of transfer (Vermillion 2001).

2.7.7 Right of Organisational Self Determination

Vermillion (1994) states that the association should have the right to determine its mission, scope of activities, basic by-laws, rules and sanctions and method for selecting and removing members. Clear policies specifying future responsibilities of farmers and agencies for water allocation at the river or aquifer level, for management of Operation and Maintenance at the system and subsystem level, for financing and for rehabilitation should be declared as soon as they are agreed upon, to minimise suspicion, confusion and resistance (Sagardoy 1994).

2.7.8 Rights to Membership in Organisation

Members that comply with rules and obligations should have the right to be members according to the association bylaws and should receive their privileges, services and benefits. This also implies the right to exclude non-members from the services provided by the association.

2.7.9 Water Rights

Perry (2001) emphasises that an orderly system of distributing water must be in place through some existing and respected regulatory framework for allocating water among farmers. Perry (2001) argues that attention should be first given to clarifying and enforcing water rights and the rules of water distribution. Where water rights, and compatible water distribution arrangements, do not exist it may be difficult to form farmer groups to manage irrigation collectively (Shah et al. 1994; Kloezen 2002). Where farmer organisations lack legal and political recognition they appear to have difficulty achieving cost efficiency, raising adequate revenue, applying sanctions and entering into contractual relationships with third parties (Vermillion and Garces-Restrepo 1994). Frederiksen (1994) suggests that an Agreement/Memorandum of Understanding that highlights the duties and responsibilities of both the parties-providers and users of water is a must. It should specify the quantity of water the farmers are entitled to, season-wise, and the persons designated for operational processes, persons to whom the disputes could be referred to. It should also state the amount of the water fees and the dates on which they are to be paid (Frederiksen, 1994). Deliveries to irrigation scheme and to individuals are thus treated as contractual obligations and water is regarded as an economic good rather than a social entitlement (Vermillion, 2001). There should be clear points of demarcation of responsibility and control where transfers of measured quantities of water are undertaken according to widely accepted agreements and rules, including payment rules (Vermillion, 2001).

2.7.10 Gender Rights

Gender is the social construction of men's and women's roles in a given culture or location. The key concepts for the study are patriarchy, gender equality, gender equity and affirmative action. Gender equality is where all human beings, both men and women, are free to develop their personal abilitities and make choices without the limitation of stereotypes. There are rights, responsibilities and opportunities that will not depend on whether they are born male or female. Gender equity refers to fairness of treatment for women and men, according to their respective needs. Gender equity and equality must be pursued in a complementary manner where gender equality is the ultimate goal. In other words, in order to achieve gender equality, it is often necessary to pursue gender equity measures. Affirmative Action refers to policies that take into account race, ethinicity, or gender to promote equal opportunity and redress historical disadvantages resulting from discrimination.

2.7.11 Agricultural Productivity

Agricultural productivity can be defined as a measure of efficiency in an agricultural production system which employs lands, labour, capital and other related resources. Dewett and Singh (1966:66) explain it as follows: "Productivity expresses the varying relationship between agricultural output and one of the major inputs, like, land or labour or capital, other complementary factors remaining the same.....”. ‘Land’ is viewed as area with different natural attributes. It realizes different rents, and its costs vary in accordance with the need and location. ‘Labour’ represents all the human rendered services, other than decision making, and ‘Capital’ is the non-labour resources employed in cultivation by the farmers.

2.7.12 Food Security

The term “food security” has been defined and used in a multitude of ways over the past two decades. Through the 1970s, food security was used with reference to aggregate food production or food availability, often at the national or global level. The work of Sen (1981) drew attention to the critical importance of access to food, particularly at the individual and household level, as distinct from food availability. Later a further crucial component was recognized: individuals’ ability to utilise the food to which they had access. Hence food availability, access, and utilisation are the three general components usually mentioned in definitions of food security today. The food security status was determined on the sampled households at Mamina irrigation scheme figure 10. It was observed that 60% of the households were food insecure.

2.7.13 Inequality

Inequality is the state of not being equal, especially in status, rights and opportunity. Alkire et al (2015) argue that well-being should be defined and measured in terms of the beings and doings valued by people. There are inequalities in the distribution of water at Mamina irrigation scheme. The plotholders at the tail-end do not receive enough water for irrigation and yet they are expected to share the water and electricity bills equally. This has affected cooperation with regard to contribution of utility bills. Furthermore the situation was exarcebated by the electricity and water authorities as they cut these services to everyone regardless of whether a user has paid or not. In addition, inequalities are visible in the structure of the Irrigation Management Committee as women hold very few posts that are not influential.

2.7.14 Availability of Markets

The success of irrigated agriculture depends on the availability of markets. The markets should provide information on crops required, when the crop is required, the quality standards, determine how the crop is to be produced, the variety preferences, the price and assurance that when the crop is finally produced it has a market. The irrigators would then determine the needs, wants, and interests of the target markets. A greater share of produce from Mamina irrigation scheme is sold in the informal market where prices are unstable but these markets have to some extent cautioned the irrigators. The market should provide assurance to pay the irrigators on time so that they invest back into their irrigation fields. The irrigators would therefore generate income for payment of bills, to finance operation and maintenance and improving livelihoods. In solving the marketing challenges the marketing model could follow the 1966-1980 marketing arrangement whereby government had a policy to create irrigation growth points that had a large core estate to provide services to the smallholder irrigators. The smallholder irrigators adopted the cropping programme of the core estate taking advantage of the marketing structure of the estate (Rukuni and Makadho, 1994).

2.7.15 Sustainable Livelihoods

A livelihood comprises the assets, skills, technologies and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both in the present and in the future, while not undermining the natural resource base (Chambers and Conway, 1992). Understanding institutional processes allows the identification of restrictions/barriers and opportunities (or ‘gateways’) to sustainable livelihoods (Scoones 1997). Since formal and informal institutions (ranging from tenure regimes to labour sharing systems to market networks or credit arrangements) mediate access to livelihood resources and in turn affect the composition of portfolios of livelihood strategies, an understanding of institutions and organisations is therefore key to designing interventions which improve sustainable livelihood outcomes. The sustainable livelihoods approach emphasises getting the institutional and organisational setting right, with emphasis on both formal and informal mechanisms. This study focused on access to particular livelihood resources such as technologies, skills and credit. Credit access would specifically focus on contract farming concentrating exclusively on seeds, pesticides and fertilisers. Evidence shows that since IMT, Mamina irrigators have never received any credit support from banks, contracting firms or government. The assets they own as a group are 3 tractors and the implements, but however all of them are not functioning. The irrigation infrastructure is communally owned while the irrigation plots are privately owned. The department of AGRITEX has played a key role in providing training to the irrigators.

2.8 CONCLUSION

Studies in the 1990s focused more on the performance of irrigation systems (Rukuni and Makadho, 1994). A first shift to study management came through (Makadho, 1994) centering on the use of the dominant gated surface irrigation schemes and their performance, focused on equity and later relative water supply. Makadho's (1994) management approach was based on fine tuning the water delivery to move towards the objectives of meeting the crop water requirements. The problem of irrigation management transfer in Zimbabwe is basically both technological and institutional. Institutions are the rules of the game in a society, or formally, the humanly devised constraints that shape human action (North 1990: 3). The key characteristics of institutions are that "they are a pattern of norms and behaviours which persist because they are valued and useful" (Merrey, 1996). Utilising institutional analysis of irrigation systems large and small around the world, Ostrom argues that the rules governing how water users interact among themselves and with irrigation managers are just as important to a project's success as are well-constructed engineering facilities (Ostrom, 1992). Manzungu (1999) argues that irrigation management should be seen as composed of different management domains where some people are more active in one area than others due to a variety of reasons. Domains refer to areas of action where some individuals have more influence than others.

Without institutional arrangements that address excludability and subtractability, common pool resources are essentially open access resources available to anyone, which are very difficult to protect and easy to deplete (McKean, 2000:28-29). A further shift in technological interventions came in 1990s, as new design concepts were introduced in Zimbabwe. Chidenga (2003) argues that designers viewed improvements mainly from a structural point of view, by looking at new technology choices. While most attention has been given to technological improvements very little has been given to institutional arrangements. Kloezen (2002: 10) drew on the work of Ostrom (1992) and Ostrom et al (1990) to summarise these as: arrangements of inclusion and exclusion of group members; rules and rights of property, allocation, distribution and use of resources and benefits; arrangement for selection of leadership and user representation; internal monitoring and auditing of everyday management, including financial; arrangements of conflict resolution and sanctioning of defaulters.

Uphoff et al (1991) proposed an activity-based description of irrigation management. He distinguishes three main types namely, control structure activities, water use and organisational activities. Productivity is largely dependent on several factors including crop genetic material, water management practices (institutional arrangements), agronomic practices, economic, performance of the irrigation technology and policy incentives to produce. Modernisation advocates the use of modern concepts in water control (Plusquellec et. al, 1994) incorporating adjustable structures and including automatically controlled systems. Such systems require operational and maintenance staff who are highly skilled with knowledge in computers, electronics and mechanics. The second dimension of water control is concerned with organisational aspects dealing with how farmers co-operate to make irrigation systems work (Lowdermilk, 1990). The third aspect deals with political aspects of domination and regulation processes involved in water utilisation (Mollinga, 1998: 27-30).

Some authors have stressed the importance of property rights in management. Coward (1986), through his concept of hydraulic property, drew attention to the issue of property creation during construction and maintenance of schemes in irrigation systems, which affects subsequent use of the infrastructure. This is quite pertinent to Zimbabwe given the communal sharing of resources in smallholder irrigation systems. The presence of many actors in the schemes raises questions regarding how the different actors relate to each other and how these relationships in turn shape management operations. The concern for how the different actors interact explains why some authors have advanced the notion of rules and roles as critical in irrigation management (see Coward, 1986; Ostrom and Gardiner, 1993). Part of this effort has been to draw the distinction between administration and management. Administration is about following predetermined schedules, criteria, instructions, guide lines etc., while management is about ensuring flexibility and adaptation and learning new methods and strategies (Uphoff et al, 1991: 26.28).

This is the development of rules and sanctions for operations and maintenance of the irrigation system, financing costs of irrigation, settlement of disputes, and modernisation and improvement of the system. Operational rules are the specific decisions and actions in the course of implementing operations (water distribution/allocation and productivity), maintenance (leaky pipes and high pumping costs), financing, dispute resolution, and modernisation and improvement of irrigation systems.

There is a research gap on organisational models that work best with IMT. Alternatives for improving productivity are agronomic improvements (for example improved crop husbandry, cropping strategies and crop varieties), technical improvements (for example improved and lower cost technologies for extracting water), managerial improvements (for example improvements in farm-level resource management or system operation and maintenance and institutional improvements (for example introduction of water pricing and improvements in water rights). Molden et al (1998) claim that success of irrigation management transfer depends on a whole set of institutional arrangements or the rules-in-use and the willingness of the users to comply and enforce and /or change the rules in the light of changing circumstances.

CHAPTER 3

SMALLHOLDER IRRIGATION FARMING, IRRIGATION MANAGEMENT TRANSFER IN ZIMBABWE AND THE GLOBAL PERSPECTIVE

3.1 INTRODUCTION

Zimbabwe is a landlocked country in the Southern African region, with an area of over 390,000 km^2, bordered by Zambia, Mozambique, South Africa, Botswana and Namibia. It is situated between about 15 and 22 degrees south latitude and about 26 and 34 degrees east longitude. Climatic conditions are largely sub-tropical with one rainy season, between November and March. Rainfall reliability decreases from north to south and also from east to west. Zimbabwe's economy is largely driven by agriculture and the majority of rural people depend on farming for their livelihoods (Rukuni and Eicher, 1994). About 86% of the rural population live in natural farming (or agro-ecological) Regions 3, 4 and 5, where rainfall is erratic and unreliable (Rukuni and Eicher, 1994). This makes dry-land cultivation a risky venture as currently the country was experiencing long dry spells of more than 21 days which gradually reduced the crop yields as the persistent moisture stress affected the crops. The success of rain fed agriculture in natural farming Regions 4 and 5 has been known to be in the order of one good harvest in every 4 to 5 years (Rukuni and Eicher, 1994). Less than half (37%) of the country receives rainfall considered adequate for agriculture (Rukuni and Eicher, 1994). Despite that rainfall is unevenly distributed and that many communal farming areas are located in the drier agro-ecological regions, the remarkable increase in maize production by Zimbabwe's smallholder farmers in the 1980s has often been referred to as Africa's green revolution success story (Eicher, 1994). This was prior to the Economic Structural Adjustment Programme (ESAP) propounded principally by the International Monetary Fund (IMF).

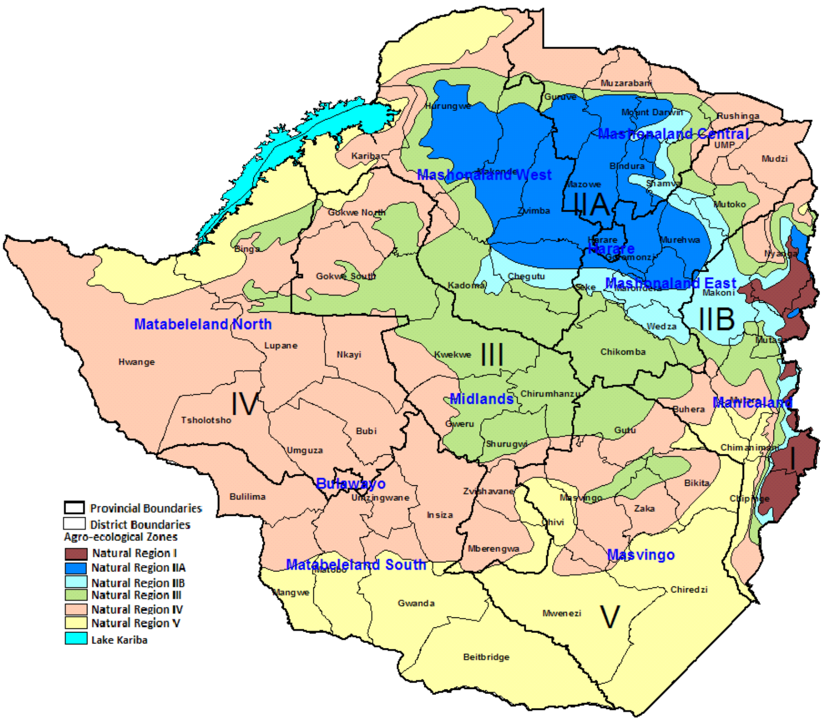
This chapter gives an overview of the question of smallholder irrigation farming, irrigation management transfer in Zimbabwe and the global perspective. It traces the socio-economic impact of smallholder irrigation development in Zimbabwe. It provides an insight of the 3 types of irrigation management. Furthermore the chapter gives a brief outline of support requirement by smallholder farmers to manage irrigation schemes. The chapter further defines operation, maintainence and modernisation. It looks at the discourses around operation and maintainance. The chapter gives a comparative analysis of various irrigation management approaches in Zimbabwe. The national perspective is triangulated with the global perspective. It gives a review of irrigation development in the world. It draws from international experience the successful size of irrigation schemes, the irrigation holding size and infrustructure development.

3.2 CONTRIBUTION OF AGRICULTURE TO THE ECONOMY

Agriculture occupies a central place in the Zimbabwean economy, contributing 15-18% of Gross Domestic Product (GDP). In addition, it contributes over 40% of national export earnings and 60% of raw materials to agro-industries (Comprehensive Agriculture Policy Framework 2014). Over 70% of the population derives its livelihoods from the agricultural sector. Agriculture-related employment supports a third of the formal labour force. In recognition of the importance of agriculture in economic development, the African Union Commission, through the Maputo Declaration of 2003, encourages member states to spend at least 10% of their National budget towards agriculture (Comprehensive Agriculture Policy Framework, 2014).

The diverse agro-climatic conditions enable Zimbabwe to grow a large variety of food and cash crops (see Figure 1). Over 23 types of food and cash crops are grown. The major food crops include maize, sorghum, pearl millet, finger millet, ground nuts, wheat, cow peas, bambara nuts and sweet potatoes. White maize is the main staple food. Cash crops include tobacco, cotton, tea, coffee, sugarcane, soya bean, sunflower and horticultural products. Zimbabwe has a well-developed livestock sector, catering for the needs of both domestic and export markets. The livestock sector comprises beef, dairy, poultry, pigs, goats and sheep (Comprehensive Agriculture Policy Framework, 2014).

Figure 1: Zimbabwe Agro-Ecological Zones (Zimbabwe Agricultural Investment Plan 2013-2018)



Source: Comprehensive Agriculture Policy Framework, 2014

Maize is the main staple food crop for the majority of the Zimbabwean population. Since February 2009, the marketing of all agricultural commodities has been deregulated, with the Grain Marketing Board (GMB) maintaining a minimum floor price (Comprehensive Agriculture Policy Framework, 2014). GMB has the mandate to maintain minimum strategic reserves of 500 000 tonnes of grain crops in physical stock. However, low productivity and production in the past few years has made it difficult to maintain strategic grain reserves at that level. The strategic grain reserve replenishment has been undertaken through imports by both government and the private sector (Comprehensive Agriculture Policy Framework, 2014). In 2016 the government imported 446 200MT and private companies imported 303 395MT. The grain stocks by January 2017 at the GMB depots were 306 539MT. Government has introduced the Command Agriculture Programme in order to increase grain production. In the 2016/17 season a total of 247 035ha of land was contracted under the Command Agriculture Programme.

Production and productivity of grain crops has been on the decline since the early 1990s. From a surplus producer of maize, Zimbabwe has become a net food importer during the past decade. This has been attributed to low producer incentives due to erosion of producer prices by inflation as well as input shortages among other challenges. National grain requirements was 1 800 000 tonnes (Comprehensive Agriculture Policy Framework, 2014).

Wheat is another strategic grain food crop. Consumption requirements are in the range of 350 000 - 450 000 tonnes/annum. Production has been below national requirements due to recurrent droughts, electricity power cuts and outages (Comprehensive Agriculture Policy Framework, 2014). The local industry has an annual off take of 170 000MT. Efforts were underway to contract 65 000ha under wheat production to banish the importation of wheat. The implementation was done under the Command Agriculture Programme.

3.3 SOCIO-ECONOMIC ASPECTS OF SMALLHOLDER IRRIGATION SCHEMES IN ZIMBABWE.

Impacts of smallholder irrigation schemes can be traced back to as early as the 1930's. Alvord (1933) claimed that Mutema irrigation scheme in Manicaland Province of Zimbabwe had alleviated famine in the area. The same author further claimed that 28 ha under irrigation in Mutema area reduced the need for drought relief grain from government by approximately 90 to 180 tons per year. Rukuni (1984) showed that, in general, yields achieved on smallholder schemes are higher than rainfed dryland yields in communal areas. Mupawose (1984) claimed that certain smallholder schemes had failed and were under-utilized. This was attributed to poor management, lack of inputs and irrigation experience by farmers. A Southern African Development Community (SADC) report in 1992 reported that most new smallholder irrigation schemes in the Southern Africa region will not cover the cost of development and operation and are therefore uneconomic. Meinzen-Dick *et al* (1993) showed that gross margins for irrigating farmers were significantly greater than for dry land farmers. They further pointed out that the effect of irrigation on increasing crop production and incomes is even more visible in the dry winter season, when dry land production is impossible because of lack of rain. The same study mentions that the majority (72%) of farmers with between 0.25 ha and 0.5 ha of irrigated land reported that irrigated land was their only source of livelihood. FAO (1997b) in a brief general overview of the smallholder irrigation sub-sector in Zimbabwe concluded that smallholder irrigation had brought many successes to farmers.

3.4 IRRIGATION MANAGEMENT IN ZIMBABWE

Chidenga (2003) claims that there are three broad types of smallholder irrigation schemes: government-managed, farmer-managed and jointly managed schemes. Government-managed schemes were developed and maintained by the Department of Agricultural Technical and Extension Services (AGRITEX). Farmer-managed schemes are developed by the government but owned and managed by the farmers' Irrigation Management Committees (IMCs) with minimal government interventions in terms of management. For jointly-managed schemes the farmers and government share the financial responsibility for operation and maintenance. For such schemes, the government is usually responsible for the headworks (i.e., dam or weir, pumping station and conveyance system up to field edge), while farmers take responsibility for the infield infrastructure (Chidenga 2003). Chidenga (2003) claims that 50 percent of the smallholder schemes are farmer-managed, 32 percent are government-managed and 18 percent are jointly managed. Policies of devolving management of resources generally assume that users will organise and take on the necessary management tasks, experience with co-management programmes shows that this does not happen everywhere (World Development, 2002).

A study done by FAO (1997a) on 10 smallholder irrigation schemes claimed that the type of management was found to be important as it affects the level of Operation and Maintenance (O&M), the cropping pattern practiced, and the general viability of the schemes. Farmer managed schemes, if properly planned, proved to have better O&M than government managed schemes. The study's findings were that all the farmer managed schemes in the study, except for Longdale irrigation scheme which was having some technical problems, have efficient O&M. The ability of some farmer managed schemes like Chitora and Wenimbi to pay for their O&M costs indicate that these schemes can be self sustaining and that the government in future should concentrate in establishing such type of irrigation schemes. The argument was that the Government managed schemes had problems because of budgetary constraints. The study further indicated that irrigation water management was a problem at schemes that did not have the responsibility to pay for O&M costs. Schemes such as Mamina and Oatlands were identified as not managing water efficiently. The reason given was that the farmers had nothing to lose since the government paid for the water and electricity bills. The study strongly recommended that cost recovery measures should be instituted to influence farmers to be more responsible. The study then concluded that the schemes be turned over into farmer managed schemes.

An important issue related to management transfer, and one that is yet to be resolved is, *what is the optimal size limit for farmer organisations which are assuming responsibility for irrigation management?* Drawing on the experiences of management transfer in more developed countries, it has been suggested that irrigation district or company management models may be better suited than farmer organisations for managing more large-scale or complex irrigation systems (Svendsen and Vermillion, 1994). Shah et al (1994) documented the greater organisational robustness of the more autonomous and accountable irrigation company model (totally locally financed and with no free riders) in contrast to government-sponsored farmer organisations or cooperatives for developing and managing tube well irrigation in Gujarat.

3.5 SUPPORTING FARMERS TO MANAGE IRRIGATION

Kadigi et al (2014) state that in order for farmers to take an active role in the management of irrigation schemes, governments will need to invest in market infrastructure and agricultural extension services as well as the capacity building of farmers. Major drawbacks hindering farmers from taking part in the management of schemes include insecure land tenure and a lack of knowledge of water management and irrigation mechanisms. In addition, insecure and unclear land rights deterred farmers from investing in management. These disadvantages, coupled with the high costs of fertilizers, seeds and pesticides, poor links to markets to sell their goods and a lack of post-harvest storage, have proved to be considerable constraints (Kadigi et al , 2012).

According to Van Koppen et al (2003), a major challenge is that irrigation management transfer is often implemented with insufficient clarity regarding ownership of the scheme. This creates problems of governance and co-management. Governments must recognise that the transfer of a scheme to participants can only take place when the scheme is running effectively and extension services are in place for training. Transaction costs must be low for participants and a variety of complementary investments must be in place (inputs and outputs, improved access to credit and secure land rights). By lowering transaction costs and providing investments in areas such as inputs and outputs, governments can tackle some of these obstacles (Kadigi et al, 2014).

3.6 OPERATION AND MAINTENANCE

Operation is defined by Uphoff et al(1991) as "all activities that result in water delivery being acquired, mobilised, conveyed, divided and supplied or actuated at the desired point which could be the field, farm, plot or the crop as appropriate". Maintenance is defined in this study as " all the activities that are carried out to ensure that the system is kept in good repair and working order (Chidenga, 2003). Maintenance becomes renovation or rehabilitation when the artefacts require a substantial degree of replacement of components of the same type and output capacity, such that the design criteria are retained. Modernisation of schemes seeks to address the current problem situation through redimensioning the capacity, use and output potential of the system (Weare 1989:15-20 in Chidenga 2003).

The government realised that it was subsidising smallholder irrigation projects too much (Hunt 1958, Roder 1965:125, cited in Manzungu and van der Zaag 1996a: 10). By 1981, irrigation levies paid by users contributed only 15% of the total operation and maintenance costs incurred by government (Pazvakavambwa, 1984:6). User contribution further plummeted with the increase in operation and maintenance costs to government while the levies charged to users remained the same over the years (Rukuni, 1988). There is debate on this issue of viability with some refuting the use of the term economic viability and instead calling for 'social schemes' (Rukuni, 1988:18, Pazvakavambwa, 1984:2). In the same line of reasoning others suggest that government should shoulder all capital costs of irrigation development, while irrigators should at least pay for all running costs (Mupawose, 1984:i-ii; Rukuni, 1988:17).

Shah et al (2002) argues that successful IMT experience worldwide was that operation and maintenance costs should be an insignificant proportion of the total income which is typically less than 5% of the gross income from farming. Shah and Vankoppen (1999) claim that if the Arabie-Olifants scheme were to be turned over to farmers in 1999, the running costs would be between 20 – 25% of the total value of the irrigated output the scheme produces. Manzungu (1999:16) notes the maintenance fees introduced in 1984 were Z$145 per hectare but covered less than one quarter of the operation and maintenance costs. Ogunwale et al (1994:11) found that although farmers paid US$52 the smallholder schemes faced challenges of frequent breakdown of pumps and sprinkler lines and poor availability of parts. This was the key reason for the decline of smallholder schemes after government withdrawal. Shah (2002) noted that gravity systems generally cost more to build but less to run than pump schemes. In the case for Mamina there are no maintenance fees introduced except for the US$65 per irrigator they contribute towards electricity and water bills.

3.7 PUMP IRRIGATION SYSTEMS

Chidenga (2003) summarises the technological trajectory in Zimbabwe which he refers to as a progressive shift from run-of-river gravity canal surface systems that were developed in Manicaland between 1912 to 1950. The need to expand irrigation to flatter areas in the middle Save valley with limited gravity head led to the introduction of lift schemes with diesel, then electric powered pumps which generated considerable power costs leading to a debate in the 1970s on the need to maximise area served and thus reduce field losses. With the advent of independence pressurised irrigation system development got technical support from FAO. Chidenga (2003) further reveals that technological change at this stage was hardly accompanied by any debate, leaving a range of irrigation system designs in a technological repertoire largely unquestioned since independence. The net result has been a number of schemes which were developed that are now showing operation and maintenance stress. This historical problem is affecting the Mamina Irrigation scheme and many other smallholder irrigation schemes.The FAO (1997a) study revealed that frequent pump breakdowns and disconnection of electricity were common at government managed schemes.

3.8 IRRIGATION TECHNOLOGIES AND WATER SOURCES

Chidenga (2003) claims that irrigation technologies in use in this sub-sector include surface irrigation, which comprises 68 percent of the schemes, and sprinkler irrigation, which makes up 32 percent of the schemes. In terms of area, 89 percent of the area is under surface irrigation and 11 percent is sprinkler irrigated (Chidenga 2003). Of late, centre pivots have been introduced in the smallholder sector , but the coverage and impact are yet to be determined. The Mamina irrigation scheme uses the draghose sprinkler system. Most smallholder schemes in Zimbabwe have water stored in medium-sized and large dams (Chidenga 2003). Other important sources have been river flow, deep motorised bore-holes, sand abstraction systems, shallow wells and springs (Chidenga 2003). The water source for Mamina irrigation scheme is Mamina dam which is a perennial water supplier.

A new water allocation system was introduced in 1997. The new system used the concept of water permits, which were issued for a five-year period and renewable if need be (FAO, 1997a). The permit system was managed by the Catchment Councils, which were appointed on a catchment basis to administer the allocation of water. The councils comprised of representatives of all stakeholders including the smallholder farmers. The permits issued to farmers could be revised at any time at the discretion of the council to ensure equitable distribution of water. During times of water shortages the Catchment Council distributes water according to its availability and ensures that all users get an equal share.

3.8.1 Block Irrigation System in Smallholder Irrigation Schemes in Zimbabwe

The block irrigation system was introduced in smallholder irrigation schemes in Zimbabwe as a mechanism to save irrigation water by using it efficiently (Manzungu 1999). This was to be achieved through scientific irrigation scheduling. Irrigation scheduling is applicable within certain narrowly defined parameters. Firstly, the crops must be in pure stands. This explains why, in block irrigation, farmers are required to grow the same crop in one stretch of land (Manzungu 1999). Secondly, the crops must be planted at the same time in order that management operations are synchronised. Consequently, crops belonging to different farmers are treated as one crop as far as irrigation scheduling and other related management aspects are concerned (Manzungu 1999). The most frequently advanced reason is efficient water use through scientific irrigation scheduling. The second advantage, which relates to economic aspects of crop production, is that it is easier to market the crop produce. Thirdly, block irrigation is conceived as making crop rotations easier to implement which ultimately results in improved maintenance of soil fertility. A related advantage is the possibility of better pest and disease control. A typical landholding per farmer in 'new' schemes where block irrigation is practised is 1.0 to 1.5 ha (Manzungu 1999).

3.9 CHARACTERISATION OF SMALLHOLDER IRRIGATION AND POTENTIAL FOR FUTURE DEVELOPMENT IN ZIMBABWE

Zimbabwe has made tremendous strides in smallholder irrigation since 1980. From about 57 malfunctioning schemes covering 2 500 ha in 1980, over 180 formal irrigation schemes have been developed over the years in communal, resettlement and small-scale purchase areas, bringing the total area under smallholder irrigation today to about 13 000 ha. In all, 155 500 ha are under irrigation, and therefore the area under smallholders is about 8.5 percent of the total irrigated area as shown in Table 1.

Table 1: Status of Irrigation Development in Zimbabwe

Sector	Area under irrigation (Ha)	As % of total area under irrigation
Large-scale commercial farms	126,000	81
Government farms	13,500	8.5
Out grower schemes	3,000	2
Smallholder (including small-scale purchase areas)	13,000	8.5
Total	155,500	100

Source: AGRITEX estimates, 1999.

Furthermore, estimates based on water availability suggest that the total potential for further irrigation development is 240,000 ha (Ministry of Lands, Agriculture and Water Development, 1994 in FAO, 2000). This potential includes water available within Transboundary Rivers such as the Zambezi and in inland dams. The smallholder irrigation sub-sector is expected to command a significant share (90,000 ha) of this potential.

3.9. COMPARATIVE ANALYSIS OF VARIOUS IRRIGATION MANAGEMENT APPROACHES IN ZIMBABWE

The FAO (1997a) commissioned a comparative compact analysis across agro-ecological zones between different irrigation systems as well as between farmer-managed and government-managed systems in Zimbabwe. Five of the schemes (Chitora, Murara, Mzinyathini, Principe and Wenimbi) were presumed to be operating well and the other five (Longdale, Mambanje, Ngezi Mamina, Oatlands and Rozora) which were under government management then were prejudged to be poor. The factors which determine the performance of an irrigation scheme included planning, group cohesion, institutional support, strength of the IMC, and choice of crops.

The study further made findings that, firstly, projects viewed by farmers as being their own performed better than projects that are viewed by them as belonging to government. Secondly, investment in operation and maintenance is determined by the feeling of ownership by the farmers. Thirdly, the question of inheritance is a critical determinant of the level of investment by the farmers. Fourthly, escalating energy costs threaten the viability of some schemes.

The study further observed that it is legitimate to develop farmer-managed irrigation schemes, as they result in very little financial burden on the government for operation and maintenance. The government, given the budgetary constraints affecting it, should find a way of handing over the existing schemes to the farmers for management.

In the studies done in South Africa, Makhura and Mamabolo (2000) observed that there are successful farmer-managed irrigation projects in the sugar industry of KwaZulu-Natal and Mpumalanga. The success is attributed to smallholders enjoying access to credit, input supply, access to markets and capacity. In addition, Shah et al (2002) observed that farmer management in smallholder irrigation was doomed to failure because of lack of access to credit and well-established markets. Contrary to the IMT proponents Jansen (1993) argued that for almost all crops, except cotton in marginal areas, irrigation is only profitable when it is subsidised by government.

3.10 GLOBAL PERSPECTIVE

3.10.1 Irrigation Development in the World

Between 1960 and 1995, the irrigated area in the world expanded by 130%, from approximately 100 million hectares (ha) to 230 million ha. In China alone, the irrigated area expanded from 16 million ha in 1950 to 50 million ha in 1994. However, after three decades of rapid increases in investment in irrigation systems, by the mid-1980s the rate of expansion of irrigated area through construction of new irrigation systems diminished to only one percent per year (Blake et al, 1994). Relatively low grain prices, rising construction costs, concern about the rapid deterioration of irrigation infrastructure and poor overall management performance, compounded by increased awareness of the potential environmental impacts of large-scale irrigation development, have all led to a slowing down in the rate of irrigation investment (Johnson, 1994). This decline in per ha support for irrigation management has seriously hampered the performance of government-developed irrigation systems (Easter, 1993). In numerous cases, it became necessary to rehabilitate irrigation systems less than 10 years after completion due to inadequate maintenance (Repetto, 1986), yet even after widespread rehabilitation, extensive training efforts and attempts to elicit farmer participation, performance has generally remained low, especially in South Asia and Africa.

Countries with successful irrigation management programmes like Mexico, Taiwan, the USA and New Zealand have had successful transfer programmes because their policies have been consistent and understood by all (Menchaca and Torregrosa 1994; Farley 1994; Vermillion and Garces-Restrepo 1994). Other countries such as Nigeria and Niger have had problems because their policies were not consistent and the involved parties have been uncertain exactly what policy the government wished to implement (Musa 1994; Longsway and Amadou 1994).

3.10.2 Designing a Charging System

Cornish et al (2004) argue that cost recovery and water demand management are two distinct objectives which require different types of intervention. For many years the World Bank has encouraged governments to employ a policy of cost recovery, on the principle that users should cover operation and maintenance costs and some of the capital costs. Although most researchers generally use the term “cost recovery”, Small and Carruthers (1991) distinguish between “cost recovery” and “irrigation financing”. Under cost recovery, all funds collected go to the government treasury department. In irrigation financing funds are returned within, or returned to, the irrigation agency to meet the actual irrigation costs. This distinction is another way of underscoring the need to go beyond a ‘simple’ calculation of the level of cost to be recovered and making explicit the way in which funds raised are used to benefit the irrigation development or the individual scheme. Charges for water or energy for lifting water are rarely adequate to cover operation and maintenance expenses. As a result irrigation infrastructure is deteriorating at a rapid rate. The most widely used charging structure, which is adequate where the sole objective is cost recovery, is a fixed cost per ha. This may vary according to crop type, with higher charges for more water demanding crops. The conclusion of most authors is that beneficiaries should pay the full ongoing cost of system operation, maintenance, replacement and upgrading of facilities. Despite indications of intent, there is no published evidence of water pricing leading to better service delivery to farmers. Johansson et al (2002) note that methods of allocating water are sensitive to physical, social, institutional and political settings, making it necessary to design allocation mechanisms accordingly. The amount users have to pay may vary in accordance with the area cultivated, season and type of crop to irrigate, but it does not vary according to the amount of water actually used. Instead, a system of water pricing relates payments to water use decisions (Small 1989). The water fee regulation supported development of a widespread tripartite system of resource mobilisation which included a fixed area fee (based on the area irrigated by a farmer), a volumetric fee (based on estimated volume of water diverted into a farmer's field), and an annual labour contribution for system maintenance (Chen and Ji 1994). However, the contrary situation is that poor service delivery leaves farmers unwilling to pay. Perry (2001) argues that in Egypt and the Republic of Iran the costs of charging individual farmers are likely to outweigh the projected benefits. Currently the government of Zimbabwe has no mechanism to address the issue of water and electricity pricing. The flat-rate tariff structure should be replaced so that farmers pay for the amount of water or electricity actually consumed. The irrigation systems need to be modernised as most control structures are located in the upper levels of the system. The preferred crop variety choices (traditional varieties) do not provide the farmers with obvious motivation for introducing water saving irrigation technologies. Molle (2003) emphasises that institutional and technical reform of the water sector is imperative and most often precede water pricing. Ward (2000) argues that if water pricing encourages farmers to use water more efficiently, they will be more likely to adopt water saving technologies. Without action to improve payment of bills and enforcement systems, policies may remain theoretically sound but unmanageable and ineffective in practice. Shah et al(2002) claims that as for the Panchkanya scheme in Nepal a member has to pay a one-time entry fee less than US$2 to enrol and annual maintenance fee of around US$7 or three man days of labour. Against this all members take 3 irrigated crops every year for water charges ranging from US$1.5-US$3.00 per hectare.

3.10.3 Crop Productivity

Oweis et al (2000) argue that the most encompassing measure of productivity used by economists is total factor productivity (TFP), which is defined as the value of all output divided by the value of all inputs, but the concept of partial factor productivity (PFP) is more widely used by economists and non-economists alike. Where land is the limiting resource, the greatest economic benefits are achieved by increasing output per unit of land. Therefore emphasis is placed on technologies that increase yield per hectare (e.g. high yielding varieties and fertiliser). Oweis et al (2000) claim that the change in PFP measured in yield per hectare is a useful indicator of the economic performance of the agricultural sector. Molden et al (1998) define water productivity as the quantity of the product divided by the quantity of the input. Physical production is expressed in terms of mass (kg), or even in monetary terms ($), to compare different crops (Molden et al, 1998). In plant breeding the development of an appropriate phenology by genetic modification, so that the durations of the vegetative and reproductive periods are matched as well as possible with the expected water supply or with the absence of crop hazards is usually responsible for the most significant improvements in the yield stability. Planting, flowering and maturation dates are important in matching the period of water scarce situation, though, farmers employ strategies to obtain more mass of production per unit of water supply, such as deficit irrigation (Perry and Narayanamurthy, 1998), supplemental irrigation (Oweis et al, 1999) or water conservation practices (Rockstrom et al, 1998).

The concept of water productivity used by plant physiologists, molecular biologists and plant breeders refers to the crop output (either grain or biomas) per unit transpiration by the plant (this is typically referred to as WUE). There has been steady improvement in grain yield per hectare through plant breeding rain-fed and, most particularly, in irrigated varieties. The development of short-season varieties, reducing the growing time from 5 months to 3.5 to 4 months, has also been a major source of water saving. Thus , there is no question that, over the past 3 decades, varietal improvement through plant breeding (aided by investment irrigation and advances in the fertiliser technology) has been the major source of increase in water productivity (Richards et al, 2013). Richards et al (2013) claim that as the potential ceiling value for the harvest index (ratio of grain to biomass) is rapidly approaching in many crops, the only way to maintain increases in yield will be to increase the biomass. In studies done by Makombe and Sampath (2010) results show that the farmer managed community system consistently out-performs the government system in production, distribution and management performance. In an evaluation done by Shumba et al (1996) on six smallholder irrigation schemes in Zimbabwe the average yields range from 2.7 to 7.4t/ha for maize at the lowest and highest yielding schemes respectively. Only one out of six schemes realised a profit margin of more than ZWD223/month per plot holder after operation and maintenance costs (currently met by government) were deducted.

Rockstrom et al (1998) argue that the best option for increasing crop water productivity lies in combining such practices as water harvesting, conservation tillage and supplemental irrigation during short dry spells with management strategies that enhance infiltration of rain, increase water holding capacity of soils and maximise plant water uptake through timeliness of farming operations and soil fertilisation. Crop water productivity (Kg / m^{-3}) varies with location, depending on such factors as cropping pattern, climatic conditions, irrigation technology, field water management and infrastructure, and on the labour, fertiliser and machinery. Oweis et al (1999) demonstrate that sustainable increases in crop water productivity can only be achieved through integrated farm resources management. This approach combines water conservation, supplemental irrigation, better crop selection, improved agronomic practices, political and institutional intervention. As highlighted above water productivity is dependent on several factors, including crop genetic material, water management practices, economic and policy incentives to produce. Evidence shows that there are many people working in parallel on means to increase the productivity of water but the efforts remain disjointed.

3.10.4 Size of Irrigation System

Shah (2002) noted that a 1 500 hectare system that serves 1 500 irrigators costs much more to manage in terms of the logistics of service delivery, fee collection, maintenance than a similar system that serves 5 large scale farmers. Moreover, it was a lot easier for 5 large farmers to come together and agree to the rules of self management than for 1 500 smallholders to do. In Turkey, 40% of the irrigated area consists of farm holdings that are 5-20 hectares in extent and where farmers cultivate high value crops for export to Europe. The Mamina irrigation scheme is a 216 hectare system with 154 irrigators.

3.10.5 Irrigated Holding Size

Chambers (1988) claims that farmers that work tiny plots are forced to pursue what he calls the “hedgehog strategy” of depending on a variety of sources to earn a livelihood. Wester et al (1995: 3) noted that the Senegal village irrigation schemes varied between 0.1-0.4 hectares. Abernethy et al (2000) state that the plot size of smallholder schemes studied in the Niger valley was 0.25 hectares. Manzungu (1999) found that the plot sizes for Nyanyadzi ranged from 0.76 hectares to 1.1 hectares. Shah et al(1999) argues that it is common for men to seek urban jobs while the women cultivate the plots. Shah (1999), claims that many plot-holders continue cultivating their plots until they are too old to work on them. Most of the Mamina irrigators have plots ranging from 1.5 hectares (139 irrigators) and 0.5hectares (15 irrigators.)

3.10.6 Irrigation Infrastructure Development

Among a number of reasons given by proponents of Irrigation Management Transfer (IMT), low productivity of many existing schemes was said to have prompted a change in investment policy away from new infrastructure and toward programmes that improve the performance of existing schemes (Water Sector Board, 2007). Jones (1995) indicates that there had been a sharp decline in World Bank lending for new irrigation schemes. Jones also states that funding for new irrigation construction had largely stopped and the emphasis had shifted to the sustainability and efficiency of existing systems. Thompson (2001) attributes this development to the fact that investments in irrigation systems were perceived to have failed to address the changing needs of irrigation services, since the rehabilitation of existing schemes was mostly carried out to restore original project objectives without taking into account the desirable changes in cropping patterns and irrigation techniques so as to allow low water consumption and high productivity practices.

A report by FAO (1997b) identified constraints that have slowed irrigation investments to include relatively high costs of irrigation development, inadequate physical infrastructure and markets, poor investments in irrigation, lack of access to improved irrigation technologies, lack of cheap and readily available water supplies. Within the SADC[2] Region, Denison and

[2] Southern African Development Community Regional Economic Community comprising 15 Member states

Manona (2007) observed that despite the South African government pouring millions of Rands into smallholder irrigation schemes, many of these had collapsed or remained under-utilised. The slow increase in the irrigable area in Zimbabwe can be attributed to the high cost of irrigation development, inadequate physical infrastructure and markets, poor investments in irrigation, lack of access to improved irrigation technologies, and lack of cheap and readily available water supplies.

3.11 CONCLUSION

The concept description of irrigation operation, maintenance and modernisation will be critically considered in developing a new model for Mamina irrigation. For purposes of this study, maintenance refers to renovation or rehabilitation and modernisation represents redimensioning the capacity, use and output potential of the system. Given the defective nature of the scheme design modernisation will be ideal to revive the irrigation scheme. Maintenance is the work needed to keep the irrigation scheme in good condition. The chapter draws on international best practices by presenting experiences of other researchers on irrigation system size and irrigation holding size. These should inform future irrigation development.

The chaper provides an overview of the pump irrigation system. The pumping of water at Mamina irrigation scheme requires a lot of energy and always spirals the electricity bills. The chapters reviews alternative solutions. The water permit system is part of the challenges affecting Mamina irrigation schemes. The chapter reviews recommendations by the literature on designing a successful charging system. The experiences will add value to the study.

CHAPTER 4
RESEARCH METHODOLOGY

4.1 INTRODUCTION

The methodology provided direction on how the data was collected. Data from interviews significantly supported and paved the way for the understanding of self governing institutions. The questionnaire on the other hand helped identify the needs of the irrigators. The source of data were primary and secondary data sources. The study implemented both primary and secondary data in answering research questions. Both data sources contributed to the objectives and helped generate conclusions. The study adopted questionnaires and an interview guide as instruments for data collection in a joint qualitative and quantitative approach. The survey strategy permitted the collection of large amounts of data which were later analysed with the help of the SPSS statistical package. Consent was sought from each individual respondent particularly before they were allowed to complete any instrument. The questionnaires were personally administered by the researcher to selected respondents with the assistance of the AGRITEX Extension personnel. Data analysis was done on SPSS software version 20. The description aspects of the findings were presented with the help of tables and graphs alongside other descriptive statistical indicators. The quantitative data collected was first coded and entered into SPSS to pave the way for easy analysis. This chapter covers the research methodology giving an insight into research approaches and techniques used in the study. The descriptive data analysis approach was used to analyse data. SPSS was used to analyse the crop productivity and food security status of the irrigation scheme.

4.2 OVERVIEW OF RESEARCH METHODS

Building on the theoretical background, a number of research questions have been identified concerning irrigation in Zimbabwe.

4.2.1 Key Informant Interviews

To find out more about irrigation management transfer and its effects on crop productivity, operation and maintenance, semi-structured qualitative interviews with Mamina irrigators were deemed an appropriate method. The interviews aimed at getting an insight on land tenure, participation and representation of women, water and electricity supply system and pricing, effects of irrigation management arrangements on equity and productivity, understand their food security status, operation and maintenance at Mamina Irrigation Scheme after IMT.

Towards identifying the physical and socio-economic constraints and opportunities to irrigation scheme operation, in general, and farming enterprises, in particular, the researcher conducted a number of interviews with various primary and secondary stakeholders. These included irrigation farmers in Mamina, local political leadership and a locally-based extension officers (see Figure 2).

Figure 2: Partipants of a Consultative Group Interview, 2015

From left to right: Mr Shayamano (Researcher), Mr Nyekete (Chairperson of Mamina Irrigation Scheme), Mr Musaka (Honourable Senator for Mhondoro) and Mrs Manditswara (Acting Chief Horticulture Extension Officer).

Source: Researcher

The key informants were officials in key government departments, parastatals and development partners in their offices. Group focus interviews were done to get a broader picture of the irrigation scheme in the different categories. The number of interviews of officials in key government departments, parastatals and development partners was decided beforehand to be 10 which was feasible within the scope of the study, but the goal was to continue interviewing people until saturation was reached, i.e. no new information was gained. Some of the interviews were conducted over the phone and face to face. A total of 3 interviews were done by phone and 7 were face to face. Generally for qualitative interviewing, face-to-face interviews are recommended over phone interviews since it is believed to give more in-depth answers and the interviewer can observe body language and how the interviewee responds physically to the questions. However, there is some evidence suggesting that answers provided in a face-to-face situation compared to over the phone are not that different and, furthermore, phone interviews provide large benefits in terms of cost- and time savings, making the method highly efficient in relation to the large volumes of data that can be collected (Bryman, 2008:457-458). Contact had already been established with some of the interviewees through the Irrigation Working Group and a network of contacts built over 12 years of the researcher's work as an Agricultural Extension Specialist.

4.2.2 Focus Group Discussions

A discussion session was held at the irrigation scheme to explain the objectives of the study with the two resident Agricultural Extension Workers. The researcher discussed the procedures with the Extension workers. The strategy was that where more irrigators in the field were found, the researcher proceeded with the focus group interviews, rather than individual interviews to save time. Focus group discussions with the Irrigation Management Committee were held. The purpose of the focus group discussions was to generate information on collective views and meanings that lie behind those views in order to clarify, extend, qualify or challenge the data collected through other methods. The optimum size of the groups was between 6 and 8 participants excluding the researcher and AGRITEX officers. The optimum group size was informed by the recognition that small groups risk limited discussion occurring while large groups can be chaotic, hard to manage for the moderator and frustrating for participants who feel they get insufficient opportunities to speak.

4.2.3 Piloting Questionnaire

A draft questionnaire was tested. The irrigators' specific requirements or understanding were used to determine the data entry. Some of the basic parameters recorded were plot details, types of crops grown, inputs, yield levels, distributin of produce by market share and water alloction. The questionnaire was then adjusted to align with the field conditions of the scheme. The issues that did not apply to the scheme were removed and those which were omitted were added.

4.2.4 Selection of the Respondents

A sample size of 30 irrigators was used. A sampling frame was obtained from the available membership list. The members or plots were categorised as ‘head, middle and tail’. This is because plots in different categories are exposed to different conditions. For example, farmers at the head are said to enjoy benefits in terms of undisrupted water supply and those at the tail are expected to endure frequent disruptions. After categorising members or plots as ‘head’, ‘middle’ and ‘tail’, a random sample was chosen for each stratum by placing names into a hat and selecting the numbers required. The interviews took place between 2014-2015 at the irrigation scheme in the fields with the irrigators.

4.2.5 Fieldwork

The researcher worked with the two AGRITEX Extension Workers who were residents of the scheme. The first meeting took place in their office where they gave an overview of the irrigation scheme and on how they came up with cropping programmes for the irrigators. The Extension workers presented the list of irrigation plotholders. Initially, the researcher wanted to interview as many irrigators as possible with the assistance of the Extension personnel but the irrigators were not easy to find in the field during day time as they irrigated between 22h00 and 06h00 during offpeak hours and the issue of time for the irrigators was raised. The strategy was to select a representive sample of 30 irrigators with 10 irrigators for each category for the questionnaires.

Each questionnaire took around 30 minutes to administer. A total of 18 men and 12 women were interviewed.The strategy was to conduct interviews, observations and questionnaires to achieve the goal of getting the key information. This method was appropriate since it put emphasis on the interviewees’ point of view and how he or she understood and framed an issue (Bryman, 2008: 436-440). This sampling approach builds on the idea that the best information is obtained by hand-picking interviewees that are most relevant to the issue being investigated and has privileged knowledge or experience about the topic (Denscombe 2010).

4.2.6 Observations

Observations were also key in the study and its focus was on the participants, irrigation technology, cropping, operations, condition, agricultural extension personnel and their interaction and relationship. Marshall and Rossman (1989) define observation as “systematic description of events, behaviours, and artifacts in a setting chosen for study”. Le Compte (1999) defines participant observation as “the process of learning through exposure to or involvement in the day to day or routine activities of participants in the researcher setting. Merrian (1998) suggests that the most important factor in determining what a reseacher should observe is the reseacher’s purpose for conducting the study in the first place. “ Where to begin looking depends on the research question, but where to focus or stop action cannot be determined ahead of time”.

4.2.7 Triangulation of Observations with Interviews, Focus Group Discussions and Survey/Questionnaire

Observation allows researchers to check definitions of terms that participants use in interviews, observe events that informants may be unable or unwilling to share when doing so would be impolite, or insensitive, and observe situations informants have described in interviews and questionnaires, thereby making them aware of distortions or inaccuracies in descriptions provided by those informants (Marshall and Rossman, 1995). Obervations provide researchers with ways to check for nonverbal expression of feelings, determine who interacts with who, grasp how participants communicate with each other, and check for how much time is spent on various activities (Schmuck, 1997). Observations would be used as a way to increase the validity of the study, as observations help the researcher have a better understanding of the context and phenomenon under study. Observations can be used to help answer descriptive research questions, to build theory, or to generate or test a hypothesis (Dewalt and Dewalt, 2002).

4.3 ANALYSIS

The themes came from the data (an inductive approach) and from the investigator’s prior theoretical understanding of the phenomenon under study (an *a priori* approach). *A priori* themes come from the characteristics of the phenomenon being studied; from already agreed on professional definitions found in literature reviews; from local, commonsense constructs; and from researchers' values, theoretical orientations, and personal experiences (Bulmer, 1979; Strauss, 1987; Maxwell, 1996). Strauss and Corbin (1990:41–47) called this "theoretical sensitivity". Investigators' decisions about what topics to cover and how best to query informants about those topics are a rich source of *a priori* themes (Dey 1993:98). In fact, the first pass at generating themes often comes from the questions in an interview protocol (Coffey and Atkinson 1996:34).

Repetition is one of the easiest ways to identify themes. Some of the most obvious themes in a corpus of data are those "topics that occur and reoccur" (Bogdan and Taylor, 1975:83) or are "recurring regularities" (Guba, 1978:53). "Anyone who has listened to long stretches of talk," said D'Andrade (1991:287), "knows how frequently people circle through the same network of ideas". The more the same concept occurs in a text, the more likely it is a theme. In pioneering work, Lakoff and Johnson (1980) observed that people often represent their thoughts, behaviours, and experiences with analogies and metaphors. Analysis, then, becomes the search for metaphors in rhetoric and deducing the schemas or underlying themes that might produce those metaphors (D'Andrade, 1995; Strauss and Quinn, 1997).

The descriptive data analysis approach was used to analysed data. SPSS was used to analyse the crop productivity and food security status of the irrigation scheme.

4.4 DATA PREPARATION

Data preparation involved checking and logging the data in; checking the data for accuracy; entering the data into the computer; transforming the data; and developing and documenting a database structure that integrates the various measures.

Checking and logging the data in involved creating a procedure for logging the information and keeping track of it until the researcher was ready to do the comprehensive data analysis. This was accomplished through using SPSS and running descriptive analyses to get reports on the data status. As soon as data was received it was screened for accuracy. This was done right away to allow the researcher to go back to the sample to clarify any problems or errors. The information was screened on the following basis:

- Are the responses legible/ readable?
- Are all important questions answered?
- Are the responses complete?
- Is all relevant contextual information included (e.g. data, time, place, researcher)?

Assuring that the data collection process does not contribute inaccuracies will help assure the overall quality of subsequent analyses.

4.4.1 Developing a Database Structure

The database structure was created within SPSS to store the data for the study so that it can be accessed in subsequent data analyses.

4.4.2 Entering the Data into the Computer

The data was entered once and a procedure was setup for checking the data for accuracy and double entries. Once the data was entered, various programmes on SPSS were used to summarise the data and to check that all the data are within acceptable limits and boundaries. For instance, such summaries enabled the researcher to easily spot whether there were persons whose data was wrongly entered.

4.4.3 Data Transformations

Once the data was entered the raw data was transformed into variables that are usable in the analyses. There was a wide variety of transformations that were performed. Some of them were:

missing values

A specific value was designated to represent missing values. For instance -99 was used to indicate that the item is missing.

4.5 STEPS TAKEN TO DEVELOP KEY CONCEPTS

4.5.1 Defining the Problem

The researcher talked with the irrigators and Agricultural Extension personnel and asked questions about the challenges on the scheme, productivity, operations and maintenance and marketing before developing a concept for a smallholder irrigation scheme.

Of critical importance were the initial questions that must be answered early to get the conceptual framework right. These questions apply whether developing an irrigation scheme (system, capability, or service) or an operational structure to employ the irrigation scheme. Researchers must ask more than "who, what, where, when, why, and how." They must develop specific questions to address broader issues, such as:

- What are the current deficiencies and gaps?
- What are the external constraints?
- What are the real-world performance drivers?
- What are the operational, security, and support concepts?

4.5.2 Research

The researcher went on to research the key issues emerging from the response of the irrigators and Agriculture Extension personnel.

4.6 THE CHALLENGES AND LIMITATATIONS THAT WERE FACED IN THE FIELD

The challenge which was faced was finding the irrigators in the field during day time as they did their irrigation operations in the evening from 22h00 to 06h00. As an outsider, reception at the irrigation scheme was not that difficult given the procedure the researcher took to enter the scheme through the AGRITEX extension officers. The challenge met was the perception by the irrigators that the exercise was an NGO activity to identify vulnerable households but with further intaractions and explanations the perception disappeared. When the irrigators saw that the AGRITEX extension officers were part of the team, the irrigators had trust in the processes and the researcher. The reseacher also interviewed women and the challenge which was very visible was that some women had their babies in the field. The challenge was trying to respond to questions and also attending to the babies proved to be hard; it resulted in the increase of the interviewing time. Some irrigators gave their special requests for the researcher to find markets for their crops. The researcher explained the main purpose of the study to the irrigators and highlighted that some of the outcomes would sensitise stakeholders in the sector to prioritise marketing as a driver to sustainable crop production and irrigation management.

4.7 RELIABILITY AND VALIDITY

By adapting the concepts of reliability and validity used in quantitative research, the quality of qualitative research can be assessed. Building on Bryman's (2008: 376-381) examination of different stances to assessing qualitative research, the following components were considered: *reliability,* referring to the potential of replicating the study at a later occasion and gaining the same results, *internal validity,* referring to how credible the findings of the study are and *external validity,* referring to the possibility of generalising the findings to other contexts. When conducting qualitative interviews there is a risk that the interviewee does not understand the questions posed by the interviewer and that the interviewer misinterprets the answers or makes subjective interpretations.

In order to enhance the reliability of the study, the following actions were taken:

i) A test interview was performed (not included in the sample), after which the interview guide was modified making sure the questions were clear and understandable.

ii) A thorough description is provided in the methods chapter of the procedures taken in conducting the study.

In order to enhance the internal validity of the study, the following actions were taken:

i. A purposive sampling was conducted to ensure that interviews were conducted with relevant actors with knowledge and experience of the field.
ii. Triangulation in terms of using more than one method was applied, i.e. interviews were complemented by document analysis to gain higher confidence in the findings.
iii. The researcher ensured the comprehensive and methodical data analysis using the SPSS software.
iv. The researcher made use of the theoretical framework in analysing the data, ensuring consistency.

In order to enhance the external validity of the study, the following actions were taken:

i. Information provided was validated by the local Agricultural Extension personnel through cross checking farmers' crop production records and experiences with the irrigators.
ii. The researcher ensured the proper introduction of the purpose of study so the irrigators did not get the impression that it was an interview for food relief and resultantly give incorrect responses.

4.8 CONCLUSION

Primary and secondary data sources used were instrumental in answering the research questions. Interviews were carried out with various primary and secondary stakeholders such as the irrigators, local political leadership, local based extension officers, senior government officials and private playes in irrigation development. Secondary data was important in capturing past change and/or development as well as helpful in the research design. It provided much of the background work and made identification of gaps more easier. Primary data captured the current situation at Mamina irrigation scheme. This enabled the targeted research issues to be addressed. Questionaires helped in identifying the needs of the irrigators. Piloting the questionnaire assisted in realigning it to field conditions. Focus group discussions clarified or challenged the data collected through the various methods. Categorising members/plots into head, middle and tail revealed interesting results of significance, highlighting that different categories are exposed to different conditions.

The inclusion of Agricultural Extension workers during fieldwork made entry into the irrigation easier. The irrigators quickly accepted the researchers intentions.

The strategy to conduct interviews, observations and questionaires was appropriate as it put emphasis on the interviewes point of view on how an issue was understood and framed. Observations were determined by the purpose of conducting the study. Research questions directed what to look for. Observations increased the validity of the study through better understanding of the context and phenomenon under study.

CHAPTER 5
OVERVIEW OF MAMINA IRRIGATION SCHEME

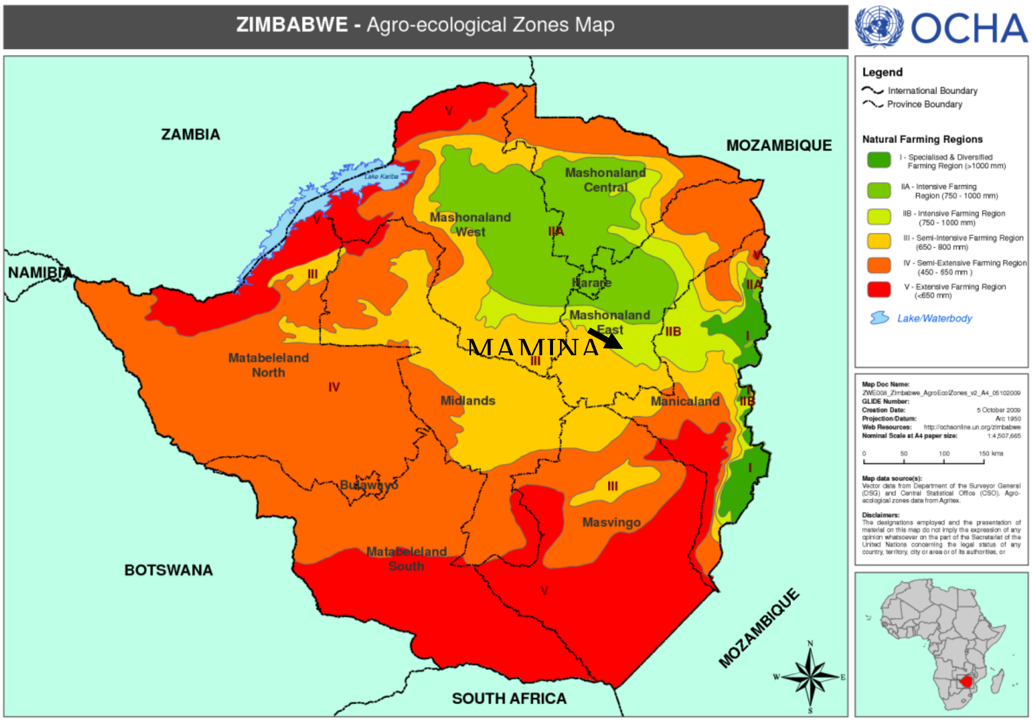
5.1 INTRODUCTION

This chapter gives an overview of Mamina irrigation scheme. It gives the location of the scheme and the agro-ecological region it falls in. Maps have been provided in the chapter to enhance the location of the irrigation scheme. The overview covers important information about the establishment of the irrigation scheme, the source of funding, the financier, the technology, institutional reforms of the Department of Water Resources into Zimbabwe National Water Authority (ZINWA), water utilisation and the devolution process.The chapter presents the land tenure structure at the scheme. It gives an overview of ownership, access and maintenance of agricultural equipment such as tractors. It traces the sustainability of the existing water and electricity supply system and pricing. It considers participation and representation of women in the IMC and decision making positions. It checks whether the irrigators received any credit support since the scheme was established. The chapter checks whether the extension services were reaching out to the irrigators. It concludes by giving views by the Member of Parliament, the honourable Senator and institutional actors.

5.2 LOCATION OF MAMINA IRRIGATION SCHEME

Mamina irrigation scheme is located 130 kms south-west of Harare. The scheme falls within Agro-Ecological Region III, which is a relatively low rainfall area with an average rainfall of 650-800mm per year (see Figure 3).

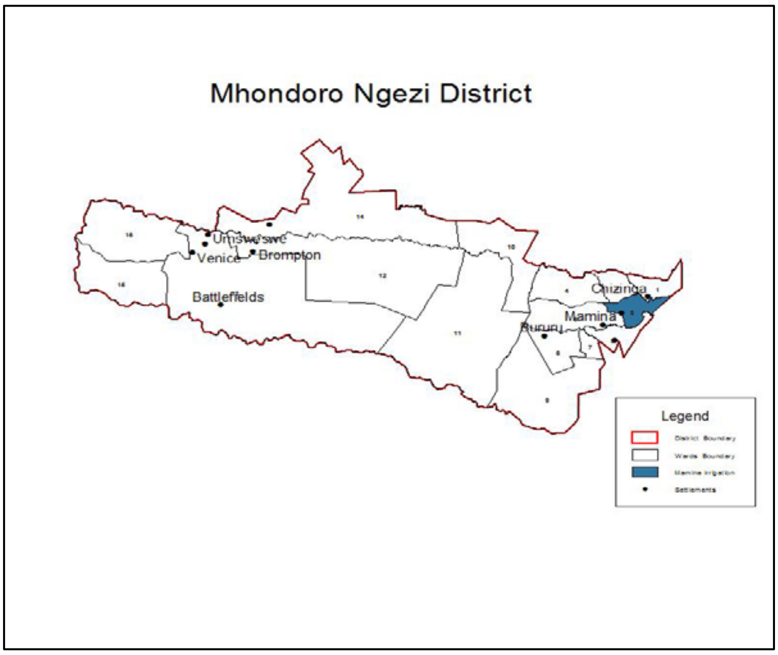
Figure 3: Map showing Agro-Ecological Regions of Zimbabwe and location of Mamina Irrigation Scheme



Source: http://reliefweb.int/map/zimbabwe/zimbabwe-agro-ecological-zones-map-administrative-boundaries-05-oct-2009

Administratively, Mamina is situated within the eastern parts of Mhondoro-Ngezi Rural District Council in Mashonaland West Province (see Figure 4). Until recently, Mhondoro Ngezi was part of Kadoma District, which has since been split into two rural district councils, the other being Sanyati. The land surrounding the scheme is part of Mhondoro communal area. The nearest service centre is Mubayira.

Figure 4: Map showing the location of Mamina Irrigation Scheme in Mhondoro-Ngezi District



Source: AGRITEX 2017 (Landuse Branch)

5.3 OVERVIEW OF MAMINA IRRIGATION SCHEME

Studies done by FAO (1997a) indicate that the irrigation land was identified in the early 1990s and established in 1994. During the planning phase, the intention was to have the scheme constructed simultaneously with Mamina dam. A German development bank called *Kreditastalt für Wiederaufbau*[3] had in 1989 provided finance for dam construction, and the scheme was to be financed through a soft loan of Zim$6,076,388 [4] extended to the Government of Zimbabwe. Irrigation infrastructure in the scheme was based on a sprinkler system in which water was first pumped into a balancing tank at a high point and then fed into the sprinkler system by gravity. Electric motor-driven pumps abstracted water from Mamina dam to settling tanks, from which the water was gravitated into the fields. Nine tanks with a total water storage capacity of 11 mega litres were available for the gravity-fed irrigation system. Each tank took one hour to fill, and water was fed via a drag hose system.

[3] Reconstruction Credit Institute.
[4] Exchange rate in July 1990 was $1USD to Zim$2.45

Water was sourced from the nearby Mamina dam, which was located on the boundary between Mashonaland East and Mashonaland West provinces. The Department of Water Resources (DWR) operated and maintained the dam and associated infrastructure up to the field edge, while the Department of Agricultural Technical and Extension Services (AGRITEX) operated and maintained the infield infrastructure. After the irrigation reforms the Zimbabwe National Water Authority was created with a mandate to operate and maintain the Mamina dam and associated infrastructure up to the field edge while the Department of Agricultural Technical and Extension Services (AGRITEX) was to provide agricultural extension services. AGRITEX was unbundled to create another Department of Irrigation (DOI) which was mandated to continue with irrigation development in Zimbabwe and provide technical backstopping to the irrigators. The Mhondoro Ngezi Rural District Council (RDC) legally owns the land on which the scheme is located. Since the establishment of the scheme, operation and maintenance (O and M) was largely government-managed. In the absence of measures to manage the use and sharing of water, some of the farmers were reported to run their sprinklers continually for up to 48 hours on one position at peak demand instead of the 12 hours for which the scheme was designed. One perception was that the problem of wasteful water use was due to farmers not being responsible for paying the costs of electricity and water supply services, hence their lack of water care (FAO, 1997a).

5.4 GOVERNMENT-MANAGEMENT FRAMEWORK

Under the government-management framework, AGRITEX was responsible for paying the scheme's electricity bills. However, by 1998 the bills had escalated to between Z$80 000 and Z$115 000 per month. The costs translated to between Z$370 and Z$532 per ha per month, which was exorbitant. The average bill of Z$100 000 per month added up to over Z$1.2million per year, which was equivalent to half (50%) of the budget allocated to AGRITEX for managing and operating all the smallholder irrigation schemes in the country. AGRITEX struggled to pay the costs, owing to financial constraints which faced government then, the Zimbabwe Electricity Supply Authority (ZESA) cut off electricity supplies for periods of up to three months, resulting in crop losses. The government-management approach gave the responsibility for infrastructure repair and maintenance to the Department of Water Resources (DWR). While this institution made efforts to ensure that dam infrastructure and water pumps were repaired and maintained, farmers complained that the DWR took too long to repair a pump whenever it broke down.

5.5 THE DEVOLUTION PROCESS

As government lacked the fiscal space to continue to support the irrigators with payment of bills, government had no choice but to concede to shifting payment of bills to the users. In effect, government's capitulation was not only informed by local experiences but it also resonated with the logic of international prescriptions for IMT. As government prepared to devolve scheme management responsibility, farmers resisted the pressure for them to accept this responsibility. Irrespective of the farmers' stance, government proceeded to put in place a gradual exit plan. In 2000, government and farmers reached an agreement in which the transfer would be implemented in a phased process in which government would initially meet the larger proportion (75%) of electricity and water costs while farmers paid the remaining quarter (25%) of the bill. The arrangement was that farmers would eventually take over responsibility for paying the entire bill as well as meet the operation and maintenance requirements of the scheme. Towards addressing farmers' needs for capacity and resilience strengthening, an organisation called the Farm-level Applied Research Methods in Eastern and Southern Africa (FARMESA) was contracted to train farmers to grow specialised horticultural crops, as well as prepare them for a shift from production of low value crops to high value crops. While the Zimbabwe Agricultural Policy Framework of 1996 guided irrigation management reforms that were implemented by national funding agencies, international organisations like FAO and the Swedish International Development Agency (SIDA) provided policy guidance and support towards irrigation reforms, such as IMT. Such support included the FARMESA project, which was financed by FAO and SIDA to develop methodologies for IMT in government-run irrigation schemes (Manzungu, 1999).

5.6 LAND TENURE

Mamina irrigation land has existed under tenure systems that were previously communal before the irrigation scheme was established. Changes in tenure were induced by the introduction of the irrigation technology. The establishment of the irrigation scheme brought in a gradual change in tenure. Some of the changes were in plotholding size and the government took greater control on who was to benefit, how the land was to be used, what to grow, how the infrastructure was to be maintained and payment of bills. These conditions changed slowly as government had limited fiscal space to meet its obligations. Government not withstanding further payment of bills and operation and maintenance had no choice but to devolve this role to the irrigators. Mamina irrigation scheme was devolved without a clear bundle of rights. The challenges facing Mamina irrigation scheme has stayed with them for a long time before and after Irrigation Management Transfer (IMT). This has influenced the researcher to propose a bundle of rights which are informed by Ostrom and a number of scholars. The bundle of rights would encompass rights to occupy a homestead, and make permanent improvements, rights to cultivate, infrastructure use right (right to operate, repair, modify or eliminate structures on the irrigation infrastructure).

Mamina irrigation scheme is 216 ha in extent. The scheme started off with 154 plot holders, of whom 139 were allocated 1.5 ha plots and 15 were allocated 0.5 ha each. Initially the majority of the 154 households who had benefited from the allocation of irrigation plots ranging in size from 0.5 to 1.5 ha were civil servants and other employed people, including ‘outsiders’. Local farmers who lost their land to irrigation and those who felt excluded from the scheme were not happy with the approach to plot allocation. Owing to the protracted contention the local Kraal head independently evicted 26 ‘outsiders’ from the scheme replacing these outsiders with 75 locally-based farmers, who included unemployed young people and widows. It is not always the regular practice when the actions of the traditional leaders benefit women especially as beneficiaries of land. Most of the customary laws discriminate against women from benefiting. This partly explained why some of the plots in the scheme had become smaller in size than the original 0.5 ha or 1.5 ha range that was designed for water management purposes. By 2015, when this study’s fieldwork was conducted, the number of irrigation plotholders was 189.This dispute resolution strategy as well as family sub-divisions of plots both contributed to the 23% increase in the number of plot holders from 154 to 189. It was observed that the smallest plot in 2015 was 0.16 ha in size, which was a small fraction (10%) of the original plot allocated. While the average size of Mamina households (5 persons) did not in itself clearly highlight the extent of this demand, plot holding irrigator households needed to be seen in the context of the broader socio-economic challenges of poverty, unemployment, food insecurity and hunger for productive land, which affected many extended families and others within the local communal area. Possible future scenarios were that, under prevailing population growth trajectories in the Mamina communal area surrounding the scheme, fecundity levels were likely to contribute to increasing demands for scheme expansion and land allocation rather than sub-division.

The data of the sampled household reveals that 90% of the existing farmers were part of the original group that was allocated irrigation plots. The rest (10%) had inherited the plots from parents (See Appendix 1). The rule inheritance arrangements state that if the plot holder dies, his or her plot will be taken over by the surviving spouse. If both spouses die, the eldest son will take over the irrigation plot. The rule clearly discriminates against the girl child as an equal heiress apparent. The institutional structures that have received particular attention in irrigation management include the Irrigation Management Committee (IMC), Traditional structures, Government Departments such as AGRITEX, Department of Irrigation (Dol), Department of Mechanisation, Department of Research and Specialist Services, parastatals such as Zimbabwe National Water Authority (ZINWA), and Zimbabwe Electricity Supply Authority (ZESA).

A good land tenure system should result in improved agriculture productivity and food security. Agricultural productivity and food security should reflect the effects of access to resources on food security and the effects of food security on access and use of resources. Research on land tenure, agricultural productivity and food security has proceeded along separate but related tracks. Land tenure has been focusing on access to land, resource use, and income generation while agriculture productivity has focused on the relationship between agricultural output and one of the major inputs, like, land or labour or capital but with other complementary factors remaining the same. Food security has been focusing on from income generation to food consumption, food availability and nutritional status. The conventional links between land and food fall within a linear framework that begins with access to resources and proceeds through production, income generation (e.g., via trade), and consumption decisions to nutritional status. Agricultural productivity and food security is affected by inequalities in the access of certain key resources hence the inclusion of inequality as a concept. Extending the bundle of rights to agricultural productivity will influence the need for markets to get incomes to pay bills and improve livelihoods.There will be need to extend the bundle of rights to right to markets and better livelihoods.

5.7 INSTITUTIONAL FRAMEWORK

The institutional framework present at Mamina irrigation scheme tends to focus on the following areas:

- rules and procedures relating to how land should be used;
- the agreed cropping programme;
- encouragement to participate by attending meetings;
- water and electricity bills shared equally (encouragement of timely payment, and penalties for defaulters);
- assigned responsibilities for repair and maintenance (pumping unit and conveyance pipes – collective action, and infield infrastructure – individual farmers);
- arrangement for dispute settlement mediated by the Irrigation Management Committee (IMC);
- inheritance of irrigation plots;
- authorisation to operate the pump (by IMC);
- allocation of times to irrigate;
- land allocation function.

Reflections on the institutional framework indicate that the IMC dominates the decision making structure. There is dominance of males in the IMC structures. Also evident is the fact that there are individuals and organisations outside the irrigation scheme that influence decisions within the community. Some of the influencial structures are government departments and parastatals. The key decision forum in the irrigation scheme is the Irrigation Management Committee. The outside groups, government departments and parastatals are viewed to be equally important in their various roles.

5.8 ROLE OF THE KEY GOVERNMENT DEPARTMENTS AND PARASTATALS

The Department of Agricultural Technical and Extension Services (AGRITEX) is responsible for providing agricultural extension services. It prepares the cropping programme with the farmers and provides advisory services in the production of the crops. The department had 2 resident Agriculture Extension Workers. The Department of Irrigation and Mechanisation is responsible for irrigation infrustructure development. Their representation is at district and provincial level. The Zimbabwe National Water Authority (ZINWA) is responsible for administering the water permit system and water allocation to field edge. The Zimbabwe Electricity Supply Authority (ZESA) is responsible for electricity distribution.

5.9 LAND TENURE ARRANGEMENT

The irrigators retained the structure of the IMC with the following posts: chairperson, vice-chairperson, secretary, vice-secretary, treasurer, five ordinary committee members and a marketing sub-committee. The responsibility of the IMC had broadened from the formulation of cropping programmes, allocation of irrigation plots, linkage with various institutions and markets, to coordinating monthly contributions, payment of bills, water allocation to the plot field edge, operation and maintenance. The role of the marketing sub-committee remained that of sourcing inputs, service providers, transport, finance, and information on new crops.

The number of irrigation management blocks had since been reduced from 7 to 5 to facilitate easier management. The new management blocks were named Blocks A, B, C, D and E. Block chairpersons are members of the umbrella IMC. A block in this case is an aggregation of many plots belonging to different farmers which are treated as one big plot (Manzungu 1999). Farmers in a particular block are supplied with water to irrigate one crop type that belongs to different farmers.

5.10 OWNERSHIP, ACCESS TO AND MAINTENANCE OF AGRICULTURAL EQUIPMENT/IMPLEMENTS

Household ownership of and access to agricultural implements influence the timeliness of on-farm cultivation and therefore result in timely land preparation that will translate to improved yields. The maintenance of tractors and implements was hampered by conflicts and power dynamics among farmers, which impacted negatively on the development of a sense of ‘ownership’ among the CPR users (see Figure 5). The tractors and implements were communally owned by Mamina smallholder irrigators and had been received from a broad-scale mechanisation programme to support the newly-resettled farmers with farming equipment, which was implemented by government during the peak of the fast track land reform programme. However, the distribution of these shared resources was not accompanied by efforts to strengthen the capacity of farmers to act collectively.

Figure 5: Broken down tractors at Mamina Irrigation Scheme

Source: Researcher (2015).

5.11 WATER AND ELECTRICITY SUPPLY SYSTEM AND PRICING

The water tariff structure varied within the farming sector – it could be A1, A2 or communal. In order to support the agrarian reform, water tariffs were reduced for all sector categories to encourage uptake and improved productivity. The reduction in the ZINWA Blend Price for water is shown in Table 2 below.

Table 2: Water Blend Price Shift from 2006 to 2017

Category	2009 to 2012	2013 –Nov 15	2017
	US$/ML	US$/ML	US$/ML
A2 Farmers	12.19	6.82	5.00
A1 Farmers	7.80	5.00	3.00
Communal Farmers	5.00	4.50	2.00
Commercial Agriculture (Estates)	12.68	9.45	12.00
Mines	25.00	50.00	50.00

Source: Researcher, 2017.

The water allocation process requires the water user to apply for a permit or agreement on the category of the farmer. The Zimbabwe National Water Authority (ZINWA) applies the user-pays-principle. The application of the user-pays-principle varies depending on ownership of the water infrastructure. In order for a consumer to access water for non-primary use, a permit or agreement is required. A permit is required for a consumer to construct their own dam or drill a borehole. A permit holder is then required by law to pay the sub-catchment council rates and the water levy. A consumer enters into an agreement with the Zimbabwe National Water Authority (ZINWA) when they wish to access water from the Authority's dams, in which case the latter is the permit holder on behalf of the Minister (see Table 3).

Table 3: The Pricing Strucure for Irrigated Agriculture

Ownership of Reservoirs and Conveyance System	Blend Price	VAT @15%	Sub Catchment Council levy @ $1/ML	Water Fund Levy @ $1.06/ML
Owned and controlled by ZINWA	√	√	√	√
Privately owned dams and infrastructure	×	×	√	√

Source: Researcher, 2017.

The water sector restructuring resulted initially in increases in the national water blend price and then its gradual reduction in the following consecutive years. The removal of electricity subsidies on pump-operated smallholder irrigation schemes resulted in frequent water and electricity cut-offs which existed during the time when the scheme was government-managed, and these outages continued to be a major problem since the transfer of management to the irrigators. The electricity tariffs schedule is indicated in Table 4 below.

Table 4: Electricity Tariff Structure

Time of use periods	Application rate (Cost/Kwh)
a) Peak	US$0.13
b) Standard	US$0.07
c) Off-peak	US$0.04

Source: Reseacher, 2017.

The electricity tariff schedule was as indicated in Table 5 below.

Table 5: The Electricity Tariff Schedule

Time of use periods	Schedule
a) Peak	Week days: 07h00-11h00 and 17h00-20h00 every day, respectively. Saturday 07h00-10h00 and 17h00-19h00, respectively. Sundays 17h00-19h00.
b) Standard	Week days:12h00-16h00 and 21h00 respectively. Saturdays 11h00-16h00 and 20h00-21h00 respectively. Sundays/Holidays 07h00-16h00 and 20h00-21h00 respectively.
c) Off-peak	Every day from 22h00-06h00.

Source: Researcher, 2017.

It was therefore advisable that crops be irrigated during the off-peak times to reduce the costs as well as allow better infiltration of water into the ground.

Although Mamina farmers re-organised themselves in 2009 and agreed to contribute monthly payments for water and electricity, their efforts were affected by high bills partly caused by the unsustainable irrigation technology, the price system and default by the irrigators. Unable to keep up with payments, the irrigators soon had to contend with bill payment arrears of US$94 000 for water and US$157 000 for electricity. These arrears resulted in frequent power-cuts, which in turn had negative impacts on productivity. The rules at Mamina irrigation scheme state clearly that anyone who continues to default payment would be evicted from the scheme but this has not taken place. However, the utility companies have a trend of cutting off (discontinuing) utility services to the whole scheme regardless of whether one member has paid or not. This is a serious challenge that has affected productivity. For example, the area under maize was 38% under season A (January – June) and 29% under season B (July – December). The reduction in area was attributed to frequent power cuts by ZESA, owing to Mamina irrigators' failure to pay their bills. Despite this, some irrigators seemed to thrive.

Towards enhancing the collection of bills and payment, irrigators had organised themselves to make monthly contributions of US$65 a month per irrigator, of which US$60 was for electricity and US$5 was for water bills. They had further agreed to irrigate for 12 hours at night during off-peak hours, when electricity charges were relatively low. Electricity at Mamina uses the maximum demand system, which means that they have their own dedicated line. During peak hours electricity costs were 18 cents per unit whilst during off-peak hours electricity costs were 4 cents per unit. In 2016 the peak electricity costs were reduced from 18 cents per unit to 13 cents per unit. This compelled the Mamina irrigators to prefer irrigating between 22h00 and 06h00 during off-peak hours. In the past when the irrigation scheme was still government-managed the farmers were said to irrigate for 24 hours at one position resulting in water and energy wastage. Collective choices set the limits. In the irrigation systems studied by Tang (1992:90-91) three types of authority rules are used most frequently:

- a fixed time slot for each irrigator;
- a fixed order for a rotational system among irrigators; and
- a fixed percentage of the total water available during a period of time.

One would have hoped that all the irrigators would receive their irrigation water equitably, but this did not succeed because of the inefficiencies in the irrigation system due to leakages along the pipe lines. There are inefficiencies in the irrigation system resulting in low pressure and inequitable allocation of water.The problem is due to three major leakages in the mainline, pressure chambers that are filled with water and broken down pressure gauges whose gate valves need attention.The irrigators contribute only towards payment of bills but there is no arrangement or plan to raise funds for operation and maintenance of the irrigation system.

5.12 PARTICIPATION AND REPRESENTATION OF WOMEN

The research conducted shows that within IMC, the representation of women within effective decision making positions is inadequate. Active participation is constrained by cultural and social barriers as well as limited time available due to their multiple roles and responsibilities. The rule that the irrigators should irrigate from 22h00 to 06h00 is one of the constraints in order to take advantage of the cost of 4 cents per unit charged during off-peak times. In the context of Mamina irrigation scheme, the women are heavily burdened as they are expected to fufil domestic responsibilities, which collectively include cooking, collection of water and firewood; attend social events, which include community meetings, weddings and funerals; perform off-scheme farm labour, which include livestock care and feeding cattle; provide irrigation farming related activities, which include recruitment of farm labour, attendance of farmer training courses and participation in irrigation scheme maintenance work. Women face tremendous barriers to success. They have limited access to productive resources such as land, finance, draught power and information to grow their irrigation plots and businesses. The study's findings highlight that 27% of the women hire draught power and also own cattle. The observed gender structure of plot holding and control of the sampled household in Mamina irrigation scheme showed that a higher proportion (40%) of Mamina women had sole control over plot holdings relative to shared control with men (23%) and sole control by men (37%). The study's findings indicate that 36% of the sampled female households have plot sizes of less than 1 ha which range between 0.32 ha-0.5 ha as compared to their male counterparts whose majority of plots range between 1 ha-1.5 ha which raises inequality issues in the plot allocation (see Appendix 1). Clarification of gender roles enhanced understandings of the socio-economic profile of irrigator households and subsequently, the ways by which different farmers responded to IMT.

5.13 ACCESS TO CREDIT

Among the 30 smallholder irrigators interviewed in Mamina irrigation scheme, only one had been able to access borrowed funding. The majority of farmers have never accessed irrigation funding. Limited availability of short-term and long-term loans has affected the irrigators' ability to fully utilise the available land in their plots. The reasons why farmers failed to apply for funding from finance institutions included their poor economic resource base, the fragmented and relatively small size of land holdings, insecurity of tenure or lack of formal land ownership rights (i.e. title deeds), and high interest rates on credit loans. These findings confirmed earlier findings highlighted in a report by the FAO (1997b).

5.14 ACCESS TO IRRIGATION EXTENSION SERVICES

Some of the extension services required by Mamina irrigators included training in agronomic practices, operation and maintenance of the irrigation systems, record keeping and irrigation scheduling, among others. Although there were locally-based agricultural extension officers in Mamina, the relationship between those officers and irrigators was said to be problematic. Respondents were generally reluctant to disclose the reasons for the tensions. It seemed plausible that the lack of effective engagement between extension officers and irrigators deprived them of opportunities to strengthen their crop production and irrigation management skills.

5.15 VIEWS OF STAKEHOLDERS

Since the introduction of IMT in Mamina, questions have been raised about the readiness of Mamina smallholder irrigation farmers to take up the transfer from government management responsibilities. On the 30^{th} of September 2015 an initiative was launched by officials of the Government of Zimbabwe, a local Member of Parliament and traditional chiefs to encourage Mamina irrigators to improve productivity, operation and maintenance (see Figure 6).

Figure 6: Launch initiative – Senior government officials, local MP, traditional chiefs and Mamina irrigators – 30 September 2015

Source: Researcher (2015).

5.15.1 Views from a local Member of Parliament

The local Member of Parliament, Mr Gava, bemoaned the level of participation in training programmes by irrigators and the lack of cooperation between irrigators and local extension officers. The parliamentarian stated that the farmers had consequently lost opportunities to improve their methods of production through adopting new innovations. He complimented research, but proposed that it should not only concentrate on the crop fields but also focus on marketing opportunities for the irrigators' produce. The Member of Parliament was surprised at the level of food insecurity in the district when the district was endowed with Mamina irrigation scheme, which had the capacity to irrigate more than 200 ha. Although farmers faced challenges with payment of electricity bills, the speaker encouraged farmers to build a relationship with the Zimbabwe Electricity Supply Authority (ZESA) to work out payment plans with the entity. He suggested a payment mechanism which allowed farmers to pay their bills termly instead of monthly, as most of the crops grown by farmers took more than three months to mature.

5.15.2 Views from Mamina Irrigators

Speaking on behalf of all irrigators in Mamina irrigation scheme, farmer Albert Gideon Musukwa[5] gave an account of how Mamina farmers used to benefit when the scheme was still under government management. He said:

> "The government used to provide us with inputs and pay for all our irrigation bills. The transfer to farmer management was introduced in phases with the first phase which entailed government meeting three-quarters of the bills and farmers meeting a quarter. In 2002 the scheme was fully farmer-managed."

According to farmer Musukwa, the FARMESA project was financed by FAO and SIDA to develop methodologies for irrigation management transfer in government-run irrigation schemes. Soil tests conducted by the Department of Research and Specialist Services (DRSS) indicated that the soil and water pH at Mamina Irrigation Scheme were acidic and therefore there was need lime the soils. The results of the soil analyses were presented by a DRSS officer, Ms Tariro. A number of other recommendations were made at the time of IMT regarding how the scheme should be run.

Mamina IMC had responded positively to those challenges and to some extent, managed to foster cooperation among the irrigators. The IMC had crafted institutions to govern water allocation, mobilise funds to offset water and electricity bills and strengthen marketing linkages. The IMC had also set new rules whereby each irrigator was compelled to irrigate for 9 hours in the evening, instead of the earlier chaotic and wasteful water use that prevailed when the scheme was government-managed. All the farmers were then supposed to irrigate

[5] Name changed to protect the identity and privacy of the respondent (who is not a public figure or institutional actor).

according to the set time and recommended schedules. However, due to the system inefficiency, the tail-end was not receiving enough water.

According to the experts, the irrigation system was supposed to be upgraded to fulfil two objectives, namely, efficient allocation of water and power saving technology. However, the upgrade was never done, and the management of the scheme was simply dumped on the irrigators without sorting out those major challenges. The irrigation system needed to be upgraded so that it distributed water efficiently and equally to the whole irrigation scheme.

5.15.3 Summary of Views by Other Institutional Actors

Other speakers acknowledged that the government of Zimbabwe had worked hard to improve the technical capacity of the irrigators through providing agricultural extension services. They also pointed out, however, that the plot size categories no longer fell into two homogenous groups but had increased in diversity and number. This affected cooperation among the irrigators. It was said that irrigators should have been informed about the effects of further reducing their plot sizes, so as to guide them to make informed decisions. Furthermore, institutions at the scheme were in need of being strengthened, in order to discourage irrigators from sub-dividing their irrigation plots. Given the increase in the number of plot holders, the poor water distribution by the system only fuelled conflicts among irrigators since those aggrieved by receiving less water tended to want to free ride and postpone payment of bills.

Marketing issues were also raised. It was pointed out that Mamina smallholder irrigation farmers were not able to compete with the globalised agro-food chains as the production costs were very high due to high input prices in the country compared to those in the Southern African Development Community (SADC) region and globally. Despite challenges such as these, irrigators had never been able to access private or public financial assistance with input costs. Since the transfer of the irrigation scheme management from government to farmers, Mamina irrigators had to grapple with constraints to in marketing their produce. They were often compelled to use informal markets. However, the capacity of farmers to engage with formal markets needed to be strengthened. In particular, the marketing committee coordinated all marketing activities and ensured that in cases of contract farming there was no side marketing, but needed support in their capacity to enable farmers to engage more competitively with markets.

5.16 CONCLUSION

Since the establishment of the irrigation scheme, operation and maintenance was government managed. In the absence of measures to manage the use and sharing of water some of the farmers were reported to run their sprinklers continually for up to 48 hours on one position at peak demand instead of the 12 hours for which the scheme was designed. During government management the water and electricity bill would reach Z$1.2million per annum claiming half (50%) of the budget allocated to the Department of AGRITEX for managing and operating all the smallholder schemes in the country. The scheme was subjected to electricity cuts for over 3 months. The government, notwithstanding the high utility bills, had no option but to devolve the management of the irrigation scheme to the irrigators without modernising the scheme. The challenge of the accumulation of the wage bill experienced during government management continued after irrigation management transfer.

CHAPTER 6
CROP PRODUCTIVITY AND FOOD SECURITY

6.1 INTRODUCTION

The irrigators have organised and cooperate on an agreed irrigation schedule. However, equitable distribution of water has been affected by three major leakages in the mainline, pressure chambers that are filled with water and broken down pressure gauges whose gate valves need attention. The scheme has rules that govern repair and maintenance work but these rules have failed to influence the irrigators to mobilise for repair and maintenance.

Some of the rules that exist on repair and maintenance are as follows:

- Repair and maintenance works for the pumping unit and the conveyance pipeline is the collective responsibility of all the farmers.
- Every farmer should pay the agreed monthly subscriptions to cater for the repair and maintenance works. Any defaulter will have water cut off from his or her plot. If the defaulting farmer continues for another six months without settling the debt, he or she will be evicted from the scheme.
- Every farmer should take care of the repair and maintenance of his or her infield infrastructure. Anyone who does not do the repair and maintenance works properly will lose his or her plot.

This chapter presents primary research findings on productivity and the food security situation of the irrigators. Primary data collected is summarised. Whereas the quantitative data collected with the survey questionnaire is presented with the help of tables, graphs and brief explanations, the qualitative data is narrated concurrently with the data and will answer the research questions as discussed in the previous chapter.

6.2 CROP PRODUCTIVITY

While the Mamina irrigators have organised themselves to cut on electricity cost by irrigating during off peak hours and making monthly contributions. Their efforts are affected by the defective irrigation system as irrigators at the tailend do not receive enough irrigation water for their crops. Farmers at the tail-end received much less water than those at the head and middle of the system because there are inefficiencies in the irrigation system resulting in low pressure and inequitable water distribution.The problem is due to three major leakages in the mainline, pressure chambers that are filled with water and broken down pressure gauges whose gate valves need attention. This had ramifications on relative productivity among different plot holders in the scheme (see Table 7). The productivity of food crops for the tail-end farmers was negatively affected (see Figure 8). While most of these farmers' crops did not get the amounts of irrigation water required up to maturity, farmers at the head and middle sections of the irrigation system showed higher levels of productivity (see Figure 8; see also Appendix 6).

In season A (January to June), 100% of the Mamina farmers located at the head achieved average yields above the standard deviation 1.03445 (See Table 6 and Table 7) against 90% of the Mamina farmers located at the middle, achieved average yields above the standard deviation 1.03445. The result indicates very little variation between yields at the head and middle of the irrigation scheme. While there are significant variations when the yield levels are compared with those at the tail end of the irrigation scheme where 70% of the Mamina farmers located at the tail end achieved average yields above the standard deviation of 1.03445 in season A (January to June). In season B (July to January), 100% of the Mamina farmers located at the head achieved average yields above the standard deviation 1.16100 (see Table 6 and Table 7), against 70% of the Mamina farmers located at the middle who achieved average yields above the standard deviation 1.16100. Only 30% of the Mamina irrigators located at the tail-end achieved average yields above the standard deviation of 1.16100 in season B (July to January). By comparing 100% at the head and 30% at the tail-end of yields above the standard deviation in season B, reflects that in this season there is a large variation between yields between the tail-end and those at the head.

In season A (January-June) average yields were higher because irrigation was used only to supplement rainfall as it was a summer season were substantial amounts of rainfall are received in those months. It was observed that for season B (a dry season) 70% of the plots at the tail-end had an average yield less than the standard deviation of 1.16100 which can be attributed to inequalities which exist in systems which affects water distribution as less irrigation water was reaching the tail-end. Most of the farmers have failed to realise a yield at the tail-end because of the water challenges realised during season B. This might be the reason why most of the times the Mamina irrigators have failed to raise enough contributions for payment of water and electricity. The farmers who fail to access irrigation water in season B are likely not to cooperate in contributing towards operation and maintenance costs.

Irrigation scheduling is concerned with the accurate determination of when and how much water to apply to maximise crop production and /or profit while maintaining a reasonably high irrigation efficiency (Pereira, 1996: 91; Burt, 1996: 273; van Hofwegen, 1996: 325). The agronomic concept of irrigation scheduling, which focuses on soil-water-plant relationships and efficiency considerations (Horst, 1996: 297), is emphasised to the detriment of two other important concepts of irrigation scheduling, namely the water delivery engineer's concept (Burt, 1996) and the institutional concept (van Hofwegen, 1996: 325) in Manzungu (1999). The water delivery engineer's concept of irrigation scheduling is about developing and implementing a schedule of deliveries which is compatible with the water delivery systems capabilities and constraints (ibid). Both the agronomic and water delivery engineer's concepts presuppose a set of rules and regulations, which govern water distribution. This normally reflects the social arrangements and power relations among and within communities, their water entitlements and their capability to adjust to their socio-cultural environment. This is the institutional concept of irrigation scheduling. Unfortunately only agronomic irrigation scheduling is considered in block irrigation. Manzungu (1999) asserts that by only considering the concept of agronomic irrigation scheduling and excluding the water delivery engineer's concept, the institutional concept worsens successful on-farm irrigation scheduling. These preconditions include:

a) reliability of water supply to make crop-based irrigation scheduling a reality;
b) predictable delivery schedules; and
c) infrastructure that ensures flexibility in water supply will in turn ensure farmers' room for manoeuvre.

Table 6: Standard Deviation – Average Maize Yield

Season	Minimum	Maximum	Mean	Standard Deviation
A (January-June)	0.4	5	1.9991	1.03445
B (July-December)	0	5	1.6126	1.161

Source: Drawn from data in Table 7 below (by researcher).

Table 7: Maize Production Seasons A and B by Plot Location

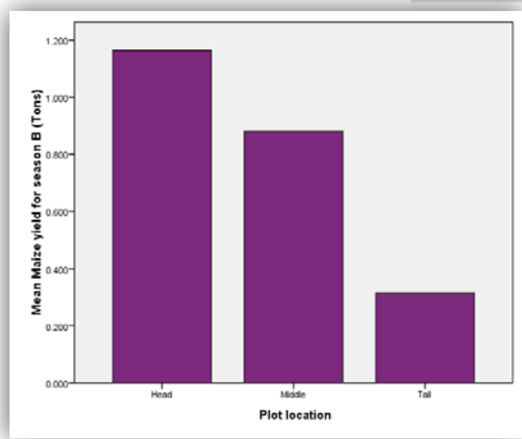
Plot location	Respondent Farmer	Maize Area A (Ha)	Average Yield A (t/ha)	Maize production A (Tons)	Maize Area B (Ha)	Average Yield B (t/ha)	Maize production B (Tons)
Head	1	0.4	5	2	0.36	5	1.8
	2	0.56	2.5	1.4	0.5	2.5	1.25
	3	0.28	2	0.56	0.25	2	0.5
	4	0.56	3.5	1.96	0.5	3.5	1.75
	5	0.28	3.2	0.896	0.25	3.2	0.8
	6	0.56	2	1.12	0.5	2	1
	7	0.28	1.5	0.42	0.25	1.5	0.375
	8	0.3	1.6	0.5	0.25	1.5	0.375
	9	0.56	3.2	1.8	0.5	3.6	1.8
	10	0.8	2.3	1.9	1	2	2
Total Sum		**4.58**	**2.7**	**12.556**	**4.36**	**2.6**	**11.65**
Middle	1	0.716	1.6	1.2	0.64	2.1	1.35
	2	0.56	2.2	1.25	0.5	2.2	1.1
	3	0.627	2.3	1.45	0.56	2.2	1.25
	4	1	1.3	1.3	0	0	0
	5	0.5	2.2	1.1	0.4	2.3	0.95
	6	0.75	1.6	1.2	0.25	0.4	0.1
	7	0.75	1.3	1	0.75	1.6	1.2
	8	0.8	1.6	1.3	1	1.3	1.3
	9	1	1.2	1.2	1	0.8	0.8
	10	0.5	0.6	0.3	0.5	1.5	0.75
Total Sum		**7.203**	**1.5**	**11.3**	**5.6**	**1.5**	**8.8**
Tail	1	0.5	2.4	1.2	0.16	2.5	0.4
	2	0.2	2.5	0.5	0	0	0
	3	0.5	2.2	1.145	0.16	0.6	0.1
	4	0.2	1.5	0.3	0.25	1.2	0.3
	5	1	1.5	1.5	0	0	0
	6	1.2	0.4	0.48	0	0	0
	7	0.16	4.6	0.75	0.24	0.8	0.2
	8	0.4	2	0.8	0.4	1.2	0.5
	9	0.75	0.5	0.4	0.75	0.6	0.45
	10	1	0.5	0.5	1.16	0.2	0.3

Total Sum	**5.91**	**1.2**	**7.575**	**3.12**	**0.7**	**2.25**
GRAND TOTAL	**17.693**	**1.77**	**31.431**	**13.08**	**1.73**	**22.7**

Figure 7: Mamina Irrigation Scheme: Examples of a non-productive tail-end plot and a productive plot at the head of the irrigation system

Source: Researcher (2015).

Figure 8: Maize yields across locations



Source: Researcher (2015).

The varying average yield levels further affected equality in income levels obtained from crop production of the scheme (see Table 7). This was attributed to the poor water supply at the tail-end as there is not much variance with the other determinants of productivity, such as input usage and management practices. Fifty percent of irrigators at the head have realised gross margins greater than the standard deviation of 333.90521 (see Table 8 and Table 9) whilst 20% of the irrigators have realised gross margins greater than the standard deviation of 333.90521 (see Table 8 and Table 9). This is in contrast to the 100% of the irrigators at the tail-end who have failed to realise gross margins above 333.90521 (see Table 8 and Table 9). The poor water distribution has greatly affected irrigators at the tail end as the irrigation water they are receiving does not satisfy the crop water requirements.

Table 8: Standard Deviation – Gross Margin for Maize

Crop	Minimum	Maximum	Mean	Standard Deviation
Maize	-122	1301	220.582	333.90521

Source: Drawn from data in Appendix 2 (by researcher).

Table 9: Maize Gross Margin Frequency in Relation to Standard Deviation

Position	Frequency	
	< Standard deviation (US$333.90521)	> Standard deviation (US$333.90521)
Head	4	6
Middle	7	3
Tail-end	10	0

Source: Drawn from data in Appendix 2 (by researcher).

Figure 9: Picture of a thriving maize field in Mamina Irrigation Scheme

Source: Researcher (2015).

6.3 OVERVIEW OF CROP PRODUCTION PRACTICES

Field research findings showed that Mamina irrigators, as a group, had diversified from maize production after the transition to farmer managed irrigation, to include high value horticultural crops. Some of the crops now grown in the irrigation scheme are green mealies, wheat, soya beans, potatoes, green beans, peas, peppers, butternuts, tomatoes, carrots and cabbages. AGRITEX extension officers developed the cropping programme for the irrigation scheme in liaison with farmers. The extension officers also provided the irrigators with advice on crop production. During the summer season most of the scheme area was put under food crops, but in winter most of the area was placed under horticultural crops, such as peas, onions and cabbages, planted in April. Green mealies and green beans were planted in July. The observed cropping programme for Mamina could be characterised as follows:

Summer crops:	Maize, green beans, potatoes, peppers and soya beans.
Winter crops:	Peas, potatoes, onions and green mealies.

Overall, the input usage rates were below optimal recommended levels with irrigators applying fertiliser rates as much as one bag or two bags per hectare. The seed rates were also below optimal level with irrigators using a seed rate of 10kgs to 15kgs per hectare. This has affected the yield levels of several crops at the scheme. For instance, yield levels for maize ranged between 0.7t/ha and 5 t/ha, comparable with the potential yields 15t/ha of maize.

6.4 FOOD SECURITY STATUS OF IRRIGATOR HOUSEHOLDS

The study used household food security status as a proxy indicator for the socio-economic status of Mamina irrigator households. The investigation selected maize, as the staple food grain consumed by virtually all the irrigator households (see Table 10; Figure 10). Findings were that 40% of the households faced a food deficit and were therefore ‘food insecure’, while 60% had surplus food.

Table 10: Food Balance Sheet*

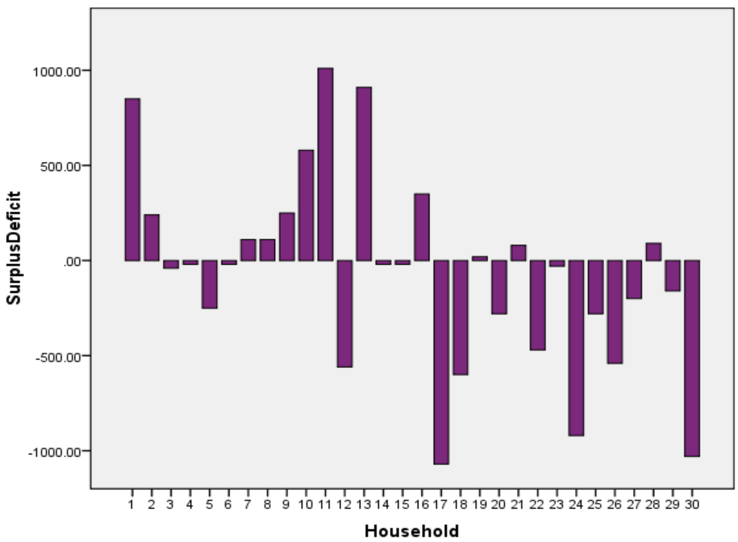
Respondent Farmer	Gender	Plot size (Ha)	Household Size	Annual Household Grain Requirement (Kg)	Maize Grain in-store (Kg)	Surplus/Deficit
1	Male	1	5	650	1500	850
2	Female	1.5	2	260	500	240
3	Female	0.32	3	390	350	-40
4	Male	1	4	520	500	-20
5	Male	1	5	650	400	-250
6	Male	1.5	4	520	500	-20
7	Female	0.5	3	390	500	110
8	Female	0.5	3	390	500	110
9	Male	1.5	5	650	900	250
10	Male	1.5	4	520	1100	580
11	Female	1.5	3	390	1400	1010
12	Female	1.5	7	910	350	-560
13	Male	1.5	3	390	1300	910
14	Female	1.5	4	520	500	-20
15	Male	0.25	4	520	500	-20
16	Male	0.5	5	650	1000	350
17	Male	1.5	9	1170	100	-1070
18	Male	1.5	5	650	50	-600
19	Male	1	6	780	800	20
20	Male	1	6	780	500	-280
21	Female	1	4	520	600	80
22	Male	0.25	4	520	50	-470
23	Male	1.5	6	780	750	-30
24	Male	1.5	9	1170	250	-920
25	Male	1.5	6	780	500	-280
26	Female	1.5	8	1040	500	-540
27	Female	0.5	5	650	450	-200
28	Female	1.5	7	910	1000	90
29	Male	1.5	7	910	750	-160
30	Female	1.5	11	1430	400	-1030
Total Sum		34.32	157	20 410	18 500	-1910

*Cereal requirement is computed from a consumptions rate of 110kg/year/person (Zimbabwe Vulnerability Assessment Committee (ZimVAC), 2015).

Source: Researcher, 2015.

Most of the food insecure households were those with household size larger than the mean household size of 5 persons. The food deficit was greater in households of male plot holders than those of female plot holders. A total of 67% of male plot holder households had food deficits compared to the 50% of female plot holder households. Furthermore, two of the three highest food deficits observed were found in households of male plot holders. However, irrespective of the plot holder gender, the burden of coping with food insecurity seemed to fall more on women than men in irrigator households, since women in Mamina assumed greater responsibilities for reproductive work, such as cooking and caring for household members, and social events, such as weddings and funerals (see Section 5.3). The increase in food security for the female households was attributed to their significant participation in training courses and important irrigation scheme meetings.

Figure 10: Mamina: Food Surplus and Deficit in Irrigator Households



Source: Drawn from data in Table 10 (by researcher).

6.4.1 Distribution of the Irrigation Scheme Produce by Market Share

Most of the crops produced in Mamina irrigation scheme were traded in informal markets, although some of the crops were also formally marketed. Market places were both on-farm and off-farm. Farmers also relied on ‘middlemen’ to market their produce. Price fluctuations affected the marketing of the irrigators’ produce. For example, the bulk of the maize produced from the month of July is sold as green mealies, which have relatively high market value. The remainder is dried and stored as grain for sale to food and beverage firms as well as individual buyers, or for subsistence food and stock-feed requirements. In the month of July water demand is very high as no rains are received during this period. Among all identified informal market places, Mbare market was the most frequented (see Table 11).

Table 11: Market share for Crop Produce from Mamina Irrigation Scheme

Market Place	Maize	Cucumber	Cabbage	Green Pepper	Potatoes	Tomatoes	Peas	Fine Beans	Butternut	Carrots	Soya Beans	Sugar Beans
Chegutu	X											
Mbare	X	X	X	X	X	X	X	X	X	X	X	X
Middlemen	X						X			X		X
On farm	X											X
Simba Breweries	X											
Irvine (Pvt) Ltd											X	
Sky limit (Pvt) Ltd											X	
Stay well (Pvt) Ltd											X	
Schools												X

Source: Reseacher 2015.

The case example of male irrigator, Mr Kalulu [6], illustrates this (see Figure 11). At the time of field data collection in 2015, Mr Kalulu had been producing crops for 2 years in Mamina irrigation scheme. He specialised in a variety of horticultural crops, such as carrots, fine beans, cucumbers and butternuts. At the time of the field survey, the farmer had half a hectare of carrots, which he sold at Mbare 'Musika' informal produce market.

[6] Name changed to protect the identity and privacy of the respondent.

Figure 11: Picture showing Irrigator, Mr Kalulu during an interview at Mamina Irrigation Scheme

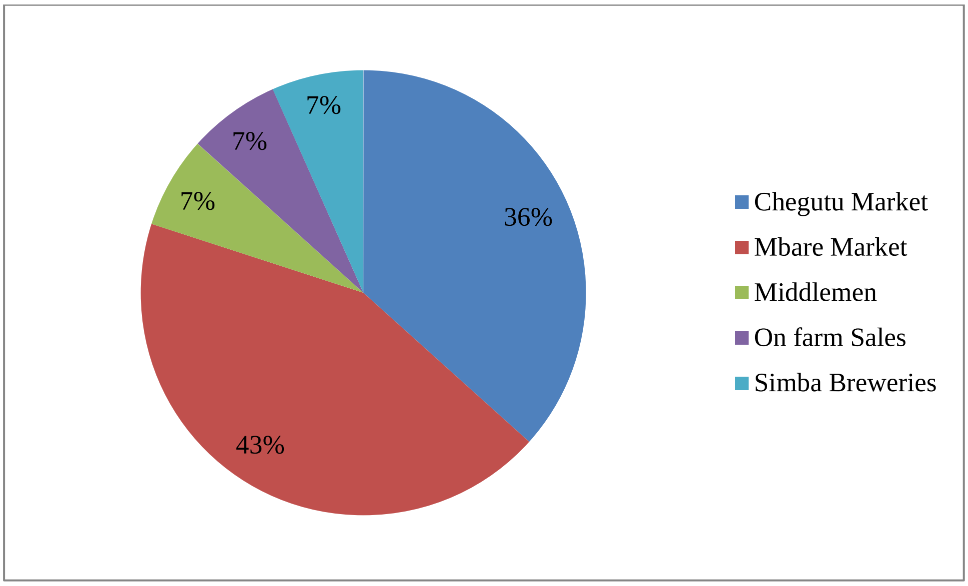
Source: Researcher (2015).

While Mbare informal market was the main market place for most of the crops produced in Mamina Irrigation Scheme, crops such as maize, soya beans and sugar beans had the most diversified markets. These crops were marketed in both formal and informal markets. The marketing was done directly through farmer engagement with markets and indirectly though middlemen.

With specific respect to maize, for example, Mbare informal market (43%) in Harare and Chegutu informal markets (36%) provided ready markets for the maize products produced by the Mamina irrigators (see Figure 12), though the prices fluctuated greatly. Price fluctuations at the Mbare market posed a major threat to smallholder irrigators as the prices were often not stable at the time of produce sale. Other portions of maize produce were bought on-farm by private companies, such as Simba Breweries, who purchased directly from the irrigators. Some of the maize produce was bought by middlemen, who bought the produce at farm gate price. The buyers brought their own transport to move the produce from Mamina. Figure 12 shows the distribution of Mamina maize produce by market share.

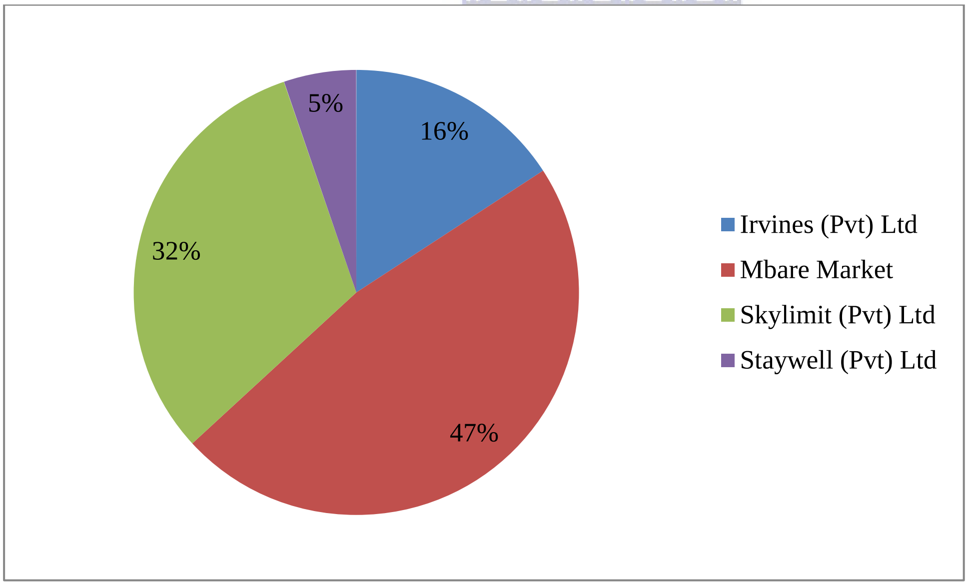
By contrast, Mamina irrigators sell their soya beans in Mbare and to private companies, such as Irvine, Sky Limit and Stay Well. Mbare Informal market receives the highest share (47%) of the soya beans produced by the smallholder irrigators (see Figure 13). At the time of field data collection in 2015, the price for soya beans was between US$550 and US$600 per ton.

Figure 12: Distribution of Mamina Maize Produce by Market Share



Source: Researcher 2015.

Figure 13: Distribution of Mamina Soya Bean Produce by Market Share



Source: Researcher 2015.

6.5 CONCLUSION

IMT institutional arrangements seem to have created some positive effects as well as many challenges in the operation of the irrigation system. The technical challenges of the irrigation technology, in particular, have critically affected equity and productivity among the irrigators. The study found that challenges tended to be related to issues associated with differences in security of water access, inherited inequalities in allocated plot sizes, overall affordability of electricity supply services and inadequate billing arrangements. Manzungu (1999) asserts that management problems are often directly related to technical design elements of an irrigation scheme. There have been few attempts in Zimbabwe towards improving existing design concepts of smallholder schemes or exploring new ones. During the 1980s there was a consensus that smallholder schemes should be simple, robust and low cost (Rukuni, 1995, in Manzungu, 1999). It was argued that such technology would be more sustainable and would facilitate farmer participation. But by 1995, the highest AGRITEX officer in charge of irrigation dismissed the simple technology philosophy by arguing that new technologies would save enormous amounts of water (Chitsiko, 1995: 15). He further disagreed with the widely held belief that “sprinkler and drip systems are more difficult for the smallholder, compared to surface irrigation”. He, instead, argued that sprinkler and drip systems had “more in-built management when compared to the latter” and were therefore easier to manage. The irrigation infrastructure at Mamina scheme was based on a sprinkler system in which water was first pumped into a balancing tank at a high point and then fed into the sprinkler system by gravity. Given that Mamina’s centralised scheme management framework had failed to resolve challenges of high operational costs, poor water management practices, farmers’ capacity constraints with respect to infrastructure maintenance and repair, and complexity of land governance and allocation issues, it was perhaps inevitable that government would seek alternative strategies to salvage productivity in Mamina (FAO, 1997a). FAO (1997a) reports that the farmers were reluctant to accept the irrigation management transfer. The farmers argued that the irrigation design was very poor and not suitable for the smallholder farmers. They also complained about the costliness of an irrigation system that first pumped water upwards to storage tanks located on the highest elevated land and thereafter gravity-fed it to the crop fields (FAO, 1997a).

CHAPTER 7

DISCUSSION AND CONCLUSION

7.1 INTRODUCTION

The results indicate that Mamina irrigation scheme, a Common Pool Resource (CPR), has gone through several challenges. The irrigators' adaptation and resilience to the several challenges reflects the endurance of self governing institutions. Despite them increasingly sinking in the many problems the irrigator had continued to operate and manage the irrigation scheme . The challenges that existed when the scheme was under government management had continued to haunt the irrigators even after transfer of irrigation management. In the early days of IMT the irrigators had signalled their reservation against inheriting a faulty irrigation scheme that was poorly designed with a pumping system that required a high power demand. The irrigators' experiences has highlighted the challenges of transferring a defective irrigation scheme. This chapter provides a synthesis of the challenges that bedevilled Mamina irrigation scheme and relate these finding to the conceptual framework and the researcher's contribution towards smallholder irrigation schemes. The mini-thesis set out to evaluate the effects of IMT on productivity, operation and maintenance at Mamina irrigation scheme.The study's aim was:

To determine the effects of irrigation management transfer on productivity, operation and maintenance at Mamina Irrigation Scheme.

The objectives of the study were to:

- Determine the rights and institutions that govern access to and use of the irrigation scheme.
- Examine the physical condition, the rules and regulations in the allocation and distribution of irrigation water in Mamina irrigation scheme.
- Determine the constraints and opportunities of the shift from a state-led irrigation system to a farmer-led irrigation system in relation to water and electricity allocation as well as the pricing system.
- Determine the relationship between water allocation and productivity across location (head, middle and tail-end) .

- Determine the extent gender is an important factor in the allocation, and decision making structures of Mamina irrigation scheme.
- Determine the food security status of the sampled households.
- Establish the strengths and weaknesses of Irrigation Management Transfer (IMT) at Mamina irrigation scheme.

The chapter draws on common pool resource concepts to explain and provide solutions to the challenges that the irrigation scheme is experiencing.

7.2 Rights and institutions governing access to and use of the irrigation scheme

Unresolved land tenure issues at Mamina irrigation scheme were a challenge, since its establishment. Mamina irrigation scheme was established on land that was once communally owned by the locals under customary laws. Government identified the area to be suitable for irrigation development, and therefore initiated the planning, designing and development of the scheme. The local communal farmers were assured irrigation plots after completion of the scheme.The potential beneficiaries feared losing part of their land which would lead in depriving their children from inheriting portions of the land. Contrary to their declared fear, the irrigation consultant failed to consider their concern in the final irrigation scheme design. The design failed to consider the original land size owned by each individual communal farmer.This meant that part of their rights to certain portions of land was withdrawn under the pretext of irrigation development. Plot allocation caused disharmony among the irrigators as they later realised that a large number of 'outsiders' were allocated plots in the scheme depriving potential local beneficiaries. At some point the Kraal Head intervened and evicted some of the 'outsiders' to settle some of the locals. Though it was a noble move, it also created its challenges as the newly resettled irrigators were allocated plot sizes less than the recommended hectarage. Transparency and respect of farmers' land rights has a long enduring effect on the sustainability of smallholder irrigation schemes.

Findings revealed that the plot allocation approach was contentious as it was supposed to benefit beneficiaries from 3 villages surrounding the scheme, as well as civil servants, schools and local authorities. Initially the majority of the 154 households who benefited from the allocation of irrigation plots ranging in size from 0.5 to 1.5 ha were civil servants and other employed people, including 'outsiders'. Local farmers who lost their land to irrigation and those who felt excluded from the scheme were not happy with the approach of plot allocation. Owing to the protracted contention the Kraal Head independently evicted 26 'outsiders' from the scheme replacing these outsiders with 75 locally-based farmers, who included unemployed young people and widows. This partly explained why some of the plots in the scheme had become smaller in size and how a number of women benefited with plots in the scheme. One study by Lam (1994) argues that a negative relationship develops between inequality in landholding and irrigation systems performance.

The above challenge reasonates with the unresolved land tenure issues that arose during designing and plot allocation. Weaker institutions have seen the membership of Mamina irrigation scheme rise from 154 to 189 plotholders, with many of the original plots being sub-divided into smaller parcels and re-distributed to their mature children. Without clearly-defined boundaries for the Mamina irrigation scheme and in the absence of institutional mechanisms to close the system from *ad hoc* entry by 'outsiders', local irrigators face the possibility that any benefits they produce through their efforts will be reaped by others who do not contribute. However, in this case the concept of 'outsider' seems problematic when applied to irrigator family members, who gain access to plots through customary land inheritance and sub-division practices and are considered by irrigators to be 'insiders', in the customary sense. Studies (e.g. Ostrom, 1992) suggest that clear boundaries are required in CPR resource contexts, such as irrigation schemes, to safeguard against 'open access' scenarios. Under open access, lack of 'ownership' makes adherence to and enforcement of rules for scheme operation and maintenance and shared water use becomes difficult, particularly when there is water scarcity and/or high demand for land. The mismatch in understandings of concepts of 'insider' and 'outsider' needs to be addressed. A review of the Irrigable Area Regulation of 1970 by Manzungu (1999) established that every plot holder was issued with three permits that were renewed every year: a permit to reside, another to graze stock and yet another to cultivate. The issuing of permits was a powerful instrument for securing the compliance of farmers. Bruce et al (1993) defined land tenure in terms of a "bundle of rights" – specific rights to do certain things with land or property.

The permit system would be supported by Constitutional-choice rules to guide the settling of disputes. Ostrom et al (1990) argue that Constitutional-choice rules determine (1) who is eligible to participate in the system and (2) what specific rules will be used to craft the set of collective-choice rules, which in turn affect the set of operational rules (Kiser and Ostrom

1982). The rules and responsibilities would be effective when crafted by the irrigators taking into consideration their environment and the physical infrastructure. Tang (1992) argues that in a self governance institution the irrigators develop rules that assign rights and responsibilities among themselves. The rules are not government-created. The irrigators are responsible for enforcing the rules they create and for resolving disputes among themselves. Further exploration reviews that the top-down approach has failed the Mamina irrigators since the inception of the irrigation scheme.

The FAO (2004) report refers to tenure as control over resources or the way in which people hold, individually or collectively, exclusive rights to land and all or part of the natural resources upon it. Rihoy (1999) states that tenure is one of the principal factors determining the way in which resources are managed and used, and the manner in which the benefits are distributed. Adams et al (1999) state that the term "land rights" may encompass rights to occupy a homestead and make permanent improvements, rights to cultivate, rights to bury the dead, and to have access for gathering natural resources such as wood. It also includes rights to transact, give, mortgage, lease, etc. areas of exclusive use, rights to exclude others, listed rights, and rights to enforcement of legal and administrative provisions in order to protect the rights holder.

7.3 IRRIGATION TECHNOLOGY PHYSICAL CONDITION

The design of the irrigation scheme affected collective action of the irrigators due to high payment arrears despite efforts in organising for payment. The system has a requirement to pump water into 11 water settling tanks each raised at 40m. The system proved to be unsustainable. In the present day solar energy pumps have proved to be sustainable, but however the only hindrance was the high initial investment. The researcher thinks that installation of solar energy pumps compares favourably against utililising the electric pumping system. Shah (2002) noted that gravity systems generally cost more to build but less to run than pump schemes. Manzungu (1999) noted that the Musengezi scheme which used the electric pumps and sprinklers was designed in such a way that all sprinklers had to be operated simultaneously when the pump was switched on.

Furthermore, the irrigation system has three major leakages in the mainline, pressure chambers that are filled with water and broken down pressure gauges whose gate valves need attention. The irrigators have not mobilised for financial contributions for operation and maintenance as they seem to grapple with water and electricity bills. In other studies done elsewhere, Shah (2002) argues that successful IMT experience worldwide shows that operation and maintenance costs were expected to be an insignificant proportion of the total income which was typically less than 5% of the gross income from farming. Shah and Vankoppen (1999) claim that if the Arabie-Olifants scheme were to be turned over to farmers in 1999, the running costs would be between 20-25% of the total value of the irrigated output the scheme produces. Manzungu (1999:16) notes that the maintenance fees introduced in 1984 were Z$145 per hectare but covered less than one quarter of the operation and maintenance costs. Ogunwale et al (1994:11) found that although farmers paid US$52 the smallholder schemes faced challenges of frequent breakdown of pumps and sprinkler lines and poor availability of parts. In the case for Mamina irrigation sheme the irrigators are not contributing to maintenance fees except for the US$65 contributed towards electricity and water bills.

These were the reasons for the decline of smallholder schemes after government withdrawal. The following rules were used to regulate for repair and maintence:

> "Repair and maintenance works for the pumping unit and the conveyance pipeline is the collective responsibility of all the farmers. Every farmer should pay the agreed monthly subscriptions to cater for the repair and maintenance works. Any defaulter will have water cut off from his or her plot. If the defaulting farmer continues for another six months without settling the debt, he or she will be evicted from the scheme."
>
> "Every farmer should take care of the repair and maintenance of his or her infield infrastructure. Anyone who does not do the repair and maintenance works properly will lose his or her plot." (FAO 2000, ANNEX C)

The set of infrastructure rights should include the right to operate, repair, modify or eliminate structures (Vermillion 1994). He implores that without this right, the association is unable or unwilling to invest in long term maintenance and repair as they are likely to consider the infrastructure as the property of the government. Where clarity is lacking about the terms and conditions for future rehabilitation and system improvements, especially regarding financing obligations, farmers are unlikely to raise a capital replacement fund (Vermillion and Garces-Restrepo, 1994). The terms and conditions for future rehabilitation and system improvements are not clear for the Mamina irrigators especially regarding the financial obligations. A systematic description should be drawn up of key maintenance processes, including a breakdown of the resources required (labour, material and equipment). The maintenance requirements for a coming year are assessed on the basis of a status survey, which involves an inventory of damage to the system. It is necessary to select suitable norms for adequate maintenance and define what the maintenance is to achieve. Most literature notes that when Water User Associations contract to a set of commitments, the irrigation agency itself does not commit to any performance standards. Where there is a clear policy that farmers must finance rehabilitation it appears more likely that they will raise a capital replacement fund once they know that they are responsible for the long term sustainability of the system (Svendsen and Vermillion 1994). Frederiksen (1994) asserts that systems designated for handing over should have reasonable operational water which should reach the tail areas in the command. Frederiksen (1994) claims that experience shows that no society is interested in taking over a system which is leaking beyond reasonable limits or is non-functioning. The experience in Maharashtra shows that there is reluctance to take over such systems (Frederiksen, 1994). The Mamina irrigators initially resisted the takeover citing poor irrigation design which yielded higher electricity bills and that the irrigators lacked the capacity to maintain the imported pumping technology.

Some literature argue that the success of IMT depended on the size of the irrigation system and the number of irrigators. Shah (2002) noted that a 1 500 hectare system that serves 1 500 irrigators costs much more to manage in terms of the logistics of service delivery, fee collection and maintenance than a similar system that serves 5 large scale farmers. Moreover, it was a lot easier for 5 large farmers to come together and agree to the rules of self management than for 1 500 smallholders to do. This brings another dimension to self management systems, namely the feasibility of coordinating a few large scale irrigators or large number of smallholder irrigators in agreeing to the rules of self management. In Turkey, 40% of the irrigated area consists of farm holdings that are 5-20 hectares in extent and where farmers cultivate high value crops for export to Europe. The Mamina irrigation scheme is a 216 hectare system with 154 official irrigators. Gyasi et al (2006) claim that market integration generates exit options as maintenance schedules that coincide with market days would receive very poor response. Similarly, higher wages (and in general, exit options) outside the schemes increase the opportunity cost of labour and reduce the incentive for households to participate in the maintenance of the irrigation schemes (Gyasi et al, 2006).

The scheme requires modernisation of the irrigation system with special attention on the pumping unit, the pipes and the pressure tanks. Some schemes in the country have been upgraded into centre pivots which is a better technology in terms of irrigation efficiency and labour requirement to shift pipes. The only hindrance in irrigators adopting the technology is its reliability on automation. Elsewhere irrigators have been trained and can operate the system. It is a gender sensitive technology as it does not require too much of the physical energy or to always be physically there during irrigation as there is no shifting of pipes. Once it is turned on it moves on its wheels. This relieves women of the several burdens they are exposed to while irrigating in the evening from 22h00 to 06h00. With the advent of improved technologies farmers can optimise the productivity based on improved technologies blended with local knowledge. This permits considerable flexibility and responsiveness to market conditions by farmers in choosing crops and cropping patterns (Vermillion 2001).

7.4 PRICING STRUCTURE OF ELECTRICITY

The pricing structure of electricity whereby cheaper rates of 4cents/unit (2014-2017) are charged during the off-peak hours in the evening from 22h00 to 06h00 has influenced a shift in the irrigation time. The rules that govern the time for irrigation were aligned with the time electricity was cheap. This rule has affected the social way of life of the irrigators as they are working at a time they are expected to be sleeping in their homes. This is one of the situations where the electricity pricing structure has influenced the tranformation of irrigation scheme rules to align with the provided electricity schedule. It influenced collective action among the irrigators as the challenge was rated a collective problem. The other challenge is that the Zimbabwe Electricity Supply Authority (ZESA) cuts electricity because non-payment for the whole scheme regardless that some irrigators had paid. This affects the irrigators who comply with their obligations to contribute towards payment of bills. It disrupts the whole system and everyone becomes insecure whether one is paying or not. It affects future investments on the irrigators' plots in terms of cropping as they are punished for non-compliance by their fellow irrigators. In the rules it is stated that those that default in payment of bills would be cut off but it appears that it is difficult to exclude someone from the electricity grid. This is because it requires the expensive process of installing separate meters on the 156 plots. This is a dilemma that has haunted Mamina irrigation scheme for a long time. The situation is exacerbated by the fact that when electricity is cut for the whole scheme crops worth thousands of dollars are lost. The rules on payment of electricity bills and defaulting are as follows:

> "Electricity bills for the scheme will be divided equally among the farmers. It is a must that each farmer pays his/her dues on time. If he/she fails to pay by the agreed date, water will be cut off from his or her plot".
>
> "If a plot holder continuously fails to pay the electricity bills, he or she will be asked to leave the scheme. The fate of the vacant plot will be decided by the IMC." (FAO 2OOO, ANNEX C)

The other dilemma affecting collective action was that electricity bills are shared equally regardless of whether one has used it or not, as the billing system provides a bulk bill which irrigators divide among themselves. These do not consider the area planted to the crop or whether one is receiving irrigation water or not. The rules threaten to evict defaulting irrigators but no one has ever been evicted on that cause.

7.5 WATER PERMIT SYSTEM

The water allocation system requires the water user to apply for a permit or agreement.The Zimbabwe National Water Authority (ZINWA) applies the user-pays-principle. In order for a consumer to access water for non primary use, a permit or agreement is required. The challange posed by the water permit system is that once people enter into an agreement with ZINWA for water allocation and use, they are already indebted to ZINWA, whether they use the water or not. The water allocation system poses a problem especially in the summer season where sometimes rains are in abundance to the extent that the irrigators may not irrigate throughout the season but because they had entered into an agreement with ZINWA, are obliged to pay. This is another reason the water bill arrears continued to spiral upwards. Johansson et al (2002), note that methods of allocating water are sensitive to physical, social, institutional and political settings, making it necessary to design allocation mechanisms accordingly. The amount users have to pay may vary in accordance with the area cultivated, season and type of crop to irrigate, but it does not vary according to the amount of water actually used. Instead, a system of water pricing relates payments to water use decisions (Small 1989). Further probes with ZINWA revealed that the irrigators are expected to install a water meter if they are to be billed through the metering system whereby they will be charged for what is used. Perry (2001) emphasises that an orderly system of distributing water must be in place through some existing and respected regulatory framework for allocating water among farmers. Perry (2001) argues that attention should be first given to clarifying and enforcing water rights and the rules of water distribution. Where water rights, and compatible water distribution arrangements, do not exist it may be difficult to form farmer groups to manage irrigation collectively (Shah et al, 1994; Kloezen, 2002). Frederiksen (1994) suggests that an Agreement/Memorandum of Understanding that highlights the duties and responsibilities of both the parties-providers and users of waters is a must. It should specify the quantity of water the farmers are entitled to, season-wise, and the persons designated for operational process, persons to whom the disputes could be referred to. It should also state the amount of the water fees and the dates on which they are to be paid (Frederiksen, 1994). Deliveries to irrigation schemes and to individuals are thus treated as contractual obligations and water is regarded as an economic good rather than a social entitlement (Vermillion, 2001). There should be clear points of demarcation of responsibility and control where transfers of measured quantities of water are undertaken according to widely accepted agreements and rules, including payment rules (Vermillion, 2001). The experience with management transfer indicates that clear water rights, with compatible water distribution arrangements, tend to exist in more successful cases of management transfer or locally managed irrigation which have been documented (Shanan and Berkowicz, forthcoming 1995; Gazmuri, 1994; Svendsen and Vermillion, 1994; Johnson et al, 1994).

The water fee regulation supported development of a widespread tripartite system of resource mobilisation which included a fixed area fee (based on the area irrigated by a farmer), a volumetric fee (based on estimated volume of water diverted into a farmer's field), and an annual labour contribution for system maintenance (Chen and Ji 1994). However, the contrary situation is that poor service delivery leaves farmers unwilling to pay. Perry (2001) argues that in Egypt and the Republic of Iran the cost of charging individual farmers are likely to outweigh the projected benefits. The flat-rate tariff structure should be replaced so that farmers pay for the amount of water or electricity actually consumed. Shah (2002) claims that as for the Panchkanya scheme a member has to pay a one-time entry fee less than US$2 to enrol and an annual maintenance fee of around US$7 or three man days of labour. Against this all members take 3 irrigated crops every year for water charges ranging from US$1.5-US$3.00 per hectare.

7.6 RELATIONSHIP BETWEEN WATER ALLOCATION AND PRODUCTIVITY ACROSS LOCATION (HEAD, MIDDLE AND TAIL-END)

The state of the irrigation scheme has affected the water distribution efficiency across locations especially at the tail-end were very little water for crop production is recieved. This has affected productivity at the tail-end. When all the farmers religiously follow the rule to irrigate in the evening between 22h00 and 06h00 it would give an impression that equity is achieved by the system but however, the tail-end is deprived of enough water. The irrigators will need to consider raising funds for operation and maintenance, and putting in place mechanisms to govern repair and maintenance. The literature acknowledges that the development of short-season varieties, which reduce the growing time from 5 months to 3.5 to 4 months, has been a major source of water and electricity saving. Thus , there is no question that, over the past 3 decades, varietal improvement through plant breeding (aided by investment irrigation and advances in the fertiliser technology) has been the major source of increase in water productivity (Richards et al , 1993).

Rockstrom et al (1998) argue that the best option for increasing crop water productivity lies in combining such practices as water harvesting, conservation tillage and supplemental irrigation during short dry spells with management strategies that enhance infiltration of rain, increase water holding capacity of soils and maximise plant water uptake through timeliness of farming operations and soil fertilisation. Crop water productivity (Kg / m^{-3}) varies with location, depending on such factors as cropping pattern, climatic conditions, irrigation technology, field water management and infrastructure, and on the labour, fertiliser and machinery. Oweis et al (1999) demonstrate that sustainable increases in crop water productivity can only be achieved through integrated farm resources management. This approach combines water conservation, supplemental irrigation, better crop selection, improved agronomic practices, political and institutional intervention. Evidence shows that there are many people working in parallel on means to increase the productivity of water but the efforts remain disjointed.

7.7 GENDER PARTICIPATION AND REPRESENTATION

Women were not significantly represented in the decision making Irrigation Management Committee (IMC) and the block committees. The rule stipulates that, ‘if the plot holder dies, his or her plot will be taken over by the surviving spouse. If both spouses die, the eldest son will take over the irrigation plot’; this rule affects the girl child. The rules should promote equal opportunities for the sons and the girl child. The women are heavily burdened as they are expected to fulfil their domestic chores as well as their increasing roles on the irrigation scheme. To influence participation by women, the irrigators could consider a rule that influences men to attend training or meetings with their wives for continuity. This is because men attend meetings and training on the scheme but in most cases do not share the information with their wives. Denys et al (2014) claim that the participation of women in water users' organisations (WUOs) was closely linked to land ownership and with women owning less than 25 percent of the land in Peru, their participation was limited. It became clear that social and technical barriers for women existed. These barriers hindered the attendance and participation of women under conditions of equality in WUO meetings and training events.

7.8 FOOD SECURITY

Overrall, the challenges of poor technology design, electricity and water cuts, electricity pricing structure, low productivity, marketing, inequality in the water distribution system, plot allocation and land disputes, have contributed to the food insecurity of the Mamina irrigators. At the irrigation scheme 60% of the sampled households were food insecure at the time of the study. The challenges facing Mamina irrigation scheme provide the structural form causing food insecurity at the scheme. Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. (World Food Summit, 1996). A secure livelihood is necessary and often sufficient condition for food security (Maxwell, 1994). Access to food derives from opportunities to produce food directly or to exchange other commodities or services for food. These opportunities, described by Sen (1981) in terms of entitlement, are based in turn on access to resources, production technologies, environmental conditions such as weather, and market conditions such as prices.

7.9 MARKETING

The widely used markets to sell produce by the irrigators are the informal markets. This is because the formal marketing system has become so sophisticated as it now determines what to produce, how to produce and when to produce. This affects the rule 'All farmers should follow the agreed cropping programme (programme agreed upon by the IMC, AGRITEX and all farmers)'. Anyone who deviates from the programme will have water cut off from his or her plot. This is an example of an external system which is trying to effect or influence change in the way decisions are made in a common pool resource by determining some of the processess. The discourse was calling for market oriented production. In a common pool resource such as an irrigation scheme selecting of what crops to grow is a collective effort by all the irrigators. This is also the requirement by the design of the scheme (blocking system). The blocking system assumes that the various plots in a portion of the field are aggregated to be one for the purpose of irrigation scheduling. The formal markets call for farmers to be organised in the various blocks to facilitate contract farming.

Globalisation has profound implications on governance. A cost reduction in one place has immediate impact in other places. Cost reductions are mainly influenced largely by technological advances through enhancing agriculture research capacity. Major formal urban markets that would have provided an opportunity for Mamina irrigators were open to foreign competition that squeezed out the irrigators. This resulted in them being relegated to informal markets. Opening markets to foreign competition whilst farmers are experiencing production inefficiencies has done little for agriculture, hence for poverty and food security. World Trade Organisation constrain the extend to which countries can protect themselves as the organisation works to reduce trade barriers and enforce agreed rules. Developing countries such as Zimbabwe need to invest in agriculture research and technology dissemination. The rights and institutions that govern access to and use of irrigation scheme, irrigation technology physical condition, pricing structure of electricity, water permit system, water allocation system, marketing and gender participation and representation are key in determining the food security of the irrigation scheme.

7.10 STRENGTHS AND WEAKNESSES

The findings presented above lead to a number of observations on the strengths and weaknesses of the irrigation water governance system in the study area.

7.10.1 Strengths (Reasons Supporting IMT)

IMT promoted collective action and improved self governing institutions on Mamina irrigation scheme. IMT relieves government from further contributing towards the water and electricity bills thereby increasing the fiscus space. When responsibility is handed over to the irrigators, they are expected to self organise for collective action. This has been observed at Mamina irrigation scheme were the farmers to some extent cooperate in the collection and payment of bills, operations and marketing of their crops. The availability of a structure such as the Irrigation Management Committee provides an opportunity for the irrigators to coordinate and manage activities. The development of an irrigation schedule on when to irrigate, hours to irrigate and who is to irrigate provides an opportunity for the irrigators to plan for collective action. A transparent water permit, pricing and allocation system enhances cooperation among the irrigators to cooperate in the contribution of the bills. Self governing institutions have a long endurance during challenges.

7.10.2 Weaknesses (Reasons Hindering IMT)

The lack of arrangements that guide the use of shared infrastructure remains a major concern. The irrigators failed to cooperate on operation and maintenance of a shared infrastructure. The lack of capacity to manage and maintain the large mechanised equipment such as tractors on the scheme was problematic. Low crop productivity hinders successful IMT as irrigators fail to contribute towards operation, maintenance and bill payment. The faulty and inefficient irrigation system hinders IMT. Lack of enforcement of penalties hinders successful IMT.

7.10.3 Key Challenges for Consideration

The failure of the irrigators to raise funds for operation and maintenance is a serious threat to successful irrigation management transfer. The continued unresolved land tenure issues are a threat to successful irrigation management transfer. Futhermore, the transfer of a defective irrigation system is a threat to successful IMT. Exported technology without local backup services and equipment was a threat to successful IMT. Unclear right to use an asset, right to obtain benefits from the asset and the right to alienate or sell an asset is a threat to successful IMT. The size of the irrigation system and a large number of beneficiaries can be a threat to IMT. Larger irrigation systems and beneficiaries have challenges in coordination and organising for collective action. The operation and maintenance costs can hinder successful IMT. Operation and maintenance costs should be insignificant for IMT to succeed. Most literature points to 5% of the gross income. The high cost of irrigation development (US$5000-US$7000) poses a threat to successful IMT. Poor access to modern technologies hinders successful IMT as most of the equipment and technologies are imported. Automated irrigation systems may be a threat to successful IMT. Such systems require operational and maintenance staff that are highly skilled with knowledge in computers, electronics and mechanics.

The problem of lack of arrangements guiding the shared use of infrastructure is not unique to only smallholder irrigation schemes, such as Mamina, but is also common in redistributed commercial farms. Collectively, this scenario will impact heavily on irrigation development and management in many farming areas under group tenure across the country. Given the observed tensions among irrigators in Mamina irrigation scheme, there will be need for the farmers to organise themselves for collective action to get around conflicts emanating from the sharing of irrigation infrastructure and water resources.

7.10.5 Lack of Guaranteed Markets

The lack of a guaranteed markets affects the sustainability of Mamina irrigation scheme as most of the time farmers are exposed to the unstable informal markets, which fail to give assurance that the products will be bought at favourable market rates. This is a general trend that has been observed among beneficiaries of fast track land reform. Prior to ESAP and related restructuring initiatives, such as IMT, government used to counter these challenges through parastatals, such as ARDA, which provided technical and marketing services to smallholders and other farmers. The irrigators would adopt the cropping programme of the core estate model, in this instance ARDA, as well as take advantage of the marketing structure of the estate. The core estate model would assist with the processing of agricultural produce for the markets. This arrangement made sure the small holder was not locked out of the value chain.

7.10.6 Management and Productivity of Irrigated Agriculture

Currently the management of schemes is not clearly spelt out in the smallholder sector. In the private sector the schemes are privately managed. In terms of management in the smallholder sector, there were three broad types of smallholder schemes: government managed, farmer managed, and jointly managed schemes. Government managed schemes were developed and maintained by the Department of Agricultural Technical and Extension Services (AGRITEX) and of late the Department of Irrigation (DOI). In the new schemes, there tends to be a shift away from this practice towards farmer managed projects. Farmer managed schemes are developed by the government but owned and managed by the farmers' Irrigation Management Committees (IMCs) with minimal government interventions in terms of management. For jointly managed schemes the farmers and the government share the financial responsibility for the operation and maintenance. For such schemes the government is usually responsible for the head works, while farmers take responsibility for the infield infrastructure. Poor agronomic practices are practised in small–scale irrigation, including planting low–yielding crop varieties and not sufficiently using fertilisers.

Smallholder irrigators face many challenges and legal obstacles that weaken their capacity to interact with other stakeholders and protect or further their interests. Smallholder irrigators elect Irrigation Management Committees (IMCs) to manage their irrigation schemes and represent the interests of members when they deal with other stakeholders. The stakeholders include Government institutions, Catchment councils (set up under the Zimbabwe National Water (ZINWA) Act (1999), finance houses, buyers and service providers, such as input suppliers and contractors. Although the IMCs can register as voluntary associations, most have not, under the law. This law does not confer legal standing on them, rendering them ineffective where legal representation is required.

There are no clear legally binding procedures in place on how to deal with smallholder irrigators who default on their responsibilities (such as payment of electricity and water bills and adhering to crop husbandry practices that minimise spreading of crop diseases) to the detriment of all other scheme members. As a result, many schemes have failed to operate fully or in some cases at all due in part to this problem.

Prior to the Land Reform Programme, government mainly funded smallholder irrigation development in partnership with donors while the commercial sector got funding from financial institutions. Before being transformed to AGRIBANK, AFC used to administer the National Farm Irrigation Fund (NFIF of 1985). Issues of collateral are at the core of the problem of funding in the sector with the current 99 year lease failing to address the problem. Presently these problems are afflicting both smallholder farmers and newly resettled farmers. There is minimal participation of the private sector in funding irrigation development. There are no guidelines on public private partnerships.

The Zimbabwe Agricultural Policy Framework led to the creation of the Farm-Level Applied Research in East and Southern Africa (FARMESA) project, financed by FAO and SIDA (a Swedish donor agency), that developed methodologies for irrigation management transfer in government run irrigation schemes (Manzungu, 1999), and the Smallholder Irrigation Support Programme (SISP), financed by the International Fund for Agricultural Development (IFAD) and the Danish International Development Agency (DANIDA) (a Danish donor agency). The policy discourse stressed the need for irrigation management transfer for reasons of improved cost recovery. The approach was silent on the rights and responsibilities of the users. As a result, irrigation management committees on most schemes lacked a legal basis for sustained operation. The severe budgetary pressures experienced towards the end of the 1990s precipitated a process of financial devolution from government to the farmers (Manzungu, 1999). Infrastructure is used under unclear arrangements. In the newly resettled areas, plot allocation did not necessarily take into account the design of irrigation schemes/facilities, resulting in severe management problems.

7.10.7 Policy Incentives to Invest in Water and Power Saving Technologies

Policy incentives to invest in water and power–saving technologies are lacking. There are no incentives to improve the local irrigation industry with a view to making irrigation cheaper by, for example, facilitating local manufacture of some irrigation equipment or components such as centre pivots and their associated kits. In some countries such as Spain Centre pivots are operated with the use of generators and this has proved to be cost effective in that country.

7.10.8 Cost Recovery Mechanisms

There was a need to introduce cost recovery mechanisms on irrigation schemes to promote irrigation sustainability. This will reduce pressure on the fiscus. Given that the cost of irrigation development continues to rise due to several factors. Development of a hectare is estimated to be in the range of US$5000-US$7 500, lack of sound cost recovery mechanisms means lack of funds to promote further irrigation development.

7.10.9 Irrigation Pump Systems

Irrigation pump systems have an effect on the viability and sustainability of irrigation projects. Poor designs have led to the failure of most irrigation schemes. The irrigation design of Mamina irrigation scheme requires high power demand to pump water into 11settling tanks 40 metres above ground. The irrigation scheme has incurred high pumping costs before and after Irrigation Management Transfer (IMT). By contrast, gravity-fed systems have proved to be more sustainable as farmers do incur any pumping costs but these have specific slope conditions and will not work on flat land such as Mamina irrigation scheme. Identification of suitable irrigation designs should be done in consultation with and cooperation of the local farmers or 'beneficiaries'. Chidenga (2003) summarises the technological trajectory in Zimbabwe which he refers to as a progressive shift from run-of-river gravity canal surface systems that were developed in Manicaland between 1912 and 1950. He claims that the need to expand irrigation to flatter areas in the middle Save valley with limited gravity had led to the introduction of lift schemes with diesel, then electric powered pumps which generated considerable power costs leading to a debate in the 1970s on the need to maximise the area served and thus reduce field losses. Chidenga (2003) highlights that with the advent of independence pressurised irrigation system development got technical support from FAO. Chidenga (2003) further claims that technological change at this stage was hardly accompanied by any debate, leaving a range of irrigation system designs in a technological repertoire largely unquestioned since independence. The net result has been a number of schemes which were developed that are now showing operation and maintenance stress. This historical problem was affecting Mamina irrigation scheme and many other smallholder irrigation schemes. Other technologies such as the solar pumping systems has gained widespread support because of their sustainability but more research is required to determine their efficiency and reasonable initial cost structure.

The combination of the concepts as presented in this thesis can help solve some of the historical challenges that have affected Mamina irrigation scheme and many other smallholder irrigated agriculture. The central government and the irrigators have their various roles to ensure a sustainable irrigated agriculture.

7.11 CONCLUSION

Since Mamina irrigation scheme was established it has undergone a cycle of accumulation of huge water and electricity payment arrears during and after IMT. At one time the bills for a year was half (50%) of the funds received by AGRITEX for managing and operating all the smallholder irrigation schemes in the country. The irrigators complained about the technology not being sustainable. The government, notwithstanding the huge water and electricity bill, resolved to transfer the irrigation management to the irrigators. The irrigators initially resisted the takeover siting the defective irrigation design which was costly to maintain. According to the irrigators, the FARMESA project was financed by FAO and SIDA to develop methodologies for irrigation management transfer in government-run irrigation schemes. Considering the above background, it appears the irrigation scheme required to be upgraded through modernisation of the system before it was transferred to reduce the burden of huge bills. Transferring a defective irrigation scheme was a threat to successful IMT.

The tenure system was in such a way that the irrigation infrastructure was to be communally managed and the irrigation plots privately managed. The Irrigation Management Commitee (IMC) was capacitated through the FARMESA project to take over the management. The IMC maintained the tenure structure that was there before Irrigation Management Transfer (IMT). The tenure arrangement was in such a way that the irrigators would develop their self governing institutions.The self governing institutions would influence the crop productivity, food security status and livelihoods.

The electricity and water billing system and the way defaulters and those who complied were sanctioned discouraged productivity. Electricity and water was cut off in the whole irrigation scheme without considering whether a user had paid or not. Punishing the whole group for non payment by other users was problematic as it did not encourage those who met their obligations on time. Frequent power cuts affected productivity, food security and the livelihoods of the irrigators. An FAO study (1997a) claims that food insecurity in the irrigation scheme was reportedly so severe that during the 1996/97 season farmers ended up approaching the government's Department of Social Welfare for food hand-outs. The irrigation scheme had failed to sustain the livelihoods of the irrigators because they were always in arrears.

Self governing institutions have shown their endurance in times of challenges. Towards enhancing the collection of bills and payment, the irrigators had organized themselves and put in place a system of contribution of bills and payments. The irrigators agreed to irrigate during off peak hours when electricity charges are low. Though this system has worked the pumping costs are still unsustainable. The only hope for the Mamina irrigators is to have an irrigation system upgrade, that will involve changing some components of the irrigation scheme. Gender issues exist at Mamina irrigation scheme. Though women are represented in the Irrigation Management Commitee (IMC) there are in less influencial positions, mostly secretarial roles. The women are heavily loaded with domestic chores and day to day irrigation activities. The irrigation time was not gender sensitive to the women. This affects the livelihoods of the farmers.

The livelihoods of the irrigators are affected by several challenges at the irrigation scheme. The challenges include a defective irrigation system that has a high electricity demand, inefficiencies in the water supply system, inequitable water and electricity billing system, low productivity, food insecurity, poor access to markets, lack of skills to maintain farm equipment, irrigators' failure to contribute towards maintenance of the irrigation scheme and farm equipment and gender inequality. DFID (1998) claims that the vulnerability context frames the external environment in which people exist. People's livelihoods and the wider availability of assets are affected by critical trends as well by shocks and seasonality.The Mamina irrigators are affected by trends, shocks and seasonality. Some of the trends that affect Mamina irrigation irrigators are governance, technological, population, resource and national/international economic trends. Weak governance affects the operation and maintenance of the irrigation scheme. The irrigators have failed to cooperate in raising funds for operation and maintenance. The irrigation technology is defective as it demands lots of energy to distribute irrigation water across the scheme. The population on the scheme has increased because 29 years after the irrigation scheme was established some family members have matured and require land to sustain themselves. The resource trends also affect the availability of assets as low input usage result in low productivity which will cause food insecurity. National/international trends affected availability of assets as the push for irrigation devolution was partly influenced by the economic structural adjustments which pushed for economic liberalisation. The shocks which affected Mamina irrigation scheme were natural, economic, conflicts, and crop health shocks. The natural shocks were the droughts of 1997 which caused the irrigators to appeal for food aid. The situation was further exarcebated by the frequent electricity cuts by the Power Utility Company, ZESA because of non payment of bills. The economic shocks affected Mamina irrigation scheme as the Zimbabwean economy deteriorated heavily since 2008. Most of the cash in banks were eroded by inflation. The health of the crops was affected by pest outbreaks with the recent outbreak of the fall armyworm which was a new phenomenon in Zimbabwe. Inequalities in the distribution of water in the system have been a source of conflict at Mamina irrigation scheme. The tail-end irrigators do not receive enough water but are expected to make equal monthly contributions. Furthermore seasonality of prices, and production affects Mamina irrigators. Production of certain crops such as onions and peas are successful in the winter season and because of this they are in short supply during the winter period when the crop is under production and available during the summer season. The prices of these crops also follow this trend that the prices are good in winter and are bad during the summer season when the crops are in abundance.

The case of Mamina needs to be seen in terms of the broader agrarian questions in Zimbabwe. In 2000, government launched the Fast Track Land Resettlement Programme (FTLRP), which resulted in most of the black farmers getting access to productive land. At the peak of land reform, the area under irrigation was 200 000 ha. This has gradually declined to 120 000 ha due to a number of factors, some of which resonate with challenges in Mamina irrigation scheme.

The launch of the FTLRP has resulted in some of the farms designed for individual occupancy being allocated to multiple farmers. These schemes were designed for a single owner/user but are now operated by multi-users. This has brought to the fore issues of Common Property Ownership on former commercial farms. Common Property Resources (CPRs) include water sources, like dams and boreholes; pumps, transformers, water conveyance systems, infield irrigation infrastructure and tobacco barns. Some farmers are installing their own individually operated infrastructure, on areas that were originally serviced by the existing infrastructure. A lack of cooperation among farmers in the newly resettled areas prevents them from sharing water, irrigation infrastructure and operational costs like water and electricity bills. Some irrigators are denied servitude to convey water across other people's fields, a problem that has been compounded by lack of experience in utilising and managing water at both the field and catchment level. As a result many farmers in such settings have ended up sharing irrigation infrastructure, ranging from water sources to irrigation pipes. Under group utilisation of farms, buried pipes that convey water from source to the fields and electricity infrastructure at the farm have become particularly vulnerable to damage as different beneficiaries carve out plots of land without the knowledge of infrastructure lay-outs.

REFERENCES

Abernethy, C.L., Sally, H., Lonsway, K., and Maman, C. (2000). *Farmer based financing of operations in the Niger Valley Irrigation Schemes,* Research Report No. 37, International Water Management Institute, Colombo, Sri Lanka.

Adams, M., Sibanda, S., and Turner, S. (1999). Land tenure reform and rural livelihoods in Southern Africa. Natural Resourses Perspectives. No. 39. London. ODI.

AGRITEX, (1999).In Food and Agriculture Organization (FAO). (2000). *Socio-economic impact of smallholder irrigation development in Zimbabwe*. SAFR/AGLW/DOC/002.

Alkire, S., Foster, J., Santos, M.E., Roche, J.M., and Ballon, P. (2015). *Multidimensional poverty measurement and analyses.* Oxford: Oxford University Press.

Alvord, (1933). In Food and Agriculture Organization (FAO). (1997b). Summary of findings of missions in selected countries in East and Southern Africa. *Irrigation Technology Transfer in Support of Food Security*. Proceedings of an FAO Sub-regional Workshop, Harare, Zimbabwe. 14 - 17 April 1997, Prepared by A. Kandiah.Ball, S. J. (2006). Policy Sociology and Critical Social Research. In: Ball, S. J. (Ed.): *Education Policy and Social Class*. London: Routledge, 9–25.

Bardhan, P. and Ray, I. (2006). "symposium on anthropologists' views on common resources: Methodological approaches to the question of the commons," economic development and cultural change, University of Chicago Press, vol. 54(3), pages 655-676.

Blake, R.O., Bell, D.E., Mathews, J.T., McNamara, R.S. and McPherson, M.P.(1994). Feeding 10 billion people in 2050: The key role of the CGIAR's International Agricultural Research Centers. A Report by the Action Group on Food Security presented to the President of the World Bank. Washington, DC.

Bogdan, R., and S. J. Taylor. 1975. Introduction to qualitative research methods. New York: John Wiley.

Bolding, A. (2004). In hot water: A study on sociotechnical intervention models and practices of water use in smallholder agriculture, Nyanyadzi catchment, Zimbabwe, Wageningen UR.

Bruce, J. Louise, F. And Calvin, N. (1993). " Tenures in transition, Tenures in conflict; Examples from the Zimbabwe Social Forest." Rural Sociology 58(4): 626-642.

Bryman, A. (2008). "Of methods and methodology", Qualitative research in organisations and management: An International journal, Vol.3 Issue 2, pp. 159-168.

Bulmer, M. (1979). Concepts in the analysis of qualitative data. *Sociological Review* 27 (4): 651–77.

Burt, C.M. (1996). Essential water delivery policies for modern on-farm irrigation management. In: *Irrigation scheduling: From theory to practice,* Proceedings of ICID/FAO workshop, Sept. 1995, Rome. Water Report No. 8, FAO, Rome. pp. 273-278.

Chambers, R. (1988). *Managing canal irrigation. Practical analysis from South Asia*, Oxford and IBH, New Delhi and Calcutta.

Chambers, R. and Conway, G. (1992) Sustainable rural livelihoods: Practical concepts for the 21st century. IDS Discussion Paper 292. Brighton: IDS.

Chen, X. and Ji, R. (1994). Overview of irrigation management transfer in China. Paper presented at the International Conference on Irrigation Management Transfer, Wuhan, PR China, September 20-24, 1994.

Chidenga, E.E. (2003). Leveraging water delivery: Irrigation technology choices and operations and maintenance in smallholder systems in Zimbabwe. Wageningen University. Netherlands.

Chitsiko, R.J. (1995). Irrigation development in Zimbabwe: Constraints and opportunities. Paper presented at ZFU workshop 'Water development for diversification within the smallholder farming sector', Harare, Zimbabwe.

Coffey, A., and Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies*. Thousand Oaks, CA: Sage.

Command Agricultural Programme (2016). Harare, Zimbabwe.

Comprehensive Agriculture Policy Framework (2014). Harare, Zimbabwe.

Cornish, G., Bosworth B, Perry C., and Burke J., (2004) Water charging in irrigated agriculture. An analysis of International experience. FAO. Rome. FAO Water Reports 28.

Coward, E.W. Jr. (1979). Principles of social organization in an indigenous irrigation system *Human Organisation*. 38:28-36. Cornell University Press New York, USA.

Coward, W. E. (1986). Direct or indirect alternatives for designing for irrigation investment and the creation of property. In Easter, W.W. (Ed.) *Irrigation investment, technology and management strategies for development.* Studies in Water. Cornell University Press. New York, USA.

D'Andrade, R. (1991). The identification of schemas in naturalistic data. In Horowitz, M.J. (Ed.) *Person schemas and maladaptive interpersonal patterns*, Chicago: University of Chicago Press, 279-301.

D'Andrade, R. (1995). *The development of cognitive anthropology*. Cambridge, UK: Cambridge University Press.

Denison, J. and Manona, S. (2007). *Smallholder irrigation, the water wheel*. Vol.2 Concepts and Cases. Wrc Report No. TT309/07 Water Research Commission and Arcus Gibb. Pretoria, South Africa.

Denscombe, M. The good research guide for small-scale social research projects, 4th Edition, Open University Press, Berkshire England.

Denys, E., Stanley, V., and Mills, A. (2014). Empowering women in irrigation management - The case of the Gender Pilot Plan in Peru, Issue 8. Agriculture and Environment Services Department. The World Bank, Washington DC.

DeWalt, K.M. and DeWalt, B.R. (2002). Participant observation: A guide for field workers. Walnut Creek, CA: Altamira Press.

Dey, I. (1993). *Qualitative data analysis: A user-friendly guide for social scientists*. London: Routledge Kegan Paul.

DFID, (1998). Sustainanble Livelihoods guidedance sheets. DFID. London.

Diemer, G. and Slabbers, J. (Eds.). (1992). *Irrigators and Engineers.* Amsterdam: Thesis Publishers.

Easter, K.W. (1993). Water markets and other mechanisms to decentralize and improve water management. Draft paper. St. Paul, Minnesota, USA: Department of Agricultural and Applied Economics, University of Minnesota.

Eicher, C. K. (1994). African agricultural development strategies. In Stewart, F. Lall, S. and Wangwe, S. (Eds.). *Alternative development strategies in Sub-saharan Africa.* London: Macmillan Press.

Farley, P.J. (1994). Privatization of irrigation schemes in New Zealand. Short Report Series on Locally Managed Irrigation. No.2. Colombo, Sri Lanka: 11MI.

Farmesa, 1997. Farming systems assessment of water harvesting in semi-arid areas of Eastern and Rift Valley Provinces of Kenya. Draft Report, Nov. 1997, Farmesa, Harare, Zimbabwe. p 83

Feeny, D., Berkes, F., McCay, B. and Acheson, B. (1990). The tragedy of the Commons: Twenty-two years later, *Human Ecology*, volume 18, Issue 1, 18 (1) pp 1-19.:

Food and Agriculture Organization (FAO). (1997a). *Smallholder irrigation and poultry development in Zimbabwe: A brief general overview*. A Paper prepared by R.J. Chitsiko for the FAO.

Food and Agriculture Organization (FAO). (1997b). Summary of findings of missions in selected countries in East and Southern Africa. *Irrigation Technology Transfer in Support of Food Security*. Proceedings of an FAO Sub-regional Workshop, Harare, Zimbabwe. 14 - 17 April 1997, Prepared by A. Kandiah.

Food and Agriculture Organization (FAO). (2000). *Socio-economic impact of smallholder irrigation development in Zimbabwe*. SAFR/AGLW/DOC/002.

Food and Agriculture Organization (FAO). (2004). *Socio-economic analyses and policy implications of the roles of agriculture in developing countries*. Summary Report, Roles of Agriculture Project, FAO, Rome, Italy.

Gazmuri, R.S. 1994. Chilean water policy. Short Report Series on Locally Managed Irrigation. No. 3. Colombo, Sri Lanka: **IIMI.**

Guba, E.G. (1978). *Toward a methodology of naturalistic inquiry in educational evaluation*. Monograph 8. Los Angeles: UCLA Center for the Study of Evaluation.

Gyasi, K.O., Engel, S., and Frohberg, K. (2006).What determines the success of community-based institutions for irrigation management? ZEF Policy Brief No. 5, Ghana.

Hardin, G. (1968). "The tragedy of the commons."Science, vol. 162, pp. 1243-1248.

Horst, L. (1996). The discrepancy between irrigation scheduling and actual water distribution: An analysis and suggestions for possible solutions. In: *Irrigation scheduling; from theory to practice*, Proceedings of ICID/FAO workshop, Sept. 1995, Rome. Water Report No. 8, FAO, Rome. pp. 297-304.

Hunt, A.F. (1958). Manicaland irrigation schemes, economic investigations, Department of Native Economics and Marketing, Salisbury, Zimbabwe.

Hyden, G. (1998). Governance issues in conservation and development. Available at: www.cdf.ufl.edu/cdf/gov.hyden.htm. [Accessed: 04/02/2017]

Jansen, D.J. (1993). Economics of irrigation. A modular methodology for comparing the benefits with the costs. A background paper prepared for the planning and water development as an input into the national irrigation policy. Harare, Zimbabwe.

Johnson, S.H. III, Vermillion, D.L., Svendsen, M., Wang Xinyuan, Zhang Xiying and Mao Xuesen. (1994). Institutional, management and performance changes in two irrigation districts: A ease study from Hebei Province, PR China. Paper presented at the

International Conference on Irrigation Management Transfer, Wuhan, PR China, September 20-24, 1994.

Johansson, R.C, Tsur, Y, Roe, T.L, Doukkali R, Dinor A, (2002). Pricing irrigation water: a review of theory and practice, volume 4, Issue 2 pages 173-199.

Jones, W.I. (1995).The World Bank and irrigation. A World Bank Operational Evaluation Study. Washington DC.

Lonsway, K. A.; Amadou, A. (1994). The transfer of irrigation management to farmer organizations in Niger. In IIMI; Wuhan University of Hydraulic and Electrical Engineering. International Conference on Irrigation Management Transfer, Wuhan, China, 20-24 September 1994. Draft conference papers. Vol.2. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI); Wuhan, China: Wuhan University of Hydraulic and Electrical Engineering. pp.145-154.

Kadigi, R.M.J., Tesfay, G., Bizoza, A., and Zinabou, G. Irrigation and water use efficiency in Sub-saharan Africa. No. 4 GDN Agriculture Policy series, Global Development Network. Washington DC.

Kiser, L. and Ostrom, E. (1982). The three words Action: A Metatheoretical Synthesis of Institutional Approaches. In Ostrom, E. (Ed.) *Strategies of Political Inquiry*. Sage, Beverly Hills, 179-222.

Kloezen, W.H. (2002). Accounting for water. Institutional viability and impacts of market-oriented irrigation interventions in central Mexico. PhD. thesis, Wageningen University, Wageningen.

Lakoff, G., and Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.

Lam, W.F. (1994). A comparative study of farmer managed and agency managed irrigation systems in Nepal: An institutional analysis. PhD dissertation. Indiana University, Bloomington, Indiana.

LeCompte, M.D., and Schensul, J.J. (1999). Analysing and interpreting ethnographic data. Book 5 of the Ethonographers toolkit.J.J. Schensul and M.D. LeCompte (Eds). Walnut Creek, CA: Altamira Press, a division of Sage Publication.

Levy, M.A., Young, O.R.and Zürn M. (1995). The study of international regimes. *European Journal of International Relations*,1:267-330.

Lowdermilk, M.K. (1990). Irrigation water control and anarchy. In Social, economic, and institutional issues in Third World irrigation management, ed. R.K. Sampath and Robert A.Y, 155-173. Boulder, Colorado, USA; Westview Press.

Makadho, J.M. (1994). An analysis of water management performance in smallholder irrigation schemes in Zimbabwe. PhD thesis, University of Zimbabwe, Harare.

Makombe, G., Makadho, J.M., and Sampath, R.K. (1998). Irrigation and drainage systems: An analysis of the water management performance of smallholder irrigation schemes in Zimbabwe. Department of Agricultural and Natural Resources Economics, Colorodo State University, Fort Collins, USA.

Makhura, M.; and M. Mamabolo. (2000). Socio-economic issues in small-scale irrigated agriculture: A literature survey of the Olifants Basin, Republic of South Africa and Southern Africa Development Community. Colombo, Sri Lanka: International Water Management Institute (unpublished report).

Manzungu, E. (1999). Strategies of smallholder irrigation management in Zimbabwe. Wageningen University, Netherlands.

Manzungu, E., and Van der Zaag, P. (eds.), (1996a), *The practice of smallholder irrigation; case studies from Zimbabwe*, University of Zimbabwe Publishers, Harare.

Manzungu, E. and Van der Zaag, P. (1996b). Continuity and controversy in smallholder irrigation, in Manzungu E.and Van der Zaag P. (eds.), *The practice of smallholder irrigation; Case studiesfrom Zimbabwe*, University of Zimbabwe, Harare, pp. 1-28.

Maxwell, D. 1996. "Measuring food insecurity: The frequency and severity of coping strategies." Food Policy 21(3): 291-303.

Maxwell, D. And Wiebe, K. (1998). Land tenure and food security: A review of concepts, evidence, and methods, Land Tenure Centre, Research paper 129. University of Wisconsin, Madison. USA.

Maxwell, S. (1994). "Food Security: A post-modern perspective." IDS working paper, no 9. Brighton: University of Sussex, Institute of Development Studies.

Marshall, C. and Rossman, G.B. (1989). Designing qualitative research. Newbury Park, CA: Sage.

Marshall, C. and Rossman, G.B. (1995). Designing qualitative research. Newbury Park, CA: Sage.

McKean, M. (2000). Common property: What is it? What is it good for? And what makes it work? In Gibson, C., McKean, M.A. and Ostrom, E. (Eds.) *People and forests: Communities, institutions and governance*. Cambridge MA: MIT Press.

Meinzen Dick, R.S. (1993). In Food and Agriculture Organization (FAO). (1997b). Summary of findings of missions in selected countries in East and Southern Africa. *Irrigation Technology Transfer in Support of Food Security*. Proceedings of an FAO Sub-regional Workshop, Harare, Zimbabwe. 14 - 17 April 1997, Prepared by A. Kandiah.Ball, S. J. (2006). Policy Sociology and Critical Social Research. In: Ball, S. J. (Ed.): *Education Policy and Social Class*. London: Routledge, 9–25.

Meinzen Dick, R.S. and Knox, A. (2007) Collective action, property rights and devolution of natural resources. Pueto Azul. Philipines.

Menchaca, J.C.M. and Torregrosa, M.L. (1994). Social aspects of the irrigation district transfer. Paper presented at the International Conference on Irrigation Management Transfer, Wuhan, PR China, September 20-24, 1994.

Merrey, D.J. (1996). Institutional contexts for managing irrigated agriculture in the institutional framework for irrigation. Proceedings of a workshop held in Chiang, Thailand?.

Merrey, D. J. (1996). *Institutional design principles for accountability in large irrigation systems*. IIMI Research Report 8. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI).

Merrian, S.B. (1998). Qualitative research and case study applications in eduction. San Francisco: Jossey Bass Publishers.

Molden, D., Rust, H.M., Sakthivadivel, R, and Makin, I. (1998). A water-productivity framework for understanding and Action, IWMI, Colombo, Sri Lanka.

Molle, F. (2001). Water pricing in Thailand: Theory and practice. DORAS Centre. Research Report No. 7. Delta Project. Kasetsart University IRD. Bangkok. Thailand.

Mollinga, P. P. (1998). On the waterfront: Water distribution, technology and agrarian change in a South Indian canal irrigation system. Ph.D thesis. Wageningen Agricultural University, Wageningen.

Mupawose, R. M. (1984). Irrigation in Zimbabwe: A broad overview. In Blackie, M.J. (Ed.) *African regional symposium on smallholder irrigation.* University of Zimbabwe, Harare.

Musa, I. K. (1994). Irrigation management transfer in Nigeria: A case of financial sustainability for operation, maintenance and management. Paper presented at the International Conference on Irrigation Management Transfer, Wuhan, PR China, September 20-24, 1994.

Nilsson, J. (1997). *Strategies and structures in the food industries.* Netherlands: Van Gorcum and Comp.

North, D.C. (1990). *Institutions, institutional change and economic performance*. New York: Cambridge University Press.

Ogunwale, S.A.; P. R. Maurya; and J. J. Owuonubi. (1994). Farmers' views on the management of irrigation schemes in Nigeria. ODI Irrigation Management Network Paper 31, April pp. 10–19.

Ostrom, E. (1992). *Crafting institutions for self-governing irrigation systems*. San Francisco: ICS Press for Contemporary Studies.

Ostrom, E, (1996). Crossing the great divide: Coproduction, synergy, and development. World Development. Vol. 24, No.6.pp.1073-1087. Indiana University, Bloomington USA.

Ostrom, (1998). A behavioural approach to the rational choice theory of collective action. Presidential Address American Political Science Association. American Political Review 92 (1): 1-22.

Ostrom, E. (2000). Collective action and evolution of social norms, *Journal of Economic Perspectives*, 14(3):137-58.

Ostrom, E. Gardner, R. and Walker, J. (1993). Rules and common pool resources. Michigan, USA; University of Michigan Press.

Ostrom, E., Walker, J., and Gardner, R. (1990). Sanctioning by participants as a means of solving social dilemma situations. Paper presented at the annual meeting of the American Political Science Association, San Francisco, August 30-September 2.

Oweis, T., Huchum, A. and Kijne, J. (1999). Water harvesting and supplemental irrigation for improved water use efficiency in dry areas. SWIM Paper 2, IWMI Colombo, Sri Lanka.

Pazvakavambwa, S. (1984). Management of smallholder irrigation systems in Zimbabwe : The committees approach. In Blackie, M.J. (Ed.) *African regional symposium on smallholder irrigation,* 5-7 September. Hydraulics Research, Wallingford/University of Zimbabwe, Harare, pp. 421-26.

Pereira, L.S. (1996) Inter-relationships between irrigation scheduling methods and on-farm irrigation systems. In: *Irrigation scheduling: From theory to practice.* Proceedings of ICID/FAO workshop, Sept. 1995, Rome. Water Report No. 8, FAO, Rome. pp. 91-104.

Perry, C.J. (1995). Determinants of functions and dyfunction in irrigation performance improvement, Water Resources Development 11(1) :25-38.

Perry, C. J. and Narayanamurthy, S. G. (1998). Farmer response to rationed and uncertain irrigation supplies. Research Report 24. Colombo, Sri Lanka: International Water Management Institute.)

Peters, P. (2000). Development encounters: Sites of participation and knowledge. Cambridge: Harvard University Press for Harvard Institute for International Development.

Plusquellec, H. (1989). Two irrigation systems in Colombia: Their performance and transfer of management to users' associations. Policy, Planning and Research Working Papers, Agriculture Production and Services, Agriculture and Rural Development Department. Washington, DC: World Bank.

Repetto, R.(1986). *Skimming the Water: Rent-Seeking and the Performance of Public Irrigation Systems.* Research Report No. 41. Washington, D.C.:World Resources Institute.

Richard, R.A. and Hall, A.J. (2013). Field crops research. Prognosis for genetic improvement of yield potential and water limited yield major grain crops. Vol 143. Pages 18-37.

Rihoy, L. 1999. Natural resource tenure in Southern Africa: An overview of key issues and policy options for communal areas in Southern Africa: Policy brief, Harare: African Resources Trust, IUCD and USAID.

Rockstrom, J., Jansson, P-E. and Barron, J., (1998). Seasonal rainfall partitioning under runon and runoff conditions on sandy soil in Niger. On-farm measurements and water balance modelling. J. of Hydrol., 210 : 68 – 92.

Roder,W. (1965). The Sabi Valley irrigation projects, Research Paper No. 99, Department of Geography, University of Chicago Press, Chicago.

Rukuni, M. (1984). In Food and Agriculture Organization (FAO). (1997b). Summary of findings of missions in selected countries in East and Southern Africa. *Irrigation Technology Transfer in Support of Food Security*. Proceedings of an FAO Sub-regional Workshop, Harare, Zimbabwe. 14 - 17 April 1997, Prepared by A. Kandiah.Ball, S. J. (2006). Policy Sociology and Critical Social Research. In: Ball, S. J. (Ed.): *Education Policy and Social Class*. London: Routledge, 9–25.

Rukuni, M. (1988). The evolution of smallholder irrigation policy in Zimbabwe: 1928- 1986. Review paper. Department of Agriculture Economics and Extension. University of Zimbabwe, Harare.

Rukuni, M. and Eicher, C.K. (eds.).(1994).*Zimbabwe's agricultural revolution*, University of Zimbabwe Publications, Harare.

Rukuni, M. and Makadho, J. (1994). Irrigation development, In Rukuni M. and Eicher, C.K. (Eds.) *Zimbabwe's agricultural revolution*, University of Zimbabwe Publications, Harare, pp. 127-38.

Rukuni, M., Eicher, C.K. and Blackie,M.J. (2006).*Zimbabwe's Agricultural Revolution, Revisited*, University of Zimbabwe Publications, Harare.

Sagardoy, J.A. (1994). Lessons learned from irrigation management transfer programs. Paper presented at the International Conference on Irrigation Management Transfer, Wuhan, PR China, September 20-24, 1994.

Schmuck, R. (1997). Practical action research for change. Arlington Heights: IRI/Skylight Training and Publishing.Scoones, I (1998). 'Sustainable Rural Livelihoods: A Framework for Analysis', IDS Working Paper 72.Brighton:IDS

Sen, A. (1981) Poverty and famines: An essay on entitlement and deprivation, Oxford: Clarendon Press.

Shah, T., Ballabh, V., Dobrial, K. and Talati, J. (1994). Turnover of state tube wells to farmer cooperatives: Assessment of Gujarat's experience, India. Paper presented at the International Conference on Irrigation Management Transfer, Wuhan, PR China, September 20-24, 1994.

Shah, T. and Van Koppen, B. (1999). Arabie-Olifants Scheme: Field notes of a mission. Unpublished.

Shah, T., Van Koppen, B., Merrey, D., De Lange, M., and Samad, M. (2002). Institutional alternatives in african smallholder irrigation: lessons from international experience with irrigation management transfer, IWMI Research Report 60,International Water Management Institute, Colombo, SriLanka.

Shumba, M. and Maposa, R. An evalution of the performance of six smallholder irrigation schemes in Zimbabwe. Irrigation and Drainage Systems. Volume 10. Issue 4. Pp 355-366.

Shanan, L. and Berkowics, S. (1995). Locally managed irrigation in Israel: Policies, planning and performance, short Report series on locally managed irrigation. Colombo, Sri Lanka. IWMI.

Small, L.E. (1989). User charges in irrigation. Potentials and limitation. In: Irrigation Drainage Syatems 3. 1989, pp. 125-142.

Small, L.A. and Carrunthers, I. 1991. Farmer-financed irrigation. The economics of reform. Cambridge. Cambridge University Press in association with IWMI.

Southern African Development Community (SADC). (1992). *SADC Regional Irrigation Development Strategy*. *Zimbabwe Country Report*. Harare, Zimbabwe.

Strauss, A. (1987). *Qualitative analysis for social scientists*. Cambridge, UK: Cambridge University Press.

Strauss, A.L. and Cobin, J. (1990). Grounded theory methodology: An overview In Denzin N.K. and Lincoln Y.S. Handbook of qualitative research. Thousand Oaks. CA: Sage Publication.

Strauss, C., and Quinn, N. (1997). *A cognitive theory of cultural meaning*. Cambridge, UK: Cambridge University Press.

Svendsen, M. and Vermillion, D. (1994). Irrigation management transfer in the Columbia Basin: Lessons and international implications. Research Monograph. Colombo, Sri Lanka: 11MI.

Tang, S. Y. (1992). *Institutions and collective action, self-governance in irrigation*. San Francisco: ICS Press.

Tapela, B.N., BuscherB., MalulekeL., Twine,W., Steenkamp, C. (2009). Guidelines for negotiating social research in communities living adjacent to transboundary protected areas; Kruger National Park, Johannesburg. University of Johannesburg.

Tapela, B. N. (2012). Livelihood Impacts of Agricultural Commercialization in Emerging Small-Scale Irrigation Schemes in the Olifants Catchment Area of South Africa. Unpublished PhD thesis, University of the Western Cape.

Thompson, R.L. (2001). The World Bank strategy to rural development with special reference to the role of irrigation and drainage. Keynote Address. 1st Asian Regional Conference and Workshop on the occasion of the 52nd IEC meeting of ICID, Seoul. New Delhi, ICID. pp. 2 - 17.

Uphoff, N., Priti R. and Roy, S. (1991). *Managing irrigation: Analyzing and improving the performance of bureaucracies.* Sage Publications: New Delhi/ Newbury Park/London.

Van Hofwegen, P. (1996). Social, cultural, institutional and policy constraints. In: *Irrigation scheduling: From theory to practice*, Proceedings of ICID/FAO workshop, Sept. 1995, Rome. Water Report No. 8, FAO, Rome. pp. 323-334.

Van Koppen, B., Parthsarathy, R., and Safiliou, C. (2003). Poverty dimensions of irrigation management transfer in large-scale canal irrigation in Andhra Pradesh and Gujarat, *Wastelands*, 18(4): 34-35.

Vermillion, D. L. (1994). Farmer-improved design changes prior to management transfer, Indonesia. *GRID*. Issue 5 (September).

Vermillion, D.L. and Garces-Restrepo, C. (1994). Irrigation management transfer in Colombia: A pilot experiment and its consequences. Short Report Series on locally managed irrigation. No.5. Colombo, Sri Lanka: International Irrigation Management Institute.

Vermillion, D. (2001) Irrigation management transfer in the Columbia basin, USA; Review of context process and results. International E-mail conference on Irrigation transfer FAO, Rome.

Ward, F.A. and Michelsen, A. (2002). The economic value of water in agriculture: Concepts and policy applications. Water Policy. Volume 5. Pages 423-446.

Water Sector Board Discussion Paper Series. (2007).Emerging Public-Private Partnerships in Irrigation Development and Management, Paper No. 10. The World Bank Group.

Wester, P., During, A., and Oorthuizen, J. (1995). Locally managed irrigation in the Senegal valley in the aftermath of state disengagement. Report . 9. Colombo, Sri Lanka: International Irrigation Management Institute.

Woodhouse, P. (1997). Governance and local environmental management in Africa. *Review of African Political Economy*. Vol. 24. Issue 74. Page 537-547.

World Food Summit, (1996). Report of the World Food Summit. Food and Agriculture Organisation of the United Nations. Rome, Italy. WFS96/REP Part One.

Zimbabwe Agricultural Investment Programme (ZAIP),(2014). A comprehensive framework for the development of Zimbabwes Agriculture Sector. Harare, Zimbabwe.

APPENDICES

APPENDIX 1 ATTRIBUTES OF THE SAMPLED HOUSEHOLDS 2015

	Plot holders Name	Gender	Plot location	Plot size	Irrigation experience	Level of ownership of the irrigated plot	Major source of draught power	Level of draught power ownership
1	Gilbert Musvibe	Male	Head	1	8	Inherited	Animal	Owned
2	Muchaneta Chayambura	Female	Head	1.5	17	Self Owned	Animal	Owned
3	Evas Zimhindo	Female	Head	0.32	15	Self Owned	Animal	Hired
4	Panganai Tavengwa	Male	Head	1	13	Self Owned	Animal	Owned
5	Steven Muchemwa	Male	Head	1	17	Self Owned	Animal	Owned
6	Keneth Masango	Male	Head	1.5	17	Self Owned	Animal	Owned
7	Gladys Mukarate	Female	Head	0.5	13	Self Owned	Animal	Hired
8	Anna Mukarakate	Female	Head	0.5	13	Self Owned	Animal	Owned
9	Onward Muchemwa	Male	Head	1.5	15	Self Owned	Animal	Owned
10	Takawira Madhake	Male	Head	1.5	4	Self Owned	Animal	Owned
11	Anna Mashake	Female	Middle	1.5	17	Self Owned	Animal	Hired
12	Martha Martin	Female	Middle	1.5	17	Self Owned	Animal	Owned
13	Goodbye Muchodo	Male	Middle	1.5	17	Self Owned	Animal	Owned
14	Victoria Chiringa	Female	Middle	1.5	17	Self Owned	Animal	Owned
15	Andrew Muchemwa	Male	Middle	0.25	11	Self Owned	Animal	Owned
16	Tawanda Vaza	Male	Middle	0.5	16	Self Owned	Animal	Owned
17	Albert G Musarurwa	Male	Middle	1.5	17	Self Owned	Animal	Owned
18	Jona Chizinga	Male	Middle	1.5	17	Self Owned	Animal	Owned
19	Edmond Bwanya	Male	Middle	1	17	Self Owned	Animal	Owned
20	John Zvareva	Male	Middle	1	17	Self Owned	Animal	Hired
21	Jane Butete	Female	Tail	1	17	Self Owned	Animal	Owned
22	Evis Jeyi	Male	Tail	0.25	6	Self Owned	Animal	Owned
23	James Dzidza	Male	Tail	1.5	15	Self Owned	Animal	Owned
24	Ownward Jey	Male	Tail	1.5	17	Self Owned	Animal	Owned
25	Stanford Ruzvidzo	Male	Tail	1.5	17	Self Owned	Animal	Owned
26	Felistus Chinguwa	Female	Tail	1.5	17	Self Owned	Animal	Owned
27	Rufaro Rumombe	Female	Tail	0.5	15	Inherited	Animal	Owned
28	Colleta Butete	Female	Tail	1.5	17	Self Owned	Animal	Owned
29	Fanuel Goteka	Male	Tail	1.5	17	Self Owned	Animal	Owned
30	Bibiyana Dzidza	Female	Tail	1.5	17	Inherited	Animal	Owned

APPENDIX 2 MAIZE GROSS MARGIN BUDGET BY PLOT LOCATION 2015

Plot location	Respondent Farmer	Quantity Sold (Kg)	Price (US$)	Gross Income (US$)	Total Variable Cost (US$)	Gross Margin Maize (US$)
Head	1	1500	0.38	570	136	434
	2	3000	0.48	1440	139	1301
	3	350	0.38	133	89	44
	4	2500	0.38	950	190	760
	5	1000	0.38	380	166	214
	6	2000	0.38	760	213	547
	7	1000	0.38	380	112	268
	8	1000	0.38	380	131	249
	9	2000	0.38	760	137	623
	10	1500	0.38	570	198	372
Middle	1	3000	0.38	1140	225	915
	2	1000	0.38	380	174	206
	3	1800	0.38	684	219	465
	4	1000	0.38	380	388	-8
	5	800	0.38	304	224.5	79.5
	6	400	0.38	152	228	-76
	7	800	0.38	304	211	93
	8	1330	0.38	505.4	400	105.4
	9	800	0.38	304	128	176
	10	300	0.38	114	219	-105
Tail	1	400	0.38	152	181	-29
	2	167	0.38	63.46	57.1	6.36
	3	145	0.38	55.1	151	-95.9
	4	300	0.38	114	236	-122
	5	1500	0.38	570	541	29
	6	500	0.3	150	135	15
	7	500	0.32	160	157	3
	8	1500	0.36	540	365	175
	9	800	0.38	304	330	-26
	10	100	0.34	34	34.9	-0.9

APPENDIX 3 MAMINA: SOYABEANS GROSS MARGIN BUDGET BY PLOT LOCATION, 2015

Plot location	Respondent Farmer	Soyabeans Sold Kg	Soyabeans prices (US$)	Gross Income US$	Total Variable Cost US$	Gross Margin US$	Remarks
Head	1to3	0	0	0	0	0	Do not grow soyabeans
	2	1500	0.48	720	112	608	Grow soyabeans
	4	1200	0.48	576	76	500	
	5	250	0.48	120	24.4	95.6	
	6	750	0.53	397.5	36	361.5	
	7	450	0.53	238.5	36	202.5	
	8	500	0.53	265	36	229	
	9	750	0.48	360	72	288	
	10	750	0.48	360	82	278	
Middle	11,12,13	0	.	0	0	0	Do not grow soyabeans
	12	1500	0.5	750	142	608	Grow soyabeans
	13	0	.	0	0	0	
	14	1500	0.5	750	152	598	
	15	0	.	0	0	0	
	16	2000	0.5	1000	158	842	
	17	300	0.48	144	166.4	-22.4	
	18	1200	0.56	672	656	16	
	19	1000	0.48	480	112	368	
	20	450	0.48	216	12	204	
Tail	21	800	0.5	400	64	336	
	22,25-29	0	.	0	0	0	Do not grow soyabeans
	23	160	0.55	88	24	64	Grow soyabeans
	24	1500	0.48	720	172	548	
	30	750	0.5	375	32.9	342.1	

APPENDIX 4 MAMINA: GROSS MARGIN BUDGET FOR POTATOES, 2015

Respondent Farmer	Potatoes Sold (Kg)	Prices for potatoes (US$)	Gross Income (US$)	Total Variable Cost (US$)	Gross Margin (US$)	Remark
1-17, 20-24, 26-30	0	0	0	0	0	Do not grow Potatoes
18	6000	0.8	4800	1440	3360	Only Potato farmers
19	3750	0.8	3000	432	2568	
25	1500	0.7	1050	490	560	

APPENDIX 5 MAMINA: GROSS MARGIN BUDGET FOR SUGAR BEANS, 2015

Respondent Farmer	Sugar beans Sold (Kg)	Sugar beans Prices (US$)	Gross Income US$	Total Variable Cost (US$)	Gross Margin (US$)	Remarks
1-16, 21-23, 25-26, 29	0	0	0	0	0	Do not grow Sugar beans
17	300	0.48	144	96	48	Sugar beans farmers
18	400	0.48	192	147	45	
19	500	0.48	240	71	169	
20	900	0.4	360	47	313	
24	300	1	300	172	128	
27	250	0.8	200	46.4	153.6	
28	500	0.5	250	141	109	
30	150	1	150	20.9	129.1	

APPENDIX 6 PRODUCTION RECORDS OF RESPONDENT FARMERS

Maize Production Season A and B by Plot Location

Plot location	Respondent Farmer	Maize area A (Ha)	Maize production A (Tons)	Maize area B (Ha)	Maize production B (Tons)
Head	1	0.4	2	0.36	1.8
	2	0.56	1.4	0.5	1.25
	3	0.28	0.56	0.25	0.5
	4	0.56	1.96	0.5	1.75
	5	0.28	0.896	0.25	0.8
	6	0.56	1.12	0.5	1
	7	0.28	0.42	0.25	0.375
	8	0.3	0.5	0.25	0.375
	9	0.56	1.8	0.5	1.8
	10	0.8	1.9	1	2
	Total Sum	**4.58**	**12.556**	**4.36**	**11.65**
Middle	1	0.716	1.2	0.64	1.35
	2	0.56	1.25	0.5	1.1
	3	0.627	1.45	0.56	1.25
	4	1	1.3	0	0
	5	0.5	1.1	0.4	0.95
	6	0.75	1.2	0.25	0.1
	7	0.75	1	0.75	1.2
	8	0.8	1.3	1	1.3
	9	1	1.2	1	0.8
	10	0.5	0.3	0.5	0.75
	Total Sum	**7.203**	**11.3**	**5.6**	**8.8**
Tail	1	0.5	1.2	0.16	0.4
	2	0.2	0.5	0	0
	3	0.5	1.145	0.16	0.1
	4	0.2	0.3	0.25	0.3
	5	1	1.5	0	0
	6	1.2	0.48	0	0
	7	0.16	0.75	0.24	0.2
	8	0.4	0.8	0.4	0.5

	9	0.75	0.4	0.75	0.45
	10	1	0.5	1.16	0.3
	Total Sum	**5.91**	**7.575**	**3.12**	**2.25**
GRAND TOTAL		**17.693**	**31.431**	**13.08**	**22.7**

Input utilisation by the Irrigators

Respondent	Maize area for A (Ha)	Maize seed quantity (Kg)	Maize basal quantities used (kg)	Maize top dressing quantity (Kg)
1	0.4	10	100	50
2	0.56	10	100	50
3	0.28	5	50	20
4	0.56	10	50	75
5	0.28	5	100	100
6	0.56	10	150	100
7	0.28	5	50	50
8	0.3	10	50	50
9	0.56	10	100	50
10	0.8	20	100	100
11	0.716	10	100	50
12	0.56	15	50	50
13	0.627	15	150	100
14	1	25	200	100
15	0.5	8	100	100
16	0.5	15	100	100
17	0.75	10	150	100
18	0.8	25	300	150
19	1	10	100	50
20	0.5	10	150	100
21	0.5	10	75	50
22	0.2	5	0	30
23	0.5	15	50	50

24	0.2	10	100	100
25	1	25	300	200
26	1.2	10	100	50
27	0.16	10	100	50
28	0.4	10	150	100
29	0.75	20	100	100
30	1	7	7	10
Total	**17.443**	**360**	**3232**	**2285**

Mamina: Tillage Costs and Labour, 2015

Respondent Farmer Household	**Tillage system cost (US$)**	**Labour time / days**	**Number of workers per operation**	**Cost of labour (US$)**
1	0	0	0	0
2	0	0	0	0
3	24	0	0	0
4	96	0	0	0
5	0	0	0	0
6	0	0	0	0
7	24	0	0	0
8	24	0	0	0
9	0	0	0	0
10	0	0	0	0
11	96	0	0	0
12	0	4	2	60
13	0	0	0	0
14	0	1	3	40
15	0	1	4	42
16	0	4	2	40
17	0	0	0	0
18	0	30	1	80
19	0	0	0	0
20	0	0	0	0
21	0	4	5	64
22	0	2	3	24

23	0	4	3	24
24	0	3	4	60
25	0	4	5	100
26	0	0	0	0
27	0	3	2	24
28	96	3	3	45
29	125	2	4	40
30	0	1	2	8

APPENDIX 7 QUESTIONNAIRE

The Trajectory from Government-Managed to Farmer-Managed Smallholder Irrigation and its Effects on Productivity, Operation and Maintenance: An Analysis of Ngezi Mamina Smallholder Irrigation Scheme in Zimbabwe.

A: Profile of the farming households on the irrigation scheme.

Plot-holders Name			
Gender	Male	Female	
Level of ownership	Self Owned	Inherited	Lease
Plot Location	Head	Middle	Tail
Irrigation plot size	(Ha)		
Land under use	(Ha)		
Dry land Farming	(Ha)		
Water Availability(Dam)	All year Round	Mid year	Not Available
Period (Years/months/days) the farmer has been irrigating (Experience)			
Does the irrigation water reach the fieds on time	Yes	No	
List the major changes in terms of roles Over the years.	1 2 3 4 5		
What are the effects of the changes in roles	1 2 3 4 5		

B. ASSETS OWNERSHIP

Asset / livestock	Type	Quantity	Condition	Year purchased	Source of funds
1. Main House					
2. Draught power: a. b. c.					
3. Mode of transport					
4. TV					
5. Radio					
6. Cell phone					
7.					
8.					
9.					
10.					
11.					
Livestock					
12. Cattle					
13. Goats					
14. Sheep					
15. Poultry					
16.					
17.					
18.					

C. Sources of income (other than irrigation farming)

Source	Approximate per annum	Remarks
Dry land crop sales		
Livestock		
Remittances		
off farm activities 1 2 3		

PROCESSING

Produce processed on the farm.

Produce (e.g. Maize)	Products(e.g. Mealie-meal)
1	
2	
3	
4	
5	
6	
7	
8	

D. Contract Farming Arrangements

Crop	Company	Contract Terms (Quality & Quantity)	Challenges	Comments

F: Crop Production Practices and Income

Crops					Marketing						
Cropping Pattern	**Area (ha)**	**Crop Stage**	**Crop Condition**	**Yield**	**Retained for Consumption**	**Quantities Sold**	**Average Price**	**Total Income**	**Buyer Market**	**Mode of Transport**	**Distance to Market**
Maize											
Wheat											
Sugerbeans											
Soyabeans											
Potato											
Tomato											
Onions											
Carrots											
Cabbage											

Crops					Marketing						
Other Crops	**Area (ha)**	**Crop Stage**	**Crop Condition**	**Yield**	**Retained for Consumption**	**Quantities Sold**	**Average Price**	**Total Income**	**Buyer Market**	**Mode of Transport**	**Distance to Market**

G: Crop production Systems

Crop Rotations	
Season 1	**Season 2**

H: Inputs Usage and Availability

Inputs	**Seed type/Crop**	**Source**			**If1, 2 and 3 specify**	**Quantity**	**Price**
Seeds		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
Pesticides		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
Fertilizers		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
Herbicides		1	2	3			

		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			
		1	2	3			

Codes

1. **Government 2. NGO 3. Private Companies**

I: Operation and Maintenance costs 2014 -2015

Type	Current bill	Arrears	Arrears 1=yes, 2=no	Contribution	Source of funding	Comments
Electricity						
Water						
Repairs and maintenance						
a.						
b.						
c.						
Levies a.						
b.						
c.						
Other costs a.						
b.						
c.						

If you have arrears in any of the above state and give reasons

....

....

....

Water Allocation

Equity	Good	Fair	Poor
Efficiency	Good	Fair	Poor
Adequacy	Good	Fair	Poor

Conflicts

Conflicts	Resolutions
1	
2	
3	
4	
5	

Institutional Support

Institution	Role	Gap

Finance

Access to Agricultural credits for the past 15years (1998-2015).

Year	Type of Credit	Amount	Balance	Repayment Period and Interest	Collateral attached	Organisation	Purpose

Management

Who is responsible for operation and management?

....
....

What Role does the Irrigation Management Commitee (IMC) play?

....
....
....
....

How many women are in the IMC and in what capacity?

....
....
....

Which activities are done as group?

....
....
....
....

What are the rules that govern the irrigation scheme?

....
....
....

How do you determine your cropping programme?

....
....
....

What other domestic, and social roles/responsibilities do you perform?

....

....

....

....

Constraints

Major Challenges in Irrigation farming	Possible Solutions