DEVELOPING PRACTICAL SOLUTIONS TO PROBLEMS AND CONSTRAINTS FACED BY SMALLHOLDER IRRIGATION SCHEMES IN SOUTH AFRICA

TC Mvelase
204508066

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Bioresources Engineering Programme
School of Engineering
University of KwaZulu-Natal
Pietermaritzburg 3201
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ABSTRACT

Globally, smallholder irrigation schemes are viewed as a key strategy for increasing agricultural production, sustaining rural livelihoods, and reducing rural poverty. Thus it is believed that an increase in the number of smallholder irrigation schemes and the rehabilitation of existing schemes can assist in fighting rural poverty and in achieving the Strategic Development Goals. The potential for smallholder irrigation schemes to contribute to poverty is inhibited by their poor performance. Smallholder irrigation schemes face major problems and constraints which have resulted in poor performance overall. The problems and constraints faced by these smallholder irrigation schemes can be classified as both external and internal. The internal problems and constraints are those that affect the farmers' ability to operate efficiently and these include cash flow problems, shortage of labour, lack of skills, knowledge and education, and lack of management skills which may be attributed to cultural factors. The external problems and constraints are those that arise from the broader agricultural environment and are usually outside the control of the farmer. These problems include market access, effective credit services, access to appropriate mechanisation and poor institutional and infrastructural support.

The South African Government has invested significant funds towards the establishment, revitalisation and rehabilitation of these schemes with the intention that these schemes will be productive and be able to achieve the set goals. Unfortunately this process has not been effective therefore an understanding of the problems and constraints facing these schemes is crucial for the development of practical solutions that will results in the schemes being viable and achieving intended goals. The proposed practical solutions to some of these problems include developing best management practices, farmer empowerment through involvement in scheme affairs, farmer training in irrigation water management and crop production, establishing and capacitating irrigation management committees (IMCs), and improved farm water management. This document contains a review of the problems and constraints faced by smallholder irrigation schemes in South Africa and practical solutions and opportunities that have been developed and implemented worldwide for the improvement of the performance of these schemes. The project proposal is also detailed in this document.

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1. INTRODUCTION

Over 275 million hectares of lands are under irrigation world-wide and these lands produce approximately 40% of the world's food production (Aquastat, 2012). In the African continent approximately 12.4 million hectares of lands are under irrigation of which 40% of this area falls within the Sub-Saharan Africa (Bembridge, 2000). In South Africa 1.6 million hectares of land are under irrigation of which 0.1 million ha is allocated to smallholder irrigation (Van Averbeke and Mohammed, 2006). Even though smallholder irrigation schemes only accounts for 3% of irrigated areas, it remains important to government because of its location in the rural areas (Sinyolo *et al.*, 2014).

Worldwide irrigation development is considered an important factor that can result in an increase in crop productivity and in improving the overall agricultural performance, but irrigation canal so results in negative environmental and human health impacts such as increased water logging, salinisation and water-borne diseases (Sinyolo *et al*., 2014). This potential has led the South African government to prioritise irrigation development (Denison and Manona, 2007).

In Africa between the year 1997 and 1999, 200 million people were food insecure and 85% of these people dwelled in the rural areas and were highly dependent on agricultural activities to sustain their livelihoods (Tafesse, 2003). Therefore, there has been a drive in African countries to revitalise existing, and develop new, smallholder irrigation schemes in order to ensure that rural people are well fed, have higher incomes from better use of available resources and to improve their livelihood (Magadlela, 1997). The South African government also believes that an increase in the number of smallholder irrigation schemes and the rehabilitation, or revitalisation of existing and abandoned schemes, can result in an increase in food output (Van Averbeke *et al.*, 2011). The government also anticipates that the new and rehabilitated smallholder irrigation schemes will be able to assist in reducing the unemployment rate and poverty within the rural communities by creating approximately 300 000 job opportunities by the year 2020 (Cousins, 2012). Therefore, the South African government has invested approximately 2 billion Rand which is equivalent to approximately R40 000/hectare from public resources in establishing, revitalising and rehabilitating smallholder irrigation schemes in South Africa (Van Averbeke *et al*., 2011).

Smallholder irrigation schemes are perceived as a solution to Africa's food crisis (Gotosa *et al*., 2002), they have the potential to contribute significantly to food security and participating homesteads have a chance of obtaining income (Van Averbeke *et al*., 2011), but their development objectives remain largely unfulfilled due to poor performance (Fanadzo, 2012).

Poor performance of smallholder irrigation schemes can be attributed to deteriorated infrastructure, uncertainty of land tenure, limited knowledge of crop production, limited farmer participation in the management of irrigation water, ineffective extension and mechanisation services, lack of extension and farmer training, lack of reliable markets and market access, and absence of effective credit services to purchase input supplies (Van Averbeke *et al.*, 2011). The factors affecting performance can be categorised into technical, agronomic, economic and social-institutional (Gomo *et al.*, 2014).

This literature review focuses on the problems and constraints faced by smallholder irrigation schemes and seek to identify opportunities for developing practical solutions to some of these problems that will take into account agronomic, technical, economic and socio-institutional issues.

This document contains seven chapters. Smallholder irrigation schemes in Africa, South Africa and KwaZulu-Natal are reviewed in Chapter 2. Chapter 3 contains a review of problems and constraints faced by smallholder irrigation schemes in Africa, South Africa and KwaZulu-Natal. Proposed practical solutions that have been implemented globally for problems and constraints experienced by smallholder irrigation schemes are presented in Chapter 4. Chapter 5 contains a discussion of the contents of the document and draws conclusions. Chapter 6 contains the details of a proposal to determine the constraints and problems that cause low production or poor performance on selected revitalised smallholder irrigation schemes and to develop strategies for sustainable water management approaches that will take into account agronomic, technical, economic and socio-institutional issues.

2. SMALLHOLDER IRRIGATION SCHEMES

Smallholder irrigation schemes are schemes which are large in terms of area but are made up of a number of plots and were designed and constructed by government and development agencies (Kay, 2001). Of interest in this review are smallholder irrigation schemes (SIS) defined as schemes which occupy land that is greater than 5 ha in size per scheme, either located in the former homelands or resource poor areas and mostly developed for the occupation of previously disadvantaged farmers in South Africa (Denison and Manona, 2007).

SIS were developed in order to utilise productive land in the rural areas, improve agricultural productivity, play a role in local economic development and improve food security and livelihoods of the rural communities (Maepa *et al*., 2014). SIS are viewed as assets to rural communities because of the potential they have in increasing and diversifying livelihood activity from plant production and, they can provide food and generate income for scheme participants and thus can provide full or partial livelihood to farmers and suppliers of goods and services (Van Averbeke and Mohammed, 2006).

2.1 History of Smallholder Irrigation Schemes (SIS) in South Africa

The development of SIS in South Africa can be categorised into the peasant and mission diversion scheme era, smallholder canal scheme era, independent homeland era and the irrigation management transfer (IMT) and revitalisation era. The peasant and mission diversion era occurred during the 19th century and was associated with mission activities and the emergence of African peasantry in the Eastern Cape province of South Africa. The main aim of these schemes was to transfer technology from colonists to the local people (Fanadzo *et al.*, 2010). Schemes developed during this period were privately owned and relied on diverting water from a river. The majority of the schemes developed during this era were found to be non-functional by the end of the 19th century (Van Averbeke and Mohammed, 2006).

The second era occurred during the period from 1930 to 1969 where 74 smallholder irrigation schemes were developed covering an area of 18 226 ha and these schemes abstracted water from rivers using concrete diversion weirs and concrete canal system. The main aim of establishing these schemes was to provide African families residing in the "Bantu Areas" with an improved livelihood. On most of these schemes, the land on which the schemes were developed on, were detribalised and ownership was transferred to the state (Van Averbeke and Mohammed, 2006). Schemes developed in this era include Bululwane and Thukela Estate in KwaZulu-Natal (Bembridge, 2000).

The third era took place between 1970 and 1990 where 62 smallholder irrigation schemes were developed covering an area of 12 994 hectares with the aim of making black people citizens of specific independent homelands and improving the economy in the homelands areas (Van Averbeke and Mohammed, 2006). Schemes developed during this era include Keiskammahoek, Tyefu, Xonxa, Ncora situated in Eastern Cape and Makhathini situated in KwaZulu-Natal (Bembridge, 2000).

The fourth era started in 1990 when South Africa was experiencing political changes and during this era 64 schemes were established covering an area of 2 383 hectares and the main aim of these schemes was to eradicate poverty and improve the quality of life for people living in rural areas and informal urban settlements (Van Averbeke and Mohammed, 2006). This aim was achieved through the Reconstruction and Development Programme (RDP) and these schemes were funded through the Independent Development Trust and several government departments such as Agriculture, Health and Public Works. Schemes developed in this era include Ndumo B, Biyela and Mzimela irrigation schemes situated in KwaZulu-Natal (Bembridge, 2000).

The Irrigation Management Transfer (IMT) and revitalisation era involved the transfer of scheme management, operation and maintenance from government to scheme participants with the aim of improving livelihood through ownership and control of resources (Van Averbeke and Mohammed, 2006). The IMT programme implemented in South Africa include the Revitalisation of Smallholder Irrigation Schemes (RESIS) and the RESIS Recharge programme in the Limpopo province. The RESIS programme was aimed at revitalising all SIS within the Limpopo province and transfer the management of the SIS to farmers (Van Averbeke and Mohammed, 2006). This involved the re-construction of scheme infrastructure and leadership and management training of farm participants to prepare them for the management transfer of the scheme (Denison and Manona, 2007). The programme was executed using a participatory approach where farmers were involved during the planning and decision making stage (Van Averbeke and Mohammed, 2006). The RESIS programme was terminated in 2005 and a new programme called RESIS Recharge was initiated to address the unresolved problems. The RESIS Recharge programme main focus was on commercial partnerships which were viewed as a key strategy for skills transfer, market access, job creation, poverty alleviation and community up liftment (Denison and Manona, 2007).

2.2 Statistics of Smallholder Irrigation Schemes (SIS)

SIS worldwide have different levels of importance, for example, SIS in Bangladesh takes up approximately 97% (Aquastat, 2015) of the total irrigation area while in South Africa SIS accounts for only 3% of the total irrigated area (Maepa *et al*., 2014). The development of SIS in African countries has been very slow compared to Asian countries and the level of development in the African countries differs from country to country (Kay, 2001). Countries such as Tanzania, Nigeria, Niger, Zimbabwe and South Africa have had a higher rate of irrigation development exceeding 2 000 ha per year (Kay, 2001). The irrigation areas occupied by SIS in selected Asian and African countries are shown in Table 2.1.

Table 2.1 Area covered by SIS in selected Asian and African countries (after Aquastat, 2015, Denison and Manona, 2007 and Maepa *et al*., 2014)

Country	Area [ha]	Fraction of total irrigation area [%]
Bangladesh	4 910 000	97
Tanzania	120 000	80
Ethiopia	95 320	59
China	36 000 000	57
India	33 000 000	50
Kenya	36 190	40
Pakistan	4 130 000	21
South Africa	49 504	3

In South Africa, 317 SIS were identified by Denison and Manona (2007) covering an area of approximately 49 504 ha. A summary of information on smallholder irrigation schemes in different provinces from the database that was developed by Denison and Manona (2007) is shown in Table 2.2.

Table 2.2 Summary of Smallholder Irrigation Schemes in South Africa (after Denison and Manona, 2007)

Province	Number of schemes	Area [ha]	Number of farmers
Limpopo	183	28 283	17 785
Eastern Cape	75	9 641	7 871
KwaZulu-Natal	36	6 621	6 174
North West	3	3 524	423
Mpumalanga	8	990	125
Western Cape	9	425	737
Free State	3	20	2
Total	317	49 504	33 117

2.3 Types of Smallholder Irrigation Schemes (SIS) Management

There are four types of management of smallholder irrigation schemes; namely ‘top down’ bureaucratically managed smallholder schemes, jointly managed schemes, community schemes and state or cooperation financed schemes (Bembridge, 2000).

The majority of the SIS in South Africa are "top-down" and jointly managed schemes (Bembridge, 2000). 'Top down’ bureaucratically managed smallholder irrigation schemes are those which are fully administered by government departments or government entities who are responsible for carrying out all the farming operations on behalf of farmers. On these types of schemes, selection of participants is not done on the basis of farming ability. These schemes usually have high recurring costs of which the returns to the famers are only a fraction of recurring costs (Bembridge, 2000). Examples of this type of schemes are the NgeziMamina Irrigation Scheme located at Mashonaland West, Zimbabwe (FAO, 2000), Tyefu Irrigation Scheme located at Eastern Cape Province of South Africa and

Makhathini Irrigation Scheme located at KwaZulu-Natal Province of South Africa. These schemes usually experiences problems and constraints in the operation and maintenance of infrastructure (FAO, 2000). Farmers in these types of scheme usually have conflicts when it comes to sharing the available water resources (Kay, 2001).

Jointly managed schemes are those in which some management functions are carried out by an irrigation development agency or government departments, while other management functions are carried out by the scheme's participants. The main aim of these schemes is food production for livelihood and the surplus is sold. In these schemes, participants are also not selected on farming ability and these schemes end up being a financial burden to government (Bembridge, 2000). The Principe Irrigation Scheme located at Mashonaland Central, Zimbabwe (FAO, 2000) and Bululwane Irrigation Scheme located at KwaZulu-Natal Province, South Africa (Bembridge, 2000) are examples of jointly managed schemes. Farmers in these types of schemes usually struggle to contribute financially towards the costs of energy, repairs and maintenance (FAO, 2000).

Community schemes are usually small in size when compared to the other types of schemes. There are mainly operated and maintained by the schemes' participants. Examples of these types of schemes are the Chitora Irrigation Scheme located in Mashonaland East, Zimbabwe and Ngonyameni Irrigation School located in the Eastern Cape Province, South Africa. These schemes do not depend on government or any agencies for maintenance and repair of the scheme as they collectively raise funds if maintenance or repair works are required (FAO, 2000).

State or cooperation financed schemes are those where participants are selected based on entrepreneurial and farming ability, financial and other resources. The bulk infrastructure which usually ends at field edges is provided by government. The scheme participants are then expected to pay for subsidised water charges, manage the scheme and make decisions pertaining to the operation of the schemes. These schemes are rare in South Africa (Bembridge, 2000). Example of these schemes, are sugar cane farms such as the Biyela, Mthandeni, DakaDaka, Sinamfini, Mansomeni and Mzondeni Irrigation Schemes located in the KwaZulu-Natal Province (Bembridge, 2000).

3. PROBLEMS AND CONSTRAINTS FACING SMALLHOLDER IRRIGATION SCHEMES

The World Bank has invested a significant amount of money towards the development of smallholder irrigation schemes worldwide and Asia has been the chief recipient receiving approximately 70% of the invested money (Campbell, 1995). Despite the large investments made in Asia, countries such as India and Pakistan have lost more than 5.5 million hectares of canal irrigated areas due to irrigation-induced soil salinity and water logging (Thapa and Gaiha, 2011).

In Africa it has been reported that there are few successful and sustainable farmer-managed irrigation schemes despite the investments that have been made towards them (Mutambara and Munodawafa, 2014). The performance of government-managed schemes is also reported to be below expectations despite several policy approaches that have been developed to address the problems and with financial support from major international donor agencies such as World Bank and Asian Development Bank (Suhardiman *et al*., 2014). Some of the problems and constraints faced by SIS in most countries took place after the implementation of the IMT policy (Muchara *et al*., 2014). For example, in South and South-East Asia, the performance of SIS declined when the farmers failed to meet the operation and maintenance costs from farming activities due to reduced input from state agencies (Muchara *et al*., 2014).

Problems and constraints faced by SIS can be classified into external and internal problems and constraints. The external problems and constraints are those that are beyond the control of the farmer and they include: natural risks, poor project planning and design, limited marketing services, ineffective credit services, insecure land tenure, inappropriate plot sizes, poor institutional and infrastructural support, inappropriate policies and legislation and restrictive administrative and social structures (Baloyi, 2010). Internal problems are those which affect the operation of the farm and they include: cash flow problems, lack of skills, knowledge and training of farmers and ineffective management (Baloyi, 2010). All these factors can be grouped into technical, agronomic, economic and socio-institutional factors as well as inadequate farmer participation (Fanadzo, 2012). An understanding of these factors will assist in generating solutions leading to improved performance of smallholder irrigation schemes and help to achieve the main objectives of these schemes.

3.1 Technical Factors

Scheme design, water reticulation and reliability, infrastructure repair and maintenance, and irrigation water management are categorised as technical factors that affect the performance of smallholder irrigation schemes (Bembridge, 2000). Infrastructural problems and poor maintenance of infrastructure have been identified as major factors which led to poor performance of SIS in South Africa (Van Averbeke *et al*., 2011).

3.1.1 Scheme design

Success and sustainability of smallholder irrigation schemes is highly dependent on the appropriate design of the scheme, but the challenge is that most irrigation schemes are designed based on water and soil requirements instead of farmers needs (Chancellor, undated). The majority of SIS in South Africa were planned and developed using a centralised design which excluded farmer participation (Fanadzo, 2012). At Bugri and Gagbriri Irrigation Schemes located in the Garu Tempane District, Ghana it was reported that the length of the irrigation canal was not enough to supply water to tail end plots and the design did not allow for enough infield irrigation infrastructures. Farmers at these plots were forced to store water in dug holes and used water cans to irrigate their plants. Farmers felt that the design of the scheme resulted in significant amount of water losses and production time was lost while collecting water from the holes (Jonah and Dawda, 2014).

The design of the Makhathini Irrigation Scheme in KwaZulu-Natal has resulted in grievances among farmers because it was designed to deliver large volumes of water to blocks of about 100 ha or more on a 7 day ordering cycle. Farmers on the scheme were allocated 10 ha plots, meaning that for the design to be economical farmers within each block must be willing to receive water at the same time and they must plant crops with similar water requirements (A 'Bear and Louw, 1994).

Farmers at Tugela Ferry Irrigation Scheme were not satisfied with surface irrigation method (furrow) practices at the scheme and they felt that it was the major cause of soil erosion and improper irrigation water management practices (Fanadzo *et al*., 2010).

3.1.2 Water reticulation and reliability

Adequacy of water supply, equity of water distribution and dependability of water supply are the main performance indicators of water delivery systems and these indicators are among the constraints that affect the performance of SIS (Gotosa *et al*., 2002).

A number of SIS experienced water shortages which resulted in low production (Magadlela, 1997) and the majority of the schemes fail to maintain a reliable and equitable water distribution system (Chancellor, undated). The Water User Associations (WUAs) managing the Bugri and Gagbriri Irrigation Scheme in Ghana has major challenges with distributing water to farmers due to the fluctuating levels of water in the reservoir. When the reservoir water levels are low, the WUAs is forced to schedule water among the various sections and group of farmers thus causing farmers with no water to abandon their allocated plots (Jonah and Dawda, 2014).

Uneven distribution of water caused conflicts and electricity payment disputes among farmers at Tsvovani Irrigation Scheme in Zimbabwe and this has affected the development of the scheme (Mutambara and Munodawafa, 2014). At the Tugela Ferry Irrigation Scheme, uneven distribution of water forced farmers to compete for water and this resulted in several farmers not receiving water when they needed it (Fanadzo *et al*., 2010). At Dzindi Irrigation Scheme in Limpopo Province, unequal distribution of water was caused by several leaks and obstructions along the canal and it has resulted in tail-end users receiving a reduced quantity of water (Van Averbeke, 2013).

3.1.3 Infrastructure maintenance and repair

Weak institutional and organisational arrangements can result in inadequate routine maintenance which in turn can reduce water delivery and shortens the life-span of the water distribution system (Van Averbeke *et al*., 2011). The majority of SIS in Southern

Africa are poorly maintained, canals are leaking, pumps are broken down and repairs are hardly done (Chancellor, undated) and management often lacks funding to undertake these tasks (Johan and Dawda, 2014).

Lack of routine maintenance at the Dzindi Irrigation Scheme caused deterioration of the infrastructure and repairs of cracks and holes along the main canal were not done (Van Averbeke, 2013). Phispon (2015) also reported that infrastructure maintenance and repairs at the Makhathini Irrigation Scheme has deteriorated over the years. Internal roads were either flooded with water from leaking pipes or covered with weeds, irrigation canals had several cracks and were overgrown with weeds and leaking pipelines were left unattended (Phispon, 2015).

3.1.4 Irrigation water management

The objective of water management is to manage the irrigation system, available water resource and reduce the movement of pollutants from irrigated lands into ground or surface water in a manner which will reduce the adverse effect of water logging and salinity (Kijne, 1989). A majority of irrigation schemes experiences salt accumulation in the soils due to improper irrigation water management practices and this salt built up has affected productivity (Wichelns and Oster, 2006). According to Machethe *et al*. (2004) farmers apply the same amount of water irrespective of the plant growth stage and this leads to over-irrigation during early growth stages of the crop and under-irrigation during advanced growth stages of the crop. Low water use efficiencies and excessive irrigation is believed to be one of the causes of low levels of crop productivity on SIS in South Africa (Fanadzo *et al*., 2010).

Over-irrigation and high water losses observed at the Guanta Small-scale Irrigation scheme in Ethiopia was attributed to the different planting dates leading to different water requirements for the same crop (Derib *et al*., 2011). In the case of Zanyokwe Irrigation Scheme, over-irrigating was caused by farmers failing to practise correct irrigation scheduling and farmers who irrigated more than 24 hours per setting (Fanadzo *et al*., 2010). Water logging and soil salinity problems were also observed at Ndumo B and

Bululwane Irrigation Schemes in KwaZulu-Natal and were attributed to restricted sub-soil permeability, limited soil depth and low inherent soil fertility (Golder Associates, 2014).

3.2 Agronomic Factors

Several agronomic factors were identified by Machete *et al* (2004) as factors which limit crop productivity in SIS and these include poor weed control practices, water management, fertilizer and plant population management, late planting and poor selection of cultivators type. Bembridge (2000) also identified poor weed control, low plant populations and inadequate pest control as a cause for low yields in SIS. The above limiting factors are a result of limited knowledge and skills in crop production among farmers and also resource constraints (Van Averbeke *et al*., 2011).

The majority of SIS in South Africa uses the cropping programme of maize production in summer and vegetables in winter (Van Averbeke, 2012). This cropping programme is perceived as unsustainable from an agronomic and ecological perspective because proper crop rotation is not carried out (Fanadzo, 2012). Farmers at Zanyokwe Irrigation Schemes were reported to be using a standard population of 40 000 plants per ha for all their maize production irrespective of the cultivar type (Fanadzo *et al*., 2010). This plant population is lower than the expected plant population of short-season cultivars (80 000 to 90 000 plants per ha) and matches the minimum requirements for medium to long-season cultivars of 40 000 to 60 000 plants per ha (Fanadzo *et al*., 2010).

In a study conducted by Monde *et al*. (2005), cited by Fanadzo *et al*. (2010), it was discovered that farmers in Zanyokwe Irrigation Scheme applied fertilizer once in two to three years and farmers at Tugela Ferry Irrigation Scheme applied unspecified amounts of basal fertilisers and minimal amount of top dressing fertiliser due to lack of finances. In a study conducted by Machethe *et al*. (2004) it was reported that farmers in the Limpopo Province applied marginal amount of inorganic fertilisers which were not based on any soil fertility analysis and recommendations.

3.3 Economic Factors

The absence of effective credit services and poor linkages to input and output markets are identified as source of the most critical problems threatening the viability of SIS in South Africa (Machethe *et al*., 2004). SIS worldwide struggle to attract sufficient investments, markets and credit from financial service providers (Maepa *et al*., 2014).

3.3.1 Access to credit

Access to effective credit facilities is vital to farmers because it affords them the opportunity of purchasing inputs such as seeds, fertilizers and to invest in technologies that can increase productivity (Obi and Pote, 2010). The major problem with access to credit is that it requires collateral, which is generally supplied in the form of land rights which most SIS farmers do not possess (Machethe *et al*., 2004). The other major issue in obtaining credit is that financial institutions require financial information of the farming enterprise which most farmers do not keep records due to lack of training (Baloyi, 2010). According to Ortmann and King (2007), financial institutions prefer to grant credit to large scale farmers who are well established than to individual smallholder farmers because smallholder farmers are associated with high risks due to quite a number of uncertainties with production.

3.3.2 Marketing issues

Access to reliable and sustainable markets is a priority to smallholder farmers because it is an opportunity for them to earn more from sales and improve rural livelihood (Van der Heijden and Vink, 2013). Access to markets also provides farmers with a platform for exchanging goods and it creates opportunities for rural employment (Jari and Fraser, 2012).

In many countries in Africa, smallholder farmers are pressured to participate in national and global markets in order to meet local and national food production goals (Snyder and Cullen, 2014), but smallholder farmers find it difficult to participate and access commercial markets due to low levels of bargaining power, low volumes of production, insufficient human, financial and physical capital, lack of transportation to markets, inability to conclude contractual agreements and poor organisational structures (Van der Heijden and Vink, 2013 & Jari and Fraser, 2012). Morton (2007) also identified inadequate support services, weak institutions, insecure land tenure and poor off farm infrastructure as other constraints contributing to lack of market access and participation.

Most farmers in South Africa are located in rural areas which are characterised by low levels of infrastructure such as poor roads and telecommunications (Baloyi, 2010). Farmers located in rural areas also have poor linkages to credit facilities, input and output markets thus making it difficult for them to transport produce to the market (Shah *et al.*, 2002). Certain smallholder farmers in Zimbabwe have difficulties in accessing agricultural inputs such as fertilizers and seeds and this has lead farmers to only use a part of their allocated plots for agricultural production (Mutambara and Munodawafa, 2014).

Farmers at Bululwane Irrigation Scheme and Thukela Estate experienced problems with marketing of produce mainly because of the distance between the scheme and nearest local market and because of the crop grown at that particular time was not in demand (Bembridge, 2000).

3.4 Socio-Institutional Factors

Socio-institutional factors include land tenure, plot sizes, operational and management, training, extension services and government policies. Van Averbeke and Mohammed (2006) identified limited farmer participation in management of water, ineffective extension and limited knowledge of crop production among farmers as part of the socio-institutional factors that results in poor performance of SIS. Insecure land tenure and sharing of water among farmers were also identified as factors which affects the domain of the irrigation scheme (Van Averbeke, 2008).

3.4.1 Land tenure

Land rights are one of the major constraints in the performance of SIS and it influences the performance of farmers on their plots (Shah *et al.* 2002) and management practices adopted by farmers (Wichelns and Oster, 2006). Insecure tenure prevents farmers from making long-term investments in their plots, and prevents a land-exchange market where farmers can be given the opportunity to sell or expand their plots (Shah *et al*., 2002). According to Magadlela (1997), farmers on most SIS complain about the insecure land tenure and they have to live with the possibility of being evicted from the land at any time. Farmers without secure land tenure are not motivated to carry out proper irrigation and crop production management (Wichelns and Oster, 2006). Issues of land tenure affect irrigation management institutions and it gives government officials and donors the power to intervene at any given time (Machethe *et al*., 2004). It also prevents poor farmers from using the land as collateral for obtaining loans or production credit arrangements which can be used to implement new methods or purchase farm inputs such as seeds and fertilizers (Wichelns and Oster, 2006). Similar to credit providers, farmers on SIS are also not willing to invest in expensive irrigation equipment if they do not have security of land (Cornish, 1998).

In Ethiopia, land allocated to SIS is controlled by the local administration therefore farmers hesitate to invest in their allocated plots due to insecure land tenure. In the rural areas of KwaZulu-Natal, the chiefs and traditional councils oversees the land tenure systems and farmers lease the land from the chief (Cousins, 2012). Farmers allocated plots in SIS in South Africa fear that when the lease agreement expires, farmers might not be allocated the same plot again (Van Averbeke *et al*., 2011).

3.4.2 Plot sizes

Farmers on SIS believe that the plots allocated to them are too small (Magadlela, 1997). The smallest plot size allocated to farmers in Zimbabwe is 0.36 ha and the smallest plot size allocated to farmers in South Africa is 600 m^2 (Maepa *et al*., 2014). The small plot sizes inhibit commercialisation, mechanisation and prevent the use of high - tech irrigation equipment that requires reasonable plot sizes (Maepa *et al*., 2014). According to a study undertaken by Machethe *et al* (2004) in the Olifants River Basin of Limpopo Province, farmers allocated smaller plot sizes (plot sizes less than 2.5 ha) experienced food shortages for a period of 2 months and farmers with plots sizes less than a 5 ha found it difficult to obtain the expected annual subsistence household income. The study revealed that farmers require at least 5.6 ha plots in order to achieve an income that is equivalent to the annual household subsistence level and avoid food shortages (Machethe *et al*., 2004).

3.4.3 Operational and management

In most of the semi-arid sub-Saharan Africa low productivity can be attributed to inefficient farm management systems (Makurira *et al*., 2007). The management, control and decisions made on farming activities on the majority of SIS in South Africa are strictly enforced by central management with little farmer participation. This set-up has led farmers on these schemes to be highly depended on government and scheme management thus resulting in poor performance when government transfers the management activities of the scheme to farmers (Fanadzo, 2012).

Farmers on these schemes make independent decision with regards to the type of crop that they can plant on their plots, crop management and irrigation water management practices (Maepa *et al*., 2014). Although farmers on the scheme make independent decision with regards to their plots, they need to work together in terms of distributing water and maintaining infrastructure in order to be able to achieve their individual goals (Fanadzo, 2012). According to Maepa *et al*. (2014), decision making made by individual farmers can pose challenges in scheme maintenance, water allocation and distribution since farmers in these schemes rely on a shared distribution system for access to irrigation water (Van Averbeke *et al*., 2011). Van Averbeke *et al*. (2011) noted that farm institutions and organisations are challenged by farmers who chose to pursue individual goals rather than collective goals and this makes it difficult for scheme committees to enforce rules. Schemes organisations tend to find it difficult to instil rules because most farmers pursue their own individual goals (Fanadzo, 2012).

Farmers at the Bugri and Gagbriri Irrigation Scheme in Ghana find it easy to default in the payment of levies because the WUAs struggle to enforce payment rules (Jonah and Dawda, 2014). The management committee at the Mooi River Irrigation Scheme also struggles to enforce rules when it comes to exclusion of non-irrigators who are currently abstracting water from the scheme (Muchara *et al*., 2014). The management of the Makhathini Irrigation Scheme also find it difficult to recover electricity and water cost from farmers due to non-monitoring of water and illegal abstraction of water by plot holders and community members (A 'Bear and Louw, 1994).

3.4.4 Training of farmers

The majority of SIS farmers lack farming knowledge and skills in crop production and farm management and this is exacerbated by the lack of interaction between farmers and extension workers (Bembridge, 2000). Farmers in these schemes have received limited training which was not appropriate to food insecure farmers because it focused on scaled down versions of commercial production practices (Fanadzo, 2012).

Farmers in Zimbabwe were found to lack knowledge in terms of operation and maintenance of the irrigation infrastructure such as water pumps, canals, and valve and approximately 70% of the farmers were not trained in basic pump repair and maintenance (Mutambara and Munodawafa, 2014). Farmers and WUAs managing the Bugri and Gagbriri Irrigation Scheme struggled to undertake infrastructure maintenance and repairs due to insufficient technical knowledge (Jonah and Dawda, 2014).

3.4.5 Extension support services

Limited access to agricultural support services affects the growth of SIS (Fanadzo, 2012). The majority of extension officers are inadequately trained in terms of technical matters pertaining to SIS infrastructure and educational process skills. According to Bembridge (2000), extension officers assigned to SIS felt that they needed training in a wide range of topics and believed that they were not competent enough to give sound advice to farmers in terms of crop production techniques, water management and irrigation scheduling. In a study conducted by Fanadzo (2012), it was reported that extension officers assist SIS in South Africa lacked skills, especially irrigation water management skills, and farmers felt that extension officers spent less contact time than before and they technical knowledge had declined over the years.

The major problem with extension officers is that they lack the skills to work closely with farmers and they often assume that communication with farmers is about instructing farmers on what to do rather than listening and working closely with farmers to solve their problems (Kay, 2001).

3.4.6 Government Policies

Government policies such as land reform has allowed farmers in South Africa to gain access to productive land, however these policies have not made provision for farmer support services and has resulted in failure of many SIS. In Zimbabwe, the fast track land reform programme also had a negative impact on SIS because banks withdrew their credit assistance and this made it difficult for farmers to procure inputs (Mutambara and Munodawafa).

4. POSSIBLE PRACTICAL SOLUTIONS FOR PROBLEMS AND CONSTRAINTS FACING SMALLHOLDER IRRIGATION SCHEMES

Agricultural productivity has to be improved significantly in order to be able to meet the growing demand for food and fiber (Wichelns and Oster, 2006). According to Derib *et al*. (2011), improvement of irrigation water management and intensificion of agricultural practices is important in responding to the inrease in population and food demand. Practical solutions have been proposed around the world to address the numerous problems and constriants facing SIS. In addition to practical solutions, opportunities for higher productivity, higher incomes and sustainability within SIS have also been derived. This chapter contains a review of developed practical solutions and opportunies for the identified problems and constraints facing SIS that can enable SIS to sustainably raise agricultural productivity, manage available resources and infratsructure, improve economic development, food security and livelihoods of rural communities.

The proposed practical solutions and opportunities can result in long term sustainability of SIS if a participatory process (farmers involvement) is utilised when implemeting them (Bembridge, 2000). Ghazouanie *et al*., (2009) supports a participatory process and believes that engineers and farmers skills should be combined in order to achieve effective diagnoses of current problems and identify reliable solutions to the problems. Worku *et al.* (2014) believes that farmers should be involved from the planning, operation and maintenance stages of an irrigation system. Participatory approaches will allow farmers to take an effective collective action on the management of irrigation water, resolve conflict over sharing of water and canal maintenance (Worku *et al*., 2014).

Synder and Cullen (2014) recommends that any proposed practical solutions and plans should take into account the different patterns of livelihoods for scheme participants and should take into account environmental and social implications. Machethe (2004) recommends that for the proposed practical solutions and opportunities to be successful and sustainable, SIS need to gain access to assets, information, infrastructure, improved technology and remunerative markets.

4.1 Scheme Design and Pressurised Irrigation Systems

To reduce irrigation water demand and usage, farmers need to make better use of existing irrigation infrastructure and must be willing to adopt new technologies (Levidow *et al.*, 2014). In cases where new irrigation systems are to be designed, the recommended irrigation technologies should be low cost, based on simple design and operation, reliability, longevity, use few imported parts, easy maintenance and low energy requirements (Cornish, 1998). Farmers should be actively involved during the project design and implementation phases and the design should be such that it responds to farmers demand rather than top down approach (Kay, 2001). Magadlela (1997) recommends that irrigation systems design for a scheme should take into account local knowledge and local customs in farming practices and it must be adaptable to farmer's behaviour and perception of land and water management practices.

Designers should also consider using pressurised irrigation systems because in this systems conveyance losses are reduced, field application is improved and the systems allows the farmer more control over the timing and depth of application thus resulting in higher water use efficiencies and higher productivity per unit of water and land (Cornish, 1998). Pressurised systems such as low-pressure centre pivot and micro-irrigation have the ability to apply water more uniformly and efficiently (Waskom, 1994).

4.2 Best Management Practices for Irrigation and Agricultural Water Use

According to Bouwer (2000) improper and unsustainable irrigation without controlling groundwater can result in water logging and salinity problems. To achieve sustainable irrigation it is vital to remove salts and drainage water in a proper manner from the soil profile (Bouwer, 2000). Agrochemical runoff and leaching problems are minimised when water-efficient methods and irrigation scheduling are integrated with water and nutrient management practices (Levidow *et al.*, 2014). Water logging and salinity problems can be reduced by investing in irrigation and drainage infrastructure and by also motivating farmers to implement best management practices for irrigation practices and agricultural water users (Wichelns and Oster, 2006).

Problems and constraints related to irrigation water management (water logging and salinity) can be improved by implementing best management practices (BMP) for irrigation practices (Waskom, 1994) and for agricultural water users (Texas Water Development Board (TWDB), 2004). BMP for irrigation practices are recommended methods, structures or practices that can be used to increase efficiency and uniformity of irrigation water as well as manage the water resource (Waskom, 1994). BMP for agricultural water users focuses on developing water conservation measures that are cost-effective and economical using site-specific management, educational and physical practices (TWDB, 2004).

Best management practices for improving water-efficiency have a potential to enhance the economic viability of the scheme while sustaining the environment without reducing the water usage (Levidow *et al.*, 2014). The best management practices that can be considered for solving irrigation water management problems and constraints in SIS include irrigation scheduling, volumetric measurements of irrigation water use, on farm irrigation audits and equipment modification (TWDB, 2004; Waskom, 1994).

Farmers on SIS need to assist in developing irrigation scheduling for their individual plots so that they can reduce the chances of over or under irrigating (TWBD, 2004). Irrigation scheduling involves the application of water based on timely measurements or estimations of soil moisture content and crop water needs and it is considered one of the most crucial best management practices for irrigation management (Waskom, 1994). Proper irrigation scheduling is achieved when farmers are able to apply enough water to fill the effective root zone without unnecessary deep percolation and runoff.

Volumetric measurement of irrigation water use gives farmers an indication on how the system is performing and the measurements can be used to improve management of the irrigated crop (TWDB, 2004). Examples of volumetric measurement methods include installation of flow meters, periodic measurements of flow, measurements of the amount of energy used, monitoring of the number of pumps and blocks operated at a given time or checking the design of the system for information (TWDB, 2004).

On-farm irrigation audits should be the first BMP undertaken in SIS in order to improve water efficiency in irrigation (TWDB, 2004). This practice involves the auditing of all the water entering the farm, water used within the farm and costs associated with water. Once the audit is completed, potential water efficiency measures can be identified and these measures will assist farmers to decide on other practices that can be implemented in order to improve irrigation water management (TWDB, 2004).

4.3 Agronomic Practices

SIS in South Africa need to engage in proper crop production practices. Therefore research needs to be conducted to identify alternative crops that can be planted under crop rotation in order to enhance soil fertility and control weed growth (Fanadzo, 2012). According to Perret (2006), farmers need to start practicing crop diversification and intensification in order to generate income, sustain livelihood and be viable. Farmers can also generate income and cover costs of equipment and production inputs by cultivating high-value crops that will allow them to gain access to an assured market (Machethe, 2004).

Farmers should be trained on how to select the appropriate crop types, varieties or cultivars, planting dates, crop management and culture practices in order to be able to manage soil moisture and increase crop yield. Improvement in crop production technologies such as the use of fertilisers, hybrid seed varieties and plant protection techniques enable farmers to achieve sustainability in food production (Gorantiwar and Smout, 2005).

4.4 Credit and Marketing Strategies

A number of innovative institutional models have been developed in Asia and the Pacific region aimed at productivity enhancement and diversification with SIS. These models include the development of farmer organisations for marketing, promotion of contract farming (for purchasing of seeds, fertilizers and access to credit), development of supply chains for high value exports, facilitating of marketing knowledge transfer from private-sector to SIS farmers and direct economic development in rural areas (Thapa and Gaiha, 2011). Furthermore, van Averbeke *et al*. (2011) states that farmers need to be assisted in developing a reliable market network where they can sell produce and purchase inputs.

The South African Department of Agriculture, Forestry and Fisheries, cited by Van der Heijden and Vink (2014), has recommended strategies which will focus on encouraging farmers to improve their market knowledge, allow farmers to access subsided inputs, channel farmers to focus on niche markets such as organics and encourage farmers to form partnerships with commercial farmers and create their own producer associations. Thapa and Gaiha (2011) also recommended that farmers form producer organisations in a form of co-operatives, associations and societies to overcome marketing challenges and constrains. The aim of the organisations will be to assist smallholder farmers to gain access to markets and ensure that farmers receive sufficient public services support and access to credit (Thapa and Gaiha, 2011).

4.5 Operation, Maintenance and Management Strategies

There is a significant need for farmers to participate in collective management of the scheme (Muchara *et al*., 2014). Shah *et al.* (2002) is of the opinion that if management of irrigation schemes was transferred to Water User Associations, the scheme performance will improve due to better operation and maintenance of the system, improved water management practices, conflicts among farmers will be resolved, more fees would be collected from farmers and crop productivity will be enhanced, thus contributing to food and livelihood security of the farmers in the schemes. Management of irrigation schemes have been transferred to WUAs on schemes such as GaruTempane District of Ghana and SIS in Ethiopia where the WUAs are in charge of the day-to-day management of the scheme (Jonah and Dawda, 2004; Awulachew *et al*., 2005). The WUAs in Ghana are dominated by scheme participants and their main role is to manage the scheme, make decisions regarding the use of scheme resources as well as to ensure that land and water is available and distributed to all users in a fair manner (Jonah and Dawda, 2014). The WUAs or committees in Ethiopia are in charge of construction, water allocation, operation, management and maintenance of infrastructure (Awulachew *et al*., 2005).

Scheme management should set-up irrigation charges which will be expected to be paid by farmers and used for operational and maintenance costs of the schemes (Shah *et al*., 2002).

4.6 Capacity Building

Training in terms of planning, design, construction, operation, management and maintenance of SIS should be provided to farmers, engineers, technicians, management team and extension officers (Kay, 2001). After training, farmers should be provided with appropriate technical support for a few years in terms of operating and maintaining the irrigation system in order to achieve optimal performance (Cornish, 1998). Donors should be willing to make investments towards strengthening of human capital and the institutional base of SIS if they want to be able to achieve long-term growth and deal with rural poverty in a sustainable manner (Machethe, 2004). Farmers should also be equipped with production skills which will allow them to improve their crop productivity and increase income (Fanadzo, 2012). Farmers in Afghanistan managed to increase their potato yield by 205% after receiving training on the proper management of potatoes, irrigation scheduling and techniques, fertiliser application and pest control (Fanadzo, 2012).

Snyder and Cullen (2014) believe farmer knowledge and expertise should be encouraged in order to create a wider range of opportunities for rural communities. This process encourages a participatory and collaborative approach which can lead to empowerment of farmers and farmer organisations as well as capacity development for farmers (Levidow *et al*., 2014).

Fanadzo (2012) recommended that the South African Department of Agriculture, Forestry and Fisheries should train extension officers in terms of good water management practices, operation and maintenance of schemes and agronomic practices in order to be able to provide sufficient support and knowledge transfer to farmers. The trained extension officers should be assigned to service SIS only.

5. DISCUSSION AND CONCLUSIONS

Even though SIS in South Africa only accounts for approximately 3% of irrigated areas, government views them as important assets because of their location in rural areas and former homelands. The South African government believes that these schemes reduce poverty, hunger and the unemployment rate in rural areas. This may be one of the reasons why government continues to channel funds towards the revitalisation and rehabilitation of existing schemes and the development of new schemes. Therefore, there is a critical need for enhancing performance and sustainability of SIS in South Africa so that SIS can be able to alleviate poverty, generate income, improve livelihood and play a role in developing the local economy. To improve the performance of SIS, an understanding of problems and constraints facing SIS in South Africa is vital. This will assist in developing practical solutions that will be beneficial to SIS and will be able to create sustainability of SIS.

It is evident that the poor performance of SIS in South Africa is not a result of a single factor but it is affected by a combination of factors such as technical, agronomic, economic and socio-institutional. These factors affect the crop productivity, operation, management, maintenance and institutional arrangements of SIS in South Africa. For example, crop productivity is affected by technical factors such as irrigation water management, water reliability and distribution, agronomic factors such as crop variety, plant, planting date and cropping, economic factor such as access to credit for purchasing of inputs and socio-institutional such as training and extension support services. Therefore, when proposing or developing practical solutions for SIS, it is vital to first determine the root cause of each problem and constraint and understand how factors such as technical, economic, agronomic and socio-institutional contribute to the problems and constraints affecting the performance of the schemes.

Several solutions have been developed and implemented for problems and constraints facing SIS in a number of countries including South Africa and these solutions have resulted in an increase in the performance of SIS. Such solutions have included the use of pressurised irrigation systems and new technologies, implementation of best management practices for irrigation such as proper irrigation scheduling and best management practises for crop production such as practicing proper cropping systems, crop rotation, selection of appropriate crop types and variety selection. Other solutions that have made a difference in the performance of SIS and in issues of farmers or group cohesion is the formation of WUAs and transfer of scheme management to the associations. The advantage of WUAs is that farmers or scheme participate form part of the association and they get to be involved in the day-to-day running of the scheme and in decision making on matters concerning the scheme.

Development of solutions to problems facing smallholder irrigation scheme should be carried out using a participatory process where skills of engineers, extension officers, farm management and farmers can be combined in order to achieve effective solutions and avoid the repetition of historical problems linked to the failure of SIS. When developing solutions to improve the performance of SIS it is important to appreciate that SIS are not a homogeneous group. Thus any agricultural development strategy must recognise that there are different categories of SIS requiring different approaches.

Further research needs to focus on the root causes of these problems for specific set up to prevent the problems from re-occurring in the future. Knowledge of the root causes of these problems will assist in developing correct practical solutions which can contribute towards the improved performance and greater sustainability of SIS.

6. RESEARCH PROPOSAL

This chapter covers the project proposal to assess the problem and constraints facing smallholder irrigation schemes in South Africa and the opportunities for developing practical solutions to some of the problems. The project is proposed to be carried out in the KwaZulu-Natal (KZN) province of South Africa.

6.1 Problem Identification and Context

South Africa has 1.6 million hectares of land under irrigation of which only about 49 500 hectares falls under smallholder irrigation schemes (Van Averbeke and Mohammed, 2006). Even though smallholder irrigation schemes accounts for about 3% of irrigated areas, it remains important to government because of its location in the former homelands which continue to be nodes of poverty (Sinyolo *et al*, 2014). The South Africa government believes that smallholder irrigation schemes can assist in achieving the Strategic Development Goals of halving poverty and hunger in the rural areas (Sinyolo *et al.*, 2014) and improve livelihoods of scheme participants (Van Averbeke *et al*., 2011).

Despite the huge potential of SIS, the majority of these schemes have failed to meet the rural development and poverty reduction goals and continue to perform below expectation (Sinyolo *et al*, 2014). The poor performance of these schemes can be attributed to technical, agronomic, economic and socio-institutional factors (Gomo *et al*, 2014). In spite of the poor performance of these schemes, government views these schemes as assets to South Africa and has therefore made significant investments towards the establishment, revitalisation and rehabilitation of these schemes (Van Averbeke and Mohammed, 2006).

The Department of Agriculture, Forestry and Fisheries (DAFF) is keen to see a positive turnaround of these schemes and thus an understanding of the problems and constraints facing these schemes is crucial for formulating practical solutions which will improve the performance of these schemes. Conducting research on problems and constraints facing smallholder irrigation schemes in South Africa is expected to contribute towards improved performance, sustainability of these schemes and the livelihood of scheme participants. The solutions generated will be applicable at different schemes, at different levels and for different stakeholders in SIS, for example at national government, provincial, scheme and individual farmer level.

6.2 Research Objectives

The main objective of this research study is to determine the current problems and constraints facing underperforming revitalised smallholder irrigation schemes within the province of KwaZulu-Natal schemes and develop practical solutions which will take into account agronomic, technical, economic and socio-institutional factors.

The specific objectives of this proposal are to:

- Objective 1: identify problems and constraints facing the Makhathini and Tugela Ferry Irrigation Schemes,
- Objective 2: analyse and identify key problems and constraints affecting the overall performance of the schemes,
- Objective 3: propose and develop practical solutions for the identified key problems and constraints for the schemes, and
- Objective 4: where feasible, assess existing SIS which are currently being revitalised against the proposed solution.

6.3 Research Questions

This research seeks to answer the following questions:

- What are the problems and constraints affecting the performance of the schemes and what are the root causes of these problems?
- Which problems and constraints do farmers perceive as the key problems affecting the performance of the scheme?
- How best can available knowledge be used together with farmers' inputs to resolve the problems and constraints faced by these schemes?

6.4 Research Methodology

The research will be carried out at Makhathini and Tugela Ferry Irrigation Schemes. The study area and methodology for each specific objective is detailed below.

6.4.1 Study area

Makhathini Irrigation Scheme is located adjacent to the Pongolapoort Dam near the town of Jozini in the Jozini Local Municipaity of the uMkhanyakude District Municipalty in KwaZulu-Natal Province as shown in Figure 6.1. The scheme covers an area of 4500 ha but currently only 3500 ha is cultivated under irrigation. The 3500 ha is divided into 262 plots with sizes ranging from 5 ha to 10 ha. The 262 plots are occupied by 314 farmers who operate as both co-operatives and individual farming units. Water for the scheme is abstracted from the Jozini Dam (Pongolapoort Dam) and conveyed by a concrete canal system to the fields. This scheme was chosen because it is one of the largest scheme in KwaZulu-Natal which has a potential to contribute to the local economy but it is faced with sveral problems and constraints that affect it performance.

The Tugela Ferry Irrigation Scheme is located in the Midlands region of KwaZulu-Natal and falls within the uMsinga Local Municipality of the uMzinyathi District Municipality as shown in Figure 6.1. The scheme covers an area of 840 ha but approximately 540 ha are currently under cultivation. Farmers at Tugela Ferry are allocated a number of small plots ranging from 0.08 to 0.15 ha and each farmer can have more than 1 small plot. The plots are occupied by 800 to 1000 producers. Water for irrigation is drawn from a diversion weir across the Thukela River and distributed to individual plots using a canal and short-furrow system.

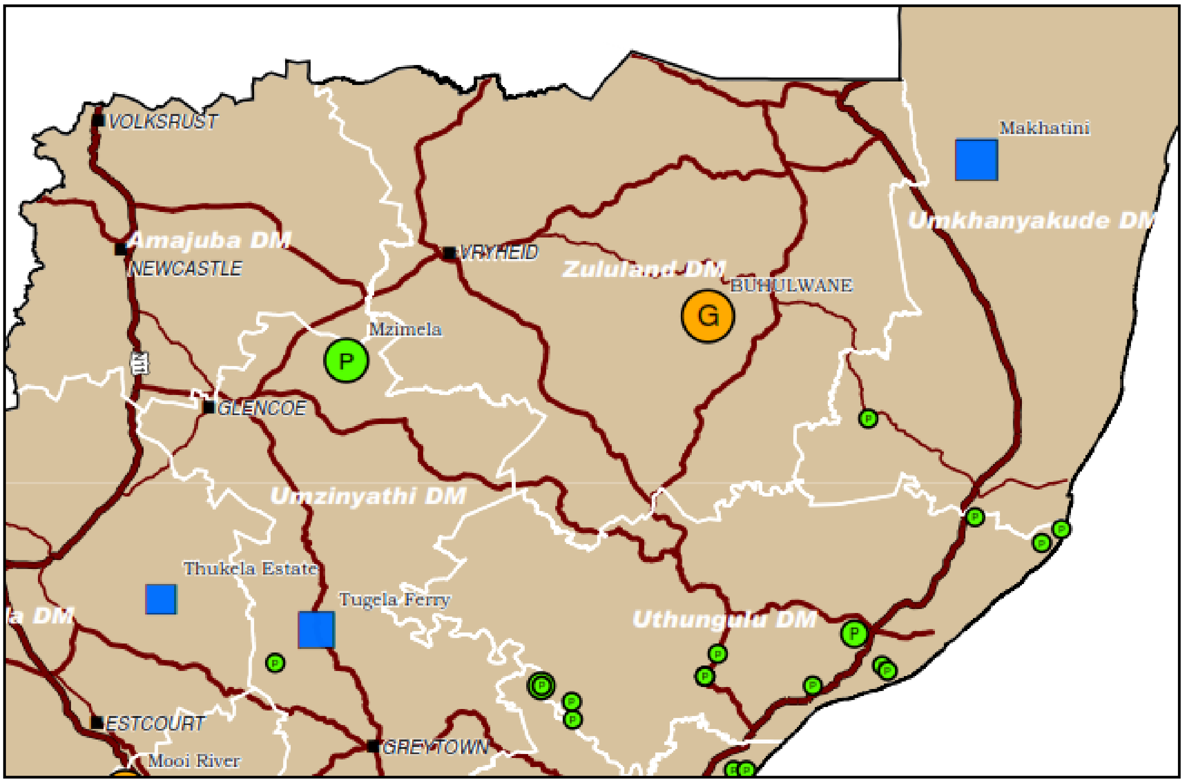


Figure 6.1 Locality map showing Makhathini and Tugela Ferry Irrigation Schemes (Denison and Manona, 2007).

6.4.2 Objectives of the Study

Objective 1: Identify problems and constraints facing Makhathini and Tugela Ferry Irrigation Schemes

Meetings, interview searches and structured interviews will be conducted to determine problems and constriants facing farmers at MIS and TFIS. Where necessary, field data collection may also be undertaken to assess the extent and impacts of particular problems. The data obtained from the interviews and field observations will be presented with a Problem Tree or a schematic representation of the prolems and cosntraints will be carried out using the Root Cause Analysis approach.

Objective 2: Analyse and identify key problems and constraints affecting the overall performance of the schemes

The Principal Components Analsyis (PCA) technique will be used to analyse and categorise problems and constraints affecting the farmers at the selected schemes. The PCA technique is relatively simple and it is able to reduce the dimensionality of data. The technique is able to develop a smaller number of key variables using a number of observed variables. Alternatively, common "prioritisation" techniques available in the market can be used to priorities problems after the problems have been ranked.

Objective 3: Propose and develop practical solutions for the identified key problems and constraints

A number of practical solutions will be developed for the key problems and constraints identified in Objective 2. The conceptual solutions will then be presented to the scheme stakeholders where they will be given a platform to comment and contribute to the conceptual solutions. Once the conceptual solutions are finalised, detailed solutions will be developed with the assistance of the scheme key stakeholders and where possible several solutions will be tested.

Objective 4: Where feasible, assess existing SIS which are currently being revitalised.

Interviews will be conducted with the project managers from the Department of Rural Development and Land Reform to obtain information on the schemes which are currently being revitalised and assess how the revitalisation process is being undertaken. The revitalisation process will also be compared to the proposed solutions in Objective 3.

6.5 Resources Required

The estimated resources required for this project are tabulated in Table 6.1.

Table 6.1 Resources required for the proposed project

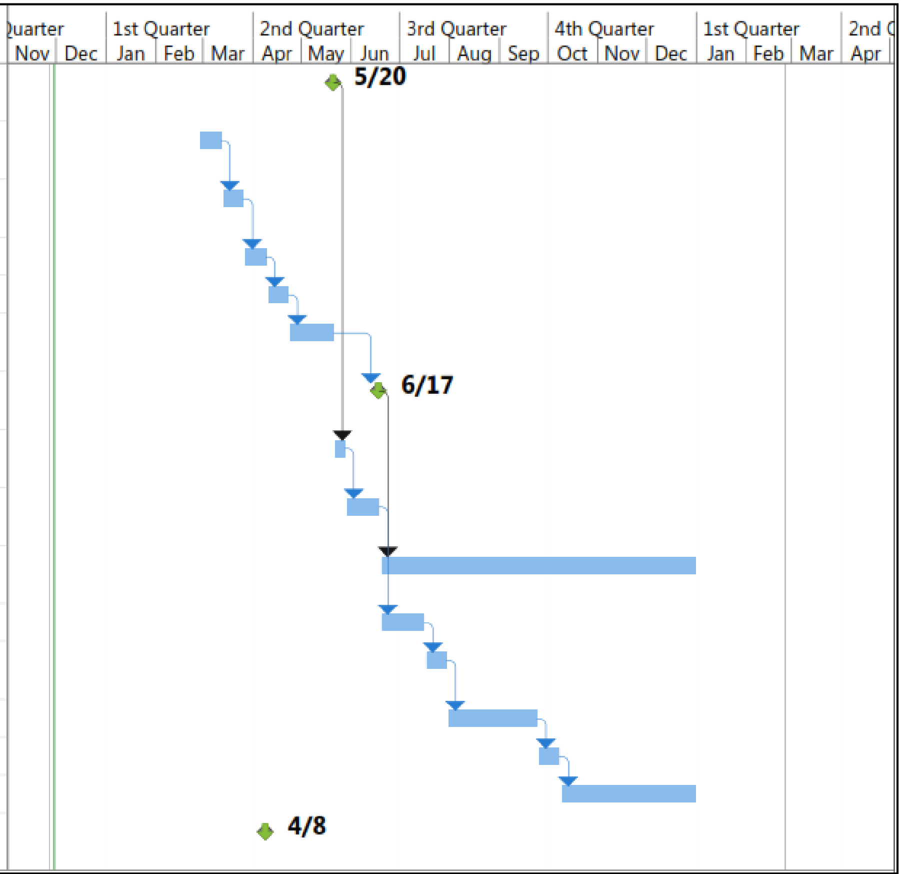
Resource	Total Costs	Source
Transport to Jozini (10 trips x 900 km)	R15 000	SHF - UKZN
Transport to Msinga (10 trips x 350 km)	R6 000	SHF - UKZN
Field Assistance (2 people @ R150 per day x 30 days)	R6 000	ARC
Total	**R26 000**	

6.6 Work Plan

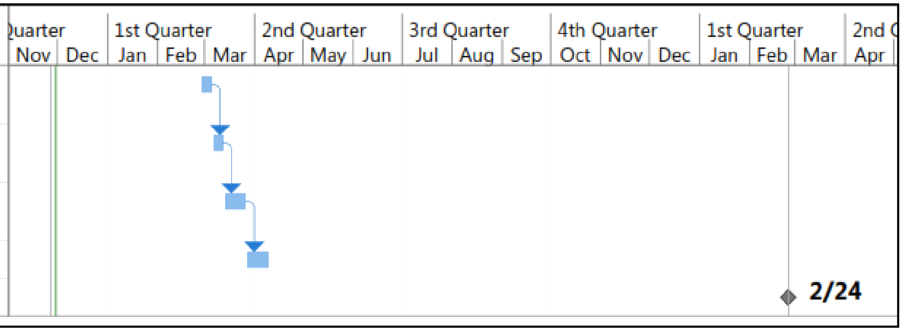
The summary of timeframes for the research is presented in Table 6.2.

Table 6.2 Timeframes for the proposed research project

ID	Task Name	Duration	Start	Finish
1	**Objective 1: Identify problems and constraints facing MIS and TFIS**	**3 mons**	**Mon 2/29/16**	**Fri 5/20/16**
2	Prepare questionnaires for structured interviews	0.5 mons?	Mon 2/29/16	Fri 3/11/16
3	Conduct meetings with scheme management committee to introduce projects	0.5 mons	Mon 3/14/16	Fri 3/25/16
4	Conduct interviews with farmers	0.5 mons	Mon 3/28/16	Fri 4/8/16
5	Site inspection visits on each scheme	0.5 mons	Mon 4/11/16	Fri 4/22/16
6	Prepare a Problem Tree or undertake a Root Cause Analysis	1 mon?	Mon 4/25/16	Fri 5/20/16
7	**Objective 2: Analyse and identify key problems and constraints**	**1 mon?**	**Mon 5/23/16**	**Fri 6/17/16**
8	Sort out collected data to be used in the PCA model	0.25 mons?	Mon 5/23/16	Fri 5/27/16
9	Use PCA model to analyse and identify key problems	0.75 mons?	Mon 5/30/16	Fri 6/17/16
10	**Objective 3: Propose and develop practical solutions to key problems and constraints**	**7 mons?**	**Mon 6/20/16**	**Fri 12/30/16**
11	Propose a number of practical solutions	1 mon	Mon 6/20/16	Fri 7/15/16
12	Conduct a meeting with scheme committee and farmers to discuss proposed solutions	0.5 mons?	Mon 7/18/16	Fri 7/29/16
13	Develop selected proposed solutions	2 mons?	Mon 8/1/16	Fri 9/23/16
14	Present developed solutions	0.5 mons?	Mon 9/26/16	Fri 10/7/16
15	Test several possible solutions	3 mons	Mon 10/10/16	Fri 12/30/16
16	**Objectives 4: Assess existing SIS which are currently being revitalised**	**1.5 mons?**	**Mon 2/29/16**	**Fri 4/8/16**



ID	Task Name	Duration	Start	Finish
17	Conduct interviews with relevant departments	0.25 mons?	Mon 2/29/16	Fri 3/4/16
18	Review documentation for revitalised projects	0.25 mons?	Mon 3/7/16	Fri 3/11/16
19	Identify problems and constraints facing these schemes	0.5 mons?	Mon 3/14/16	Fri 3/25/16
20	Assess proposed intervention measures	0.5 mons?	Mon 3/28/16	Fri 4/8/16
21	**Final MSc: Thesis Document**	**3 mons**	**Mon 12/5/16**	**Fri 2/24/17**



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