

**EVALUATION OF INSTITUTIONAL INTEGRATION, FARMER PARTICIPATION
AND PERFORMANCE IN SMALLHOLDER IRRIGATION SCHEMES IN
KWAZULU-NATAL, SOUTH AFRICA**

by

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ABSTRACT

Smallholder irrigation schemes (SIS) are pivotal in sustaining livelihoods and creating employment in rural communities of South Africa. The South African government has made efforts to rehabilitate and revitalize such schemes; however, current realities of poor scheme performance, low farmer participation and dilapidated infrastructure raise questions about providing the irrigation improvements. SIS beneficiaries are usually low-income farmers faced with various production constraints, whose success rests on the schemes' institutional environments. The government adopted the Irrigation Management Transfer to foster collective responsibility and rule compliance and to improve the performance and to decentralize the management of SIS. However, in many cases, the lack of awareness of formal institutions and stakeholder involvement hinders the effective management of the schemes.

Given the shortcomings of the SIS, this study evaluates institutional integration, farmer participation and SIS' water-user performance. The study's specific objectives were to assess the institutional integration in the SIS governance in KwaZulu-Natal (KZN) Province, South Africa; to assess the determinants of the household-level perceptions of scheme governance; to evaluate the determinants of farmer's participation in the management of SIS and lastly; to estimate water-use performance in SIS. The study adopted qualitative and quantitative techniques to address the objectives. Data were collected from 341 households across four SIS in KZN. Focus group discussions and key informant interviews were held to obtain more information on scheme governance. The chosen schemes have different features such as institutional arrangements, farmer composition, and production challenges, and are representative of the average SIS in South Africa.

The study evaluated the horizontal and vertical institutional integration of water governance in SIS. Stakeholder interactions in the schemes were assessed through Exploratory Social Network Analysis to identify, categorize, and investigate stakeholder challenges. The Management Transition Framework, an interdisciplinary framework for evaluating water systems, management processes and multi-level governance regimes, was adopted to analyse institutional integration. Considering that good governance is a prerequisite for the effective

management of common-use resources, the determinants of perceptions of governance were evaluated using the multiple regression model.

Principal Components Analysis, Structural Equation Modelling, and multiple regression were used to generate participation in management indices, evaluate the relationship between management constructs and evaluate the determinants of water-users' participation in SIS management, respectively. Furthermore, the study assessed the performance of water-users across the four SIS, given their different institutional arrangements. Technical Efficiency was used as a proxy for water-user performance and was measured using Cobb-Douglas and Trans-log production functions. A Stochastic Meta-Frontier Analysis (SMFA) method was employed to measure the overall efficiency of water-users across schemes and determine technical gap ratios.

In assessing institutional integration in SIS governance, the study found that information asymmetries hindered horizontal integration. Simultaneously, the fiscal and capacity challenges, low accountability, and transparency amongst stakeholders led to the lack of vertical integration. The results indicate a lack of integration in SIS governance. Empirical results show that farmers that are satisfied with the informal institutions, being the rules and norms set locally to govern the scheme farmers, value the involvement of the traditional authorities in scheme management, including their contribution in rule enforcement. Age, agricultural training, water adequacy, participation in scheme activities, psychological capital and land tenure have a positive effect on perceptions of governance.

The study found that irrigators who participated in the regulation and control of SIS also participate in information sharing activities. Furthermore, participation in SIS management is composed of four management constructs that have different determinants. The study found that governance perceptions, land tenure security, credit access, and co-operative membership are determinants of participation in the management of SIS. In evaluating water-user performance, the SMFA results yielded an overall average meta-efficiency of 0.85, which is relatively high. The efficiency model results showed that perceptions of governance, farmer psychological capital, land tenure security, credit access, co-operative membership, and gender significantly affect water-users' performance.

The study recommended the need for stakeholders to understand existing institutions and their roles, i.e., The Department of Agriculture, Fisheries and Forestry, Department of Water and Sanitation, extension officers. Synergies and improved coordination among institutions are prerequisites for effective governance. Additionally, transparency and accountability should be improved to attain vertical integration. Awareness of formal institutions and stakeholder involvement should be encouraged to foster farmer participation in SIS management. Improved stakeholder engagement and inclusion of informal institutions in policy formulation can achieve integration and better water management in the schemes.

Farmers should receive and participate in agricultural and irrigation training to increase their participation in irrigation scheme management, which can foster the sustainable use of water. Interventions should strengthen institutions and focus on the empowerment of farmers through relevant training, land tenure security, and credit access. Furthermore, improved water supply adequacy and its availability for use in the schemes should enhance its productivity.

DECLARATION 1 - PLAGIARISM

I, *Lerato Phali*, declare that:

I. This research reported in this thesis, except where otherwise indicated, is my original research.

II. This thesis has not been submitted for any degree or examination at any other university.

III. This thesis does not contain any other persons' data, pictures, graphs or other information, unless expressly acknowledged as being sourced from those persons.

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a. Their words have been re-written but the general information attributed to them have been referenced; or

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Signed: LE Phali Date: 22 December 2020

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We hereby agree to the submission of this thesis for examination:

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3. Prof G Makombe (Co-supervisor)

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DECLARATION 2 - PUBLICATIONS

The following manuscripts form part of the research presented in this thesis.

Manuscript 1 - Chapter 3 of this thesis

Phali L, Mudhara M, Ferrer S and Makombe G. An assessment of institutional integration in water governance of rural smallholder irrigation schemes: Evidence from Kwazulu-Natal Province, South Africa. (Under review: *Water Policy*)

Manuscript 2 - Chapter 5 of this thesis

Phali L, Mudhara M, Ferrer S and Makombe G. Determinants of farmers' participation in the management of smallholder irrigation schemes in Kwazulu-Natal Province, South Africa (Under review: *Journal of Economics and Behavioural Sciences*)

Manuscript 3 - Chapter 4 of this thesis

Phali L, Mudhara M, Ferrer S and Makombe G. Household-level perceptions of governance in smallholder irrigation schemes in Kwazulu-Natal Province, South Africa. (Under review, *Irrigation and Drainage Systems*)

Manuscript 4 - Chapter 6 of this thesis

Phali L, Mudhara M, Ferrer S and Makombe G. Evaluation of Water-User Performance in smallholder irrigation schemes in Kwazulu-Natal Province, South Africa: A Stochastic Meta-Frontier Analysis (Under review, *Development in Practice*)

Conference Papers

Phali L, Mudhara M, Ferrer S and Makombe G. Evaluation of water-user performance in Smallholder Irrigation Schemes in KwaZulu-Natal, South Africa. Paper presented at the 19th Annual Waternet Symposium 2019, Livingstone, Zambia.

Phali L, Mudhara M, Ferrer S and Makombe G. An assessment of institutional integration in water governance of rural smallholder irrigation schemes: Evidence from Kwazulu-Natal

Province, South Africa. Paper presented at the 18th Annual Waternet Symposium 2018, Swakopmund, Namibia.

DEDICATION

This thesis is dedicated to Salome and Japhta Phali.

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TABLE OF CONTENTS

ABSTRACT.....	ii
DECLARATION 1 - PLAGIARISM.....	v
DECLARATION 2 - PUBLICATIONS.....	vii
DEDICATION.....	viii
ACKNOWLEDGEMENTS.....	ix
LIST OF TABLES.....	5
LIST OF FIGURES.....	6
CHAPTER 1: INTRODUCTION.....	7
1.1. Background.....	7
1.2. Study Justification.....	9
1.3. Problem Statement.....	11
1.4. Objectives.....	12
1.5. Outline of the thesis.....	13
1.6. References.....	14
CHAPTER 2: LITERATURE REVIEW.....	19
2.1. Background.....	19
2.1.1. Overview of Smallholder Agriculture in South Africa.....	19
2.1.2. Irrigation farming in South Africa.....	20
2.2. Challenges of smallholder irrigation schemes.....	21
2.3. Policies, strategies, rules, and regulations of smallholder irrigation schemes in South Africa.....	23
2.4. Water management organizations in South Africa.....	25
2.5. Institutional integration in water resource management.....	28
2.6. Stakeholder mapping/analysis.....	29
2.7. Integration dimensions within water resource governance.....	31
2.8. Farmer participation in smallholder irrigation schemes.....	32
2.9. Farmer performance in smallholder irrigation schemes.....	34
2.10. Study analytical methods	
2.11. Summary.....	37
2.12. References.....	38

CHAPTER 3: AN ASSESSMENT OF INSTITUTIONAL INTEGRATION IN WATER GOVERNANCE OF RURAL SMALLHOLDER IRRIGATION SCHEMES: EVIDENCE FROM KWAZULU-NATAL PROVINCE, SOUTH AFRICA.....	48
Abstract.....	48
3.1. Introduction.....	49
3.2. Methodology.....	53
3.2.1. Theoretical and Conceptual Framework.....	53
3.2.2. Study Areas.....	54
3.2.3. Sampling and data collection.....	55
3.2.4. Data analysis.....	56
3.2.4.1. Social Network Analysis.....	56
3.3. Results and Discussion.....	57
3.3.1. Application of the adapted Management Transition Framework to assess vertical and horizontal integration in SIS in KwaZulu-Natal.....	57
3.3.2. Social network of issues and challenges affecting stakeholders in smallholder irrigation schemes in KwaZulu-Natal.....	62
3.4. Conclusions and Recommendations.....	65
3.5. References.....	65
CHAPTER 4. HOUSEHOLD-LEVEL PERCEPTIONS OF GOVERNANCE IN SMALLHOLDER IRRIGATION SCHEMES IN KWAZULU-NATAL PROVINCE.....	70
Abstract.....	70
4.1. Introduction.....	70
4.2. Methodology.....	73
4.2.1. Conceptual Framework.....	73
4.2.2. Data collection and sampling.....	75
4.2.3. Study area.....	74
4.2.4. Empirical Methods.....	76
4.2.4.1. Principal Components Analysis (PCA).....	76
4.2.4.2. Multiple Regression Model.....	76
4.3. Results and discussion.....	78
4.3.1. Descriptive Statistics.....	78
4.3.2. Principal components analysis of farmers' understanding and perceptions of governance of SIS in KZN.....	79
4.3.3. Results of the determinants of farmers' perceptions of governance.....	83
4.4. Conclusions and recommendations.....	86

4.5. References.....	87
CHAPTER 5: DETERMINANTS OF FARMERS' PARTICIPATION IN THE MANAGEMENT OF SMALLHOLDER IRRIGATION SCHEMES IN KWAZULU- NATAL PROVINCE, SOUTH AFRICA.....	
Abstract.....	90
5.1. Introduction.....	90
5.2. Methodology.....	94
5.2.1. Conceptual Framework.....	94
5.2.2. Empirical methods of data analysis.....	95
5.3. Results and Discussion.....	99
5.3.1. Descriptive Statistics.....	99
5.3.2. Structural Equation Model Analysis Results.....	100
5.3.4. Principal Components results of contributors to participation in management indices	102
5.3.5. Multiple regression results of the determinants of farmer's participation in the management of SIS.....	104
5.4. Conclusions and Recommendations.....	107
5.5. References.....	108
CHAPTER 6: EVALUATION OF WATER-USER PERFORMANCE IN SMALLHOLDER IRRIGATION SCHEMES IN KWAZULU-NATAL PROVINCE, SOUTH AFRICA: A STOCHASTIC META-FRONTIER ANALYSIS.....	
Abstract.....	112
6.1. Introduction.....	112
6.2. Methodology.....	115
6.2.1. Theoretical Framework.....	115
6.2.2. Study Sites and Data Collection.....	116
6.2.3. Empirical method of evaluating technical efficiency of water-users in SIS.....	118
6.3. Results and Discussion.....	121
6.3.1. Description of explanatory variables and descriptive statistics.....	121
6.3.2. Technical Efficiency estimations of water-users in SIS.....	125
6.4. Conclusions and Policy Recommendations.....	131
6.5. References.....	132
CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS.....	
7.1. Purpose of the study.....	137
7.2. Conclusions.....	138

7.3. Recommendations.....	139
7.4. Study limitations.....	141
7.5. Areas for further research.....	141
Appendix 1. Questionnaire.....	142
Appendix 2: Ethical Clearance-Declaration of Consent.....	155

LIST OF TABLES

Table 3.1. Interaction between actors and processes in water management and their roles....	58
Table 3.2. Closeness coefficient of challenges constraining institutional integration in SIS..	63
Table 4.1. Description of explanatory variables.....	77
Table 4.2. Descriptive statistics of explanatory variables.....	78
Table 4.3. Principal components analysis of farmers' perceptions of SIS governance.....	81
Table 4.4. Multiple regression model of the determinants of HGI.....	84
Table 5.1. Description of explanatory variables.....	98
Table 5.2. Descriptive statistics of water-users in SIS.....	99
Table 5.3. Covariances and correlations between latent management constructs.....	102
Table 5.4. Determinants of farmer's participation in the management of SIS.....	105
Table 6.1. Efficiency score distribution of water-users in SIS in KZN.....	125
Table 6.2. Technology gap ratios and average technical efficiency scores in KZN SIS.....	126
Table 6.4. Stochastic frontier estimates of technical inefficiency in SIS.....	130

LIST OF FIGURES

Figure 3.1. Social facets of the Management Transition Framework and OECD governance gaps showing linkages in smallholder irrigation scheme management.....	54
Figure 3.2. Social network of pertinent issues in SIS in KwaZulu-Natal.....	64
Figure 4.1. Linkages in the social facets of SIS management.....	73
Figure 6.1. Concept of a Stochastic meta-frontier.....	116

CHAPTER 1: INTRODUCTION

This chapter presents the background of the thesis, the problem statement and justification of the study. It further puts across the objectives and research questions. The outline and structure of the thesis are also presented.

1.1. Background

The South African government has made the reduction of the incidence of poverty one of its key objectives (Fransman and Yu, 2019). It has made efforts in this regard through the formulation of the National Development Plan (NDP) and subscribing to the United Nations' Sustainable Development Goals (SDG). The NDP is focused on poverty reduction through creating jobs, reducing inequality, and ensuring food and water security in the country (Cumming *et al.*, 2017). The country has seen a reduction of poverty as indicated by a decline of at least three percentage points in the national poverty headcount ratio over the past two decades (Statistics South Africa (StatsSA), 2018). However, the progress has been slow, as seen by the high rates of poverty and inequality which currently exist in the country (Zizzamia *et al.*, 2019). Although South Africa is food secure at a national level, about 20% of South African households had inadequate access to food in 2017, while in 2018, about 11% (6.8 million) of South Africans experienced hunger (StatsSA, 2018). Studies have shown that poverty is particularly rife in rural areas (Muchara *et al.*, 2014; Sinyolo *et al.*, 2014; StatsSA, 2018; Claasen, 2020), which has led to government's priority in enhancing development in rural areas (Sewell *et al.*, 2019).

One of the critical interventions has been smallholder irrigation schemes (SIS), which has been deemed to enhance agricultural productivity and combating rural household food insecurity (Sinyolo *et al.*, 2014). An SIS is defined as “an agricultural project that was constructed specifically for occupation by African farmers, and that involved multiple holdings, which depended on a shared distribution system for access to irrigation water and in some cases also on a shared water storage or diversion facility” (Van Averbeke, 2012: 413). They were predominantly put in place with the primary focus of food production (Van Averbeke, 2012). As of 2011, South Africa had 302 SIS (Van Averbeke *et al.*, 2011). Even though the establishment of SIS is an old strategy which serves to enhance development in rural areas, they have undergone changes in the past decades such as revitalization and rehabilitation to improve the productivity of farmers (Van Averberke, 2012)

Across the globe, SIS often face similar challenges, some of which stem from farms being too small to be economically viable (Damianos and Giannakopoulos, 2002; Meinzen-Dick *et al.*, 2002; Tittonel *et al.*, 2007; Knieper *et al.*, 2010). Some of the SIS have “low levels of technology” (Mudau, 2010). One of the challenges SIS face is access to appropriate institutions and organizations that can provide them with requisite assistance (Muchara *et al.*, 2014). In efforts of improving SIS, the government has established formal institutions to improve the functionality, performance, and stakeholder engagement in SIS (*ibid*, 2014; Dirwai *et al.*, 2019).

Irrigation development has gone through different phases in South Africa. It is, however, suggested that current economic realities create difficulties in justifying the novel irrigation developments (Van Averbeke, 2008; Sinyolo *et al.*, 2014). In 1912, the South African Government promulgated its first Irrigation and Water Conservation Act. The act aimed to promote the development of irrigation. However, according to Mudau (2010), the developments emanating from the act were characterized by large-scale, uncoordinated private irrigation development. After 1975, substantial development of irrigation schemes took place, which focussed more on the rehabilitation of irrigation schemes (Van Averbeke *et al.*, 2011).

Rehabilitation is an engineering-centred concept, involving the restructuring of infrastructure to ensure adequate water supply and the re-design of systems (DAFF, 2012). However, even after the rehabilitation, irrigations schemes still underperformed in terms of water reliability, deterioration of physical infrastructure, and the institutional set-up constraints (Bembridge, 2000). As such social dynamics, in the form of institutions and local human capital were included in the development of SIS (Averbeke *et al.*, 2011). This resulted in a process called revitalization in 2004, which is a philosophy that includes both the re-design of existing infrastructure and engagement with the organizational and social dynamics of water distribution and allocation (Maepa *et al.*, 2014). The revitalization also includes the agricultural production system, human capital development, marketing, and business development (DAFF, 2012).

Through revitalization, provincial governments decided to transfer the management of the irrigation schemes to the farmers that used the water resources (Van Averbeke, 2012). This process was referred to as the Irrigation Management Transfer (IMT). IMT in South Africa was introduced in 1996 in the Eastern Cape and ended in 1998 in Limpopo Province.

Furthermore, several new SIS were established in the late 1990s, which were aligned with the Reconstruction and Development Programme (RDP), which was the national development framework (Van Averbeke, 2012). Despite the extensive and varied approaches employed by the government to improve the efficiency of SIS as a tool for development, most SIS still face various challenges. According to Perret (2002), the lack of a transparent institutional environment and low farmer participation makes it challenging to direct SIS production from subsistence purposes to those of commercial autonomy. With the new democratic dispensation in 1994 also came different water usage acts and promulgations.

The 1998 National Water Act 36 started when the implementation of IMT ended in Limpopo Province. The act stipulates, amongst other things, that water is a common asset, with the government as the public trustee. The Act was mandated to ensure that South Africa's water resources are protected, used, developed, conserved, managed, and controlled (Schreiner, 2013). The Act gives rise to the National Water Resource Strategy (NWRS), which is aimed at promoting equity, job creation and development (DWA, 2006). Under the strategy, organizations such as Water User Associations and Catchment Management Agencies were formed. The agencies are meant to co-ordinate water-related activities and water management institutions, to develop and implement Catchment Management Strategies (CMS) and to encourage local community participation (Karodia and Weston, 2001).

The government has made concerted efforts to address poverty by enhancing the performance of SIS through existing policies and institutions within the management of SIS. However, despite the reported investments and pronouncements, the performance of schemes has been below expectation, farmer participation is still deemed unsatisfactory, and integration challenging to achieve (DWA, 2006). Numerous studies (Fanadzo *et al.*, 2010; Manona *et al.*, 2010; Gomo *et al.*, 2014; Muchara *et al.*, 2014b) have explored why this is the case through focussing on technical and socio-economic aspects in SIS, however, concentrating on institutions and the role of governance in the schemes could shed light into why government's efforts have not been realised.

1.2. Study Justification

SIS have the potential to alleviate poverty and improve household food security in rural areas (Sinyolo *et al.*, 2014). Faced with technical challenges, such as deteriorated infrastructure, low water supply (Dirwai *et al.* 2019), the success of the irrigation schemes also hinges on the mandated policies and strategies that were established to support farmers (Machete *et al.*,

2004). The governance in irrigation schemes plays a role in their farmers' performance, as it includes organizational structures that are responsible for the management of schemes (Perret, 2002). As such, the inclusion of institutional variables in performance analysis is necessary. Institutions give a basis for human cooperation and encourage stable interaction (Nielsen *et al.*, 2013). For successful integrated resource management, it is fundamental that institutional analysis is performed. Due to the roles different stakeholders play in water resource governance, the management thereof tends to be complex (Carlson and Stelfox, 2009). The various stakeholders have their priorities and approaches to achieve their goals, decreasing the likelihood of a well-coordinated system (Viesmann, 2011). Therefore, to minimize failure, it is vital to identify and understand the roles of the stakeholders within a system. Evaluating institutional integration and challenges affecting key stakeholders involved in SIS can help identify gaps and areas of improvement to ensure effective governance at different administrative levels, and across different sectors (WWF, 2005). This can help the government adapt the current arrangements and help the involved stakeholders collaborate and coordinate to ensure that policies, strategies, and programs achieve their mandates.

Furthermore, given the vast literature on scheme performance, particularly from the technical point of view, an evaluation of institutional integration can provide a possible cause of the underperformance of schemes, from a social perspective (Knieper *et al.*, 2010). Farmers are key players in SIS as they are the primary users and are primarily involved in the governance and management of schemes; therefore, assessing their perceptions is important. Perceptions of governance affect involvement/participation and consequently, performance in SIS (Cookey *et al.*, 2016). Assessing the determinants of governance perceptions and their determinants at household level helps in identifying which institutions and institutional arrangements farmers are satisfied with. This would help in formulating arrangements, particularly at the local level, that create an enabling environment for the sustainable use and performance of, as well as participation in SIS.

Given that scheme management has been decentralized, it becomes crucial to understand which activities farmers participate in and what determines the level of participation. The participation of farmers in scheme management enables water users to learn from each other and ascertain the impacts of their individual and collective actions on resource sustainability (Muchara *et al.*, 2014). It also validates that users have a stake and responsibility on the state of, and sustainability of the resource (Khalkheili and Zamani, 2009). Therefore, understanding the determinants of farmer's participation in the management of SIS and

considering the relationships between various management activities in SIS is important. It is useful in framing policy interventions in irrigation management, as well as informing which management activities can be improved in SIS. The method of irrigation affects water access, availability, which consequently affects the productivity of the farmers (Gomo *et al.*, 2014). Considering schemes with varying irrigation systems and institutional arrangements in the estimation of farmer performance will enable policy recommendations to be made, to improve technical efficiency and to provide an opportunity to enhance performance through improved institutional arrangements, subject to technical agro-production constraints. This will improve farmer productivity and therefore enhance their economic well-being. Water-user performance analysis is particularly important given the increased reliability of production on irrigation water usage and the contribution of smallholder production to rural food security (Makombe *et al.*, 2017).

This is the first study to assess institutional integration in SIS in KZN and to investigate the perceptions of governance in SIS at household level in South Africa. It further adds to the literature by evaluating determinants of farmers' participation in the management of SIS and considering the inter-relationships between management activities in the schemes.

1.3. Problem Statement

Some of the challenges farmers face in SIS are of an institutional nature (Perret, 2002) and require an evaluation of the existing institutions to help understand why schemes in South Africa are underperforming potentially. The Integrated Water Resource Management (IWRM) is a sustainable and balanced approach of water resource management adopted in South Africa, which amalgamates social equity, economic efficiency, and environmental sustainability (GWP, 2000; Pradhan *et al.*, 2014). IWRM emphasises decentralisation through new institutions, procedures, accountability standards and new planning processes. However, the multi-stakeholder and multi-disciplinary characteristics of SIS in the country may inhibit the successful implementation of IWRM due to sector fragmentation, problems with the institutional set-up and coordination, shortcomings in law and policy enforcement, as well as low stakeholder involvement (Varis *et al.*, 2014). The policies, strategies, rules, and regulations that are meant to support smallholder farmers might not be implemented in a way that will make them useful in what they were mandated to do. Thus, resulting in adverse effects on the welfare of scheme beneficiaries.

Literature has shown that farmers' involvement in scheme management contributes to improved scheme performance (Meinzen-Dick *et al.*, 2000; Khalkheili and Zamani, 2009; McKay and Keremane, 2006; Muchara *et al.*, 2014). Given that farmers are actively involved in scheme management, it then becomes imperative that they are aware of the institutional arrangements in irrigation management. Awareness and understanding of institutions, the inclusion of members in decision-making processes, and transparency of governance are needed for improved scheme management (McKay and Keremane, 2006; Hassenforder and Barone, 2019).

Despite the efforts of including farmers in the management of SIS in South Africa, through the Irrigation Management Transfer (IMT) programme and the Participatory Irrigation Management (PIM) reform, farmers' participation in the management of schemes is still weak (Van Averberke, 2012). Farmer's participation enables water users to ascertain the impacts of their individual and collective actions and validates that users have a stake and a responsibility on the state of and sustainability of the resource (Muchara *et al.*, 2014). The lack of farmer participation in the management of SIS has the potential of destabilizing the environment for sustainable water use. Low farmer participation also makes it challenging to direct SIS production from subsistence purposes to those of commercial autonomy (Perret, 2002), and subsequently negatively affects farmer performance. The lack of proper institutional arrangements can also hinder irrigation performance, which can be defined as the productivity and effective utilization of the schemes in relation to the available resources such as water and land (Bos *et al.*, 2005). In general, SISs in the country are underperforming due to a combination of infrastructural and economic factors (Van Averberke *et al.* 2011; Sinyolo *et al.* 2014). However, often overlooked, is the potential effect of institutional arrangements on farmers' performance in SISs. Due to the underperformance of SIS in the country (Dirwai *et al.*, 2019), it is crucial to evaluate the factors that affect the performance of smallholder farmers as well as their understanding of policies, strategies, rules and regulations in SIS in different areas. This could shed light on why the government's efforts and interventions in SIS have not yielded the expected benefits. Given the problems mentioned above, the study objectives are outlined below.

1.4. Objectives

This study was undertaken as part of a project (K5/2556/4) initiated, managed and funded by the Water Research Commission (WRC) entitled, 'Assessment of Policies and Strategies for the Governance of Smallholder Irrigation Farming in KwaZulu-Natal Province, South

Africa.’ The general objective of this study is to contribute to knowledge through evaluating integration in the governance of SIS and how institutions play a role in farmer participation and performance.

The specific objectives of the study are:

- To assess institutional integration in water governance of rural SIS in KwaZulu-Natal. The Social Network Analysis (SNA), was used for addressing this objective.
- To evaluate household-level perceptions of governance in SIS in Kwazulu-Natal. The Ordinary Least Squares regression (OLS) and Principal Components Analysis (PCA) were employed for addressing this objective. To evaluate the determinants of farmers’ participation in the management of SIS in Kwazulu-Natal. The Structural Equation Modelling (SEM) was employed for addressing this objective.
- To evaluate water-user performance in SIS in KwaZulu-Natal. The Stochastic Meta-Frontier Analysis (SMFA) was employed for addressing this objective.

Research Questions

- What is the state of institutional integration in water governance of SIS in KwaZulu-Natal?
- What influences farmer’s perceptions of governance in SIS in KwaZulu-Natal?
- What are the determinants of farmers’ participation in the management of in SIS in KwaZulu-Natal?
- What are the determinants of farmers’ performance in SIS in KwaZulu-Natal?

1.5. Outline of the thesis

This thesis is written in paper format and is composed of seven chapters, including an introduction, literature review, four empirical chapters and a concluding chapter. The same data was used for the third, fourth, and fifth empirical chapters and hence, the description of the study area and data collection methods are presented in the third chapter, to which all the subsequent chapters refer. Chapter 2 presents a review of the literature on the development of, institutions and organizations in, institutional integration, stakeholder analysis, farmer participation, and performance in SIS. Chapter 3 focuses on the evaluation of institutional

integration in the governance of SIS, followed by Chapter 4, which assesses farmer's perceptions of governance in SIS. Chapter 5 focuses on the determinants of farmer's participation in the different constructs of management in SIS. In Chapter 6, the evaluation of the performance of farmers in SIS is presented, followed by the concluding chapter, which presents conclusions and recommendations drawn from the study.

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CHAPTER 2: LITERATURE REVIEW

This chapter presents a review of literature on smallholder irrigation schemes (SIS), institutions, farmer participation and performance. The chapter outlines smallholder agriculture, irrigation farming, and challenges of smallholder farmers in South Africa. It further highlights institutions and organizations involved in SIS governance as methods and the need for stakeholder mapping. The chapter presents concepts of institutional integration, farmer participation and performance in SIS. The review indicates that SIS is multi-disciplinary and multi-faceted, requiring the involvement of various stakeholders. It also shows that farmer participation in SIS can take different forms, and that performance can be measured in multiple ways. The review also presents various socio-economic and agricultural factors that affect farmer participation and performance.

2.1. Background

2.1.1. Overview of Smallholder Agriculture in South Africa

Contributing less than 2.5% to the Gross Domestic Product (GDP) and employing about 10% of the total population (Calzadilla, 2014), the agricultural sector in South Africa uses more than 80% of available land and around 60% of available water (GRAIN SA, 2015). The industry consists of a dualistic production structure comprised of commercial and small-scale agriculture (Mudhara, 2010; Thamaga-Chitja and Morojele, 2014). However, small-scale agriculture is less developed and resourced, with most smallholder and subsistence farmers being prone to food insecurity (Baiphethi and Jacobs, 2009; Thamaga-Chitja and Morojele, 2014).

A significant amount of the world's poor people is based in rural areas (Markelova *et al.*, 2009). About 72% of poverty-stricken South Africans are based in rural areas (Neves and Toit, 2013). Considering that smallholder agriculture is primarily practised in rural areas, efforts to lessen poverty rates should be focussed on smallholder agriculture (Markelova *et al.*, 2009). Smallholder farmers are defined in numerous ways subject to the area and context. However, in South Africa, they generally refer to those farmers owning small-based plots of land on which they grow subsistence crops, mostly relying on family labour in former homelands (DAFF, 2012). Machete *et al.* (2004) and Fanandzo (2012) employment of the term smallholder irrigation sector is used in reference to small-scale farmers, resource-poor

farmers, peasant farmers, food-deficit farmers, household food security farmers, land reform beneficiaries and emerging farmers.

Smallholder farmers face challenges ranging from old-fashioned technologies, low returns to production, high seasonal labour fluctuations, limited market access, inadequate infrastructure, and poor organizational support (DAFF, 2012; Jari and Fraser, 2009; Lahiff and Cousins, 2009). Production usually takes place in communal gardens, individual gardens or on open rangelands with women, mainly farming for household consumption (Lahiff and Cousins, 2009). Factors such as farm size, distribution of resources amongst different crops, resource distribution between food and cash crops, livestock, and off-farm activities, use of external inputs and the fraction of food crops sold are used to characterize different smallholder farmers (DAFF, 2012). One other significant characterization of smallholder farmers is whether they practice irrigated or dry-land farming.

2.1.2. Irrigation farming in South Africa

Climate change, high fluctuations in annual rainfall and frequent incidents of drought makes agricultural crop production in most parts of the country essentially risky. More than 60 per cent of the country obtains, on average, less than 500 mm of rain per annum (Cousins, 2013). As a result, most smallholder farmers practice dry-land farming. About 1.3 million ha of land in South Africa is irrigated; however, smallholder farmers only utilize 0.1 million ha (Van Averbeke, 2011). These smallholder farmers are either irrigation scheme farmers, individual irrigation farmers, communal gardeners, and home gardeners (Van Averbeke, 2008).

Irrigation farming is a costly practice and the largest user of run-off water in South Africa (Reinders, 2011). However, through irrigated agriculture, increased crop productivity and agricultural performance can be ensured, resulting in increased opportunities for poverty alleviation (Namara *et al.*, 2010; Sinyolo *et al.*, 2014). Increased production could subsequently lead to higher incomes, thus reducing the likelihood of food insecurity in rural communities (Tibesigwa and Visser, 2015). Furthermore, evidence suggests that irrigation farming for smallholders can significantly reduce poverty in rural communities (Adam *et al.*, 2016; Sinyolo *et al.*, 2014).

While several irrigation methods exist, they vary according to their components, cost, and performance and generally they can be classified into three groups. These are 'flood-irrigation systems, mobile irrigation systems which are self-propelled, and static systems which remain stationary while water is applied (Reinders, 2011; McCarthy *et al.*, 2015).

These systems are expensive to purchase and maintain, therefore the development of irrigation schemes has given smallholders an opportunity to water access.

2.2. Challenges of smallholder irrigation schemes

South African SIS underperformance is attributed to various physical, social, and economic factors (Machethe *et al.* 2004; Van Averberke, 2011; Muchara, 2014). Lack of human capital, general lack of technical skills, limited extension support, in-field water-use inefficiency, and poor infrastructure are some of the problems that are predominant in SIS (Van Averberke, 2011; Muchara, 2014; Agide *et al.*, 2016). Additionally, the poor performance of schemes is influenced by several other issues including, operational rules, property rights systems, accountability issues and informal and formal arrangements (Muchara, 2014). These issues form part of the governance and the institutional arrangements within the scheme, both of which are key in the success and sustainability of SIS

Governance is about making decisions and includes the capacity to implement them (Muller, 2012; Muchara, 2014). It requires transparency, accountability, as well as participation from the involved stakeholders (Muchara, 2014). Institutions are defined in several ways in different schools of thought. In water resource management, institutions are ground rules for resource use, and can either be formal and informal. The former includes policies, rules, regulations, organizations, plans, procedures, while the latter represents norms, traditions, practices, and customs (Bandaragoda, 2000; Muller, 2012; Muchara, 2014).

Although water is a natural good, water resources such as irrigation schemes cannot be characterised as such because they are rivalrous (consumption by one water user can reduce the amount available for the next user) and are excludable (Muller, 2012). As such, they can be identified as a Common Pool Resource (CPR) since they serve groups of farmers that depend on a shared distribution system to access irrigation water. The success of a CPR can be hindered by what Hardin (1968) identified as the “tragedy of the commons”, whereby individuals overuse and exhaust a common pool resource even though it may not be in their best interest to do so. This could result from a lack of individual ownership of a resource and the inability to restrict the resource usage by the individuals accessing it, a characteristic of weak institutional arrangements. Although the notion of the “tragedy of the commons” was widely accepted, Van Vugt (2009) argued that users are not always solely driven by utility maximization or self-interest, but also take account of the broader implications of their actions for other users and the environment.

Ostrom (1990) also suggests that a CPR can be successfully governed to avoid over-exploitation when the following exist. Clearly defined boundaries; congruence between appropriation and provision rules and local conditions; collective choice arrangement; monitoring, graduated sanctions; conflict-resolution mechanisms; minimal recognition of rights to organize and nested enterprises.

- ***Clearly defined boundaries:*** Such clear boundaries ensure that positive and negative externalities are internalized. In that way, the users are responsible, bear the penalties of negative externalities, and enjoy the benefits of positive externalities (Ostrom, 1999).
- ***Congruence between appropriation and provision rules and local conditions:*** Local rules are often set according to the time, place, resource units available, and are location specific. National rules and regulations that are established hardly consider the different characteristics in each user community, which could hinder the goal of preventing over-exploitation. The rules set at the national level should align, to some extent, to local norms, practices, and strategies (Ostrom, 1999).
- ***Collective choice arrangements:*** This involves users who benefit from the CPR participating in modifying the rules affecting it. Ostrom (1999) noted that CPR adhering to this principle, together with the first two, are at a better position of tailoring rules according to their circumstances and environments, which could ultimately lead to better management of the resource.
- ***Monitoring:*** Rules can be successfully enforced, provided there is adequate monitoring that takes place within the system. For this principle, monitors are accountable to the users or may be the users themselves (Ostrom, 1990).
- ***Graduated Sanctions:*** Ostrom (1999) suggests that if users disobey operational rules, they should be punished with graduated sanctions.

She also notes that if the first five principles are adhered to, then that will constitute a successful case. If beneficiaries of CPR are included in setting operational rules (Design Principle 3), to be enforced and monitored (Design Principle 4), “using graduated sanctions (Design Principle 5), that define who has rights to withdraw from the CPR (Design Principle 1), and that effectively restrict appropriation activities given local conditions (Design Principle 2), then the commitment and monitoring problems are solved” (Ostrom, 1999: 3).

- ***Conflict-Resolution Mechanisms:*** CPR users as well as officials, should have access to low-cost mechanisms of resolving conflicts. If a group of people are to share a resource over a while, it is necessary that disputes are addressed and resolved. Ensuring low-cost conflict resolution mechanism is vital for rule enforcement (Ostrom, 1999).
- ***Minimal recognition of rights to organize:*** Governmental authorities should recognize rules and regulations formed at the local level. If authorities do not acknowledge the locally formed rules, it may be challenging for users to sustain a rule-led CPR in the long-run (Ostrom, 1999).
- ***Nested Enterprises:*** Rules are organized and enforced through multiple layers of nested enterprises. This is a system whereby there would be organizations that exist within an even larger organization. Thus, there can be different rules in various layers of organization. (Ostrom, 1999).

Clarity of system boundaries affects the performance of SIS through the limited capacity for farmers to manage water efficiently. Muchara (2014) reported that there were no proper systems to record actual land under irrigation and the quantity available in the Mooi River irrigation scheme, KwaZulu-Natal Province. Sinyolo *et al.* (2014) found that in the Tugela Ferry irrigation scheme, farmers compete for water, and some farmers could not access water at times. The uncertainty of water access consequently affects household crop production. Despite the adoption of the eight design principles, Ostrom (1999) also indicates that CPRs could still fail. Such failure could be due to corruption and opportunistic behaviour, dependency on external stakeholders, and officials not considering the indigenous knowledge and institutions.

The continued underperformance and challenges faced by SIS has led to the government establishing institutions to improve the performance of South African irrigation schemes (DAFF, 2012; Fanadzo, 2012). The next section reviews the literature on the acts, policies, strategies, and programmes that govern SIS in South Africa.

2.3 Policies, strategies, rules, and regulations of smallholder irrigation schemes in South Africa

In November 2010, the South African government released a document titled “The New Growth Path”, where it outlined its plans to create about 300 000 new jobs by 2020 through establishing smallholder farmer schemes (Department of Economic Development, 2010).

Similarly, Machethe *et al.* (2004), suggest that before the release of the New Growth Path, the South African government had made a substantial investment in smallholder farming/irrigation as a means of benefiting smallholder farmers in rural areas. About R2 billion has been invested in establishing, revitalising and rehabilitating SIS (Fanadzo and Ncube, 2018).

A government dossier that addresses the preceding issue is the Strategic Plan for South African Agriculture released in November 2001. This dossier emphasizes the need to pay attention to small-scale agriculture, to promote efficiency and make the sector more competitive in the international market. It also seeks to provide production support and to encourage an increase in the number of new small-scale and medium-scale farmers (DAFF, 2012).

Water must be managed appropriately for sustainable development to prevail (Teutsch and Kru"ger, 2010; Kalbus *et al.*, 2012). In 1912, the South African Government promulgated its first Irrigation and Water Conservation Act. This act aimed to promote the development of irrigation. The act was characterised by large-scale, uncoordinated private irrigation development (Mudau, 2010). As a result, this resulted in the constructions of large schemes such as Great Fish, Clan William, Graaff-Reinet, Lower Sundays River, and Hartebeespoort. In 1913, a Homeland Act was introduced and inter alia, its principal effect was that portions of land be given to black South Africans for use, however, were restricted to relatively small parts of the country. A combined total of these lands covered about 13% of the total land area in 1994 (Vink & Kirsten, 2003).

Post-apartheid, the different provincial governments decided to "dismantle the agricultural homeland parastatals and transfer the management of smallholder irrigation schemes to the farmer communities who benefitted from them" (Averbeke, 2012:419). This process was referred to as the Irrigation Management Transfer (IMT). One of the best water legislations, the National Water Act, Act 36 of 1998, was mandated to offer vital reform of the law pertaining to water resources (Schreiner, 2013). The purpose of the Act is to ensure that South Africa's water resources are protected, used, developed, conserved, managed, and controlled (Schreiner, 2013). Some key factors underlying the National Water Act are to meet basic human water needs, encourage fair access to water, to redress the consequences of past racial and gender segregation, and to establish suitable institutions. Emanating from the National Water Act is the National Water Resource Strategy (NWRS). The first edition of the

strategy, mandated in 2004, describes how water resources will be used and protected according to the requirements of existing policies and laws (DWAF, 2004). In 2006, the second edition of the NWRS was released, NWRS2. The NWRS2 addresses the objective set out in the first edition of the strategy, being the promotion of equity, job creation, growth, and development. However, the main aim of the NWRS is to ensure that water is used to support fair and sustainable social and economic transformation and development (DWA, 2006).

The Irrigation Strategy emanated from the NWRS2 and is vital in formulating programmes for SIS. The core focus points of the strategy include institutional arrangements, irrigation research, revitalization, and increased management and efficiency of water use. The purposes of the strategy are to increase the contribution of irrigated agriculture to GDP, create employment opportunities and to increase equity of access to previously disadvantaged groups to irrigation water. It aims to contribute to food security at the household and community level (DAFF, 2015). The strategy also seeks to target the technical aspects of irrigation, through revising and refining revitalization of SIS, scaling up scheme-based effort to expand irrigation regions, increase fund allocated to training farmers as well as to increase investment in research (DWA, 2015).

2.4. Water management organizations in South Africa

The South African smallholder irrigation sector is characterized by polycentric governance. It is multidisciplinary and links numerous sectors. As such, there are various stakeholders involved. The SIS sector, particularly agricultural water use, are relevant to the health and welfare of smallholder producers and consumers through nutrition, which is part of the core focusses of the Health and Social Development departments. It requires that producers in irrigation schemes have secure land tenure, therefore touching on the mandate of the Department of Land Affairs and Reform. There is a need for water use and revitalization of irrigation schemes, the directives of the Department of Water and Sanitation (DWAS), and the Department of Public Works, which is responsible for the construction of infrastructure. It requires agricultural production and significantly impacts the environment, which are the mandates of the Department of Agriculture, Fisheries and Forestry (DAFF) and the Departments of Environmental Affairs (DEA), respectively. It also requires the support of local key players, such as district councils, municipalities, and traditional authorities (DAFF, 2011).

All the involved departments have the responsibility of upholding the Batho Pele Initiative, which was introduced in October 1997, to stand for the better delivery of goods and services to the public. The initiative necessitates transparency, politeness, and the openness of public servants. The following stakeholders are essential in the service delivery in South African SIS:

i) *i) Water Management Agencies*

The NWRS provides a framework, driving how water resources are to be managed in Water Management Agencies (WMA). In October 1999 nineteen WMA's were established (Karodia and Weston, 2001). Since then, viability assessments on the management of these WMA's have been done concerning various factors. These include water resources management, available funding, capacity, skills, and expertise. After the assessment, it was proposed that the 19 WMA's be merged into nine (DWA, 2006). The advantages of consolidating the WMA's into fewer ones are that it would lead to the improved management of integrated systems. It would be easier to distribute technical skills over fewer institutions.

ii) Catchment Management Agencies

Within WMA's, Catchment Management Agencies (CMA) are established throughout the country, as outlined by the Natural Water Resource Strategy. Upon establishment, these agencies are to co-ordinate water-related activities and water management institutions. The agencies are also to develop and implement Catchment Management Strategies (CMS) and encourage local community participation (Karodia and Weston, 2001). The CMA's in the different WMA's collaborate national, provincial, and local governments and other water management institutions and associations. Key players in the management of water resources are the Water User Associations (WUA) (Kemerink *et al.*, 2013).

iii) Water User Associations

Water User Association (WUA) are cooperative associations that embark on water-related activities for the benefit of individual farmers and water users and generate income through water use charges (Backeberg, 2006). As stipulated by the NWA, former irrigation boards were transformed into water user associations to incorporate farmers that did not previously qualify to access water resources due to no formal water entitlement (Faysse, 2004). WUA's have enabled previously disadvantaged farmers to partake in the management of water

resources and are responsible for the management of irrigation schemes (Perret and Geysler, 2007).

iv) Department of Agriculture, Fisheries and Forestry

The Department of Agriculture, Fisheries and Forestry (DAFF) is a crucial role player in SIS. The department is responsible for guiding irrigated agriculture, and for coordinating effective communication in the irrigation sector through formulating institutional arrangements. The department is responsible for developing guidelines for the revitalization of schemes, and for creating an environment in which other stakeholders in the public and private sector can participate. Through consulting with research institutions such as the ARC and WRC, they can fund research projects related to irrigation in South Africa and is also responsible for reviewing the Irrigation Strategy every ten years (DAFF, 2015).

v) Department of Water and Sanitation

The Department of Water and Sanitation (DWS) is responsible for the development of irrigation schemes. They are responsible for establishing the Coordinating Committees on Agriculture Water (CCAW) and for allocating funds for irrigation initiatives. The department also plays a role in providing extension support to irrigation farmers on issues relating to the management and scheduling of irrigation and drainage systems. It deals with infrastructure management and works hand in hand with DAFF on matters involving water pricing, legal action concerning unlawful water users and the authorization/ licensing of water use. DWAS implements the Water-Based Rural Livelihoods and Food Security Implementation Framework (*ibid*, 2015). Overall, the DWAS responsible for planning, policy formulation, legislation, national strategy formulation, institutional development, coordination, monitoring and auditing water resource systems (Machete *et al.*, 2004).

vi) The Department of Rural Development and Land Reform, Department of Environmental Affairs

The Department of Rural Development and Land Reform (DRDLR) is responsible for land reform, land allocation and development, and supports the revitalization of SIS. The Department of Environmental Affairs (DEA) plays a role in the environmental regulation of SIS and the implementation of laws. The department ensures that the National

Environmental Management Act (NEMA) and its regulations are adhered to in irrigation schemes (DAFF, 2015).

vii) Other institutions

Other state-owned institutions which play a role in SIS are the Agricultural Research Council (ARC) and the Water Research Commission (WRC). The ARC provides agricultural research information. Water Research Commission funds water-related research projects. The Private sector consists of financial institutions, Non-governmental Organizations (NGO), and academic institutions that participate in the development and training of smallholder farmers (*ibid*, 2015). Local traditional authorities also play a role as they usually lease out the land and have a say in the administration and allocation of plots. In most irrigation schemes, irrigation committees are selected and are responsible for allocating water to individual plots. They also overlook issues such as sprinkler scheduling and agricultural activities in the schemes (Machete *et al.*, 2004). Given all the organizations involved in water management and the existing policies, acts and strategies, there must be an alignment of policies, coordination of processes and cooperation of stakeholders, to ensure the success of a system (DAFF, 2011). The following section reviews the literature on institutional coordination and integration in water resource management.

2.5. Institutional integration in water resource management

The Integrated Water Resource Management (IWRM) is a sustainable and balanced approach of water resource management which has been adopted by South Africa. It amalgamates social equity, economic efficiency, as well as environmental sustainability. It is deemed an important tool that recognizes linkages in disciplines (Pradhanet *et al.*, 2014). However, various problems have hindered the adoption of IWRM. Varis *et al.*, (2014) noted that in many workshops all over the world, the key failure elements of water governance include, strong sector fragmentation, problems with the institutional set-up and coordination, shortcomings in law and policy enforcement as well as a shortage of stakeholder involvement and participation.

For IWRM to be successful and to obtain sustainable development, addressing institutional challenges and encouraging coordination between stakeholders are needed (Viesmann, 2011; Rahmawati *et al.*, 2014). The WWF (2005) defined a stakeholder as “any individual, group,

or institution who has a vested interest in a project area and/or who potentially will be affected by project activities and have something to gain or lose if conditions change or stay the same". Due to the different roles played by various stakeholders in water resource governance, the management of water resources tends to become complicated. It is, therefore, vital to identify and understand the roles of the stakeholders within a system. This includes their interests, potential conflicts, and appropriate strategies to lessen failures (WWF, 2005).

2.6. Stakeholder mapping/analysis

The identification of stakeholders and their objectives helps in evaluating coordination, collaboration as well as integration; thus, it is crucial to construct a stakeholder map. Stakeholder mapping or analysis defines social and natural dimensions affected by a decision and an action. It includes identifying persons, parties, and organizations that are affected by decisions and actions. It categorizes the different groups according to their involvement in the decision making and action implementation process (Reed, 2009). Stakeholder analysis generates information on actors, to evaluate and understand their objectives, interests, and influence on the decision- making process (*ibid*, 2009). It is about identifying the actors, their connections, and their interests in the network (Newcombe, 2003).

Stakeholder mapping is important in facilitating the transparent implementation of activities, and to also assess the feasibility of future policy options (Reed, 2009). It can help improve communication within the networks, manage coordination problems as well as strengthen alliances (Warner, 2006). Stakeholder analysis enhances transparency and equity and decision making and can also be done in several ways. Taking inventory of all parties that could have a role in making decisions, prioritizing their roles and dynamics is key in the mapping (Reed *et al.*, 2009).

The 4Rs tool has been commonly used to analyse how parties relate to each other, as well over resources, by characterizing them according to their rights, responsibilities, revenues/benefits (Salam and Noguchi, 2006; Reed *et al.*, 2009). The tool is used to identify stakeholders, differentiate between, and categorise stakeholders, as well as investigating relationships between stakeholders (Reed *et al.*, 2009).

i) Identifying stakeholders:

Stakeholders can be identified using expert opinion, focus group discussions, semi-structured interviews, or a combination of the aforementioned. Adding additional stakeholders as the

evaluation continues is possible as the analysis continues, however, there is a risk that some parties may be omitted (Salam and Noguchi, 2006; Reed *et al.*, 2009).

ii) Categorizing stakeholders:

Categorizing stakeholders can either be done through analytical categorization, where the researcher carries out the analyses by observing, and is also led by some theoretical viewpoint on how the system works. It can also be done in a reconstructive way, in which the categorization is done by the stakeholders, to get a pure reflection of their roles (Hare and Pahl-Wostl, 2002).

iii) Analyze stakeholder relationships:

There are three commonly used principal methods of analysing stakeholder relationships in natural resource systems, namely, social-network analysis, actor-linkage matrices and knowledge mapping analyses (Wasserman and Faust, 1994; Cole 1998; Reed *et al.*, 2009).

➤ Social Network Analysis

Social Network Analysis (SNA) enables the researcher to gain insights on communication and influence between stakeholders. It is conducted using matrices to put data according to relational ties between parties. This allows a researcher to determine whether there are positive or negative relations between stakeholders and how strong the links are. Data used can be collected through interviews, observations, and questionnaires (Reed *et al.*, 2009)

➤ Actor-linkage matrices

Like SNA, Actor-linkage matrices make use of keywords rather than numbers. Actor-linkage matrices help in determining if conflicts and cooperation exist between stakeholders. Using rows and columns, social grids are constructed and interrelations between them are classified using keywords (Wasserman and Faust, 1994; Reed *et al.*, 2009).

➤ Knowledge mapping

Knowledge mapping involves specifying roles as well as responsibilities and the knowledge expressed by stakeholders. It is vital in developing improved innovation and competitive advantage (Cole, 1998).

All three methods help in evaluating cooperation and coordination once the stakeholders and their roles and ties have been established.

Evaluating integration within the management or governance of water resource is important for sustaining stakeholder engagement and helps identify gaps within the system, as well as any need for policy intervention (Smith *et al.*, 2015). Improved coordination, as well as collaboration of institutions enhances the efficiency of the system (Vietmann, 2011) and evidence shows that effective water resource governance systems are those that have cross-level coordination (Gupta and Pahl-wostl, 2013). It has also been noted that integration across sectors and administrative levels are necessary for IWRM (Pahl-Wostl, 2009)

2.7. Integration dimensions within water resource governance

Given the importance of integration in water resource management and considering that the institutional arrangements in the water sector are multifaceted, integration is often hard to achieve. This is due to fragmented institutional structures, poor relationships between stakeholders and poor coordination, which results in a lack of clarity about roles and responsibilities (Carlson and Stelfox, 2009).

Effective integration necessitates collaboration in governance that is intended to cope with “scale dependencies and interactions, uncertainty and contested knowledge, and interdependency among diverse and unequal interests” (Fish *et al.*, 2010; 5623). In natural resource governance, often there several stakeholders that explicitly or implicitly share policy and action making authority. They collectively share responsibility, development, and implementation across different sectors (horizontally), between different levels of government, from national to local (vertically), between the public and private sector, as well as across various parties across sectors, at the sub-national level (Ostrom *et al.*, 2010; Charbit, 2011).

The coordination among public stakeholders at different levels of government and across sectors enhances efficiency, equity, and sustainability of natural resource governance. It can further be classified in sectoral, territorial, and organizational dimensions (Charbit, 2011). Sectoral integration is the ‘joining up’ or combining of different public policy domains and their associated stakeholders in a territorial area (Kidd and Shaw, 2007). For example, there is sectoral integration when policies in the agricultural sector are aligned in one way or the other with policies in the water and sanitation sector, resulting in cross-conformity. Territorial

integration is “the integration of public policy domains between territories” (*ibid*, 2007:317) and incorporates vertical and horizontal integration.

Horizontal integration refers to the facilitation of cooperation among government entities at the same level (Kidd and Shaw, 2007; Herrfahrtdt-Pähle, 2013). Vertical integration is policy coherence across the different levels within a system (Kidd and Shaw, 2007). The last type of integration in a human system is organizational integration. Organizational integration distinguishes between strategic and operational integration. The former is linked with the alliance of strategies, programmes, and initiatives, while the latter is the alignment of delivery mechanisms (*ibid*, 2007). An integrated system ensures an institutional environment that is conducive for participation by all stakeholders, particularly farmers (Muchara *et al.*, 2014).

2.8. Farmer participation in smallholder irrigation schemes

In recent decades, it has been widely accepted that public participation, that is, the involvement of individual and organised public members in the decision-making processes, brings about an opportunity to improve natural resource management by incorporating the knowledge, values and perspectives of the public (Özerol, 2012; Muchara *et al.*, 2014).

Participation is a process in which stakeholders influence policy formulation and management decisions affecting their communities, and they establish a certain sense of ownership (Guy, 1994; Khalkheili, 2008). Farmers are the significant users of irrigation systems (Özerol, 2013); therefore, the collective action of farmers is required to ensure the sustainability of irrigation systems (Muchara *et al.*, 2014; Özerol, 2013). Through participation, farmers can establish institutions for sustainable water management; it is for this reason that Participatory Irrigation Management (PIM) has been adopted in South Africa.

PIM is a philosophy that is centred on involving farmer or water users in the operation, management, and maintenance of irrigation systems in tertiary and secondary levels (Kulkarni and Tyagi, 2012). This translates to the farmer being a “water manager” (Gomo *et al.*, 2014). The benefits of a farmer participating in the management of an irrigation system, are that it builds a sense of ownership, fosters collective action, and improves rule compliance (Ostrom 1990; Özerol, 2012). Participation validates that users have a stake and a responsibility in the state and sustainability of the resource and increases the likelihood of users adhering to the rules. Farmer participation improves compliance in that users can “keep an eye” on their actions as well as other users, and that collective commitments, such as

attending meetings, are practised by everyone. (Ostrom, 1990; Özerol, 2012; Muchara *et al.*, 2014).

Farmer participation in SIS is not uniform as some water-users opt for participating in some respects in the scheme over others (Muchara *et al.*, 2014). Farmers can choose to participate in the operations and management of the schemes, and Gyawali (2009) found that this could be improved by the inclusion of farmers in the decision-making process of the operation and maintenance activities. Farmers may also choose to participate in the collective maintenance of infrastructure by providing labour to clean up the canals and fix dilapidated infrastructure (Sharaungua and Mudhara, 2018). Muchara *et al.* (2014) note that farmers participate financially through contributing finance towards infrastructure repairs and towards the running of the WUA. They also participate in information dissemination activities and regulation and control through reporting unlawful use of water, reporting the theft of irrigation infrastructure, and reporting damages and water leakages within the major irrigation infrastructure.

Literature shows that a combination of institutional, social, and physical factors affects farmer participation (Damianos and Giannakopoulos, 2002; Meinzen-Dick *et al.*, 2002; Karli *et al.*, 2006; Khalkheili, 2008; Muchara *et al.*, 2014). Studies have shown that factors such as co-operative membership, stakeholder engagement (Meinzen-Dick *et al.*, 2002; Khalkheili, 2008). Agricultural training of the farmers, the farm's economic size, participation by neighbours or relatives, age, and basic education have been found to influence farmer participation in SIS (Damianos and Giannakopoulos, 2002). Significant factors also include farm labour, family size and income, which all have a positive influence on farmer participation in irrigation management.

Adenkule *et al.*, (2015) found that factors such as inadequate response to farmers' need by officials, lack of irrigation training, lack of water availability, equitability, and adequacy affect the motivating factor for farmers to participate in irrigation farming. Oriola (2006) found that unreliable supply and distribution of irrigation water results in farmers being unwilling to participate in SIS.

Due to the nature of farmer participation in SIS, different methods have been used to evaluate farmer participation. Using a Spearman correlation test, the relationship between farmer participation in irrigation management and selected variables in the Doroodzan Dam Irrigation Network, Iran, was investigated. Muchara *et al.* (2014) used a Tobit regression model

to evaluate the factors affecting farmer participation in irrigation water management in the Mooi River Irrigation Scheme, South Africa. In some cases, binary choice models such as the Probit model are adopted to analyse the determinants of participation (Fischer and Qaim, 2012; Adekunle *et al.*, 2015), this is done when participation is considered a choice and step-wise decision, where farmers participate or not. Adekunle *et al.* (2015), adopted a two-stage sampling procedure then used the logistic regression model to identify factors that affect participation in the Lower Niger River Basin Development Authority in Nigeria. Participation, especially in the irrigation scheme management is essential as it also influences scheme and farmer performance (Khalkheili, 2008; Özerol, 2012; Muchara *et al.*, 2014).

2.9. Farmer performance in smallholder irrigation schemes

Institutions affect the different entities involved in a system. They have the potential to affect the costs of exchange and production, as well as the behaviour of decision-making entities. In comparing any sets of institutions, the likelihood of better performance is higher, where transaction costs are less; a result of favourable institutional arrangements (Bandaragoda, 2001). Irrigators face challenges such as lack of market access, high transaction costs, low capital endowments, and water-supply related issues (Van Averberke, 2011; Sinyolo, 2014). In addition to these challenges, institutional arrangements and water management also influence irrigators' performance, mainly agricultural and economic performance (Lecina, 2011).

Farmer performance can be analysed and measured in different ways according to the context at hand, including but not limited to accounting, economic, agricultural, and environmental (performance) indicators have been used (Speelman *et al.*, 2008; Tchale, 2009; Verhofstadt and Maertens, 2014). The most common is efficiency analysis. Efficiency can be estimated by comparing the observed output to the potential maximum optimum output, given the total inputs used (Schmidt, 2008; Speelman *et al.*, 2008). Efficiency can also be based on different measures, namely, technical, economical, and allocative. Technical efficiency is attained when a farm can produce the maximum feasible output from a given bundle of inputs, or by using the minimum feasible amounts of inputs to produce a certain level of outputs, using certain technology (Ojo, 2006; Speelman *et al.*, 2008). Therefore it can either be “output” or “input” oriented.

Economic efficiency considers the optimal use of inputs to produce a certain level of output, given the price of the outputs (Tchale, 2009). Allocative efficiency considers the ability of a

farmer to choose optimum input levels given their respective factor prices (Ojo, 2006). Therefore, economic efficiency considers both technical and allocative efficiency and considers input and output combinations on the production function and the expansion path (Seitz, 1970; Ali and Byerlee, 1991; Ojo, 2006). Farm performance can also be evaluated using non-economic indicators such as environmental performance and social performance. Examples of these could be less use of inorganic pesticides and better labour compensation, respectively (Kimura and Le Thi, 2013).

Several social, physical, and economic factors that affect farmer performance have been highlighted in the literature. Land size could either positively or negatively affect farm performance (Manjunatha *et al.*, 2013; Dlamini and Masuku, 2013; Rajendran *et al.*, 2015). Social factors such as farmer groups, cooperatives, market access, distance to the market and access to extension services have been highlighted as factors that can improve farm performance (Mumba *et al.*, 2012; Debebe *et al.*, 2015; Herbert, 2015). Land ownership has also been found to positively affect farm performance (Manjunatha *et al.*, 2013; Ebarle *et al.*, 2015). Economic factors that positively affect farm performance include low production cost, high agricultural yields and high prices and low marketing costs (Dlamini and Masuku, 2013; Ebarle *et al.*, 2015; Mushi and Ngaruko, 2015).

Due to different characteristics across farms, such as commodities produced, farm size and scope, various indicators have been adopted to evaluate performance. Titonell *et al.* (2007) used grain yield, labour productivity, gross margins, and economic returns to labour to measure efficiency in smallholder Kenyan farms. Reidsma *et al.* (2007) used to farm net value added per hectare (fnv/ha) and farm-value-added per annual work unit (fnv/ awu) to represent farmers' income. To measure the economic performance of farmers, they evaluated the relationship between revenues and crop yields. They chose the income calculation methods because fnv/ha would indicate economic performance relative to land. In contrast, fnv/awu can link farmers income to GDP per capita, thus relating farm performance to the general socio-economic performance of the region. Gross farm revenues, as well as non-marketable crops at existing prices, have also been used to measure agricultural performance of farms (Verhofstadt and Maertens, 2014).

A simple way of measuring efficiency is considering the output and input ratio, which is expressed as the gross agricultural output and farm cash expense. This yields a value of how much a farmer receives for his produce, given the amount of cash they have spent on inputs.

Thus, subsidies and grants are not included in the estimation (Kimura and Le Thi, 2013). Using the net operating income per full-time equivalent labour, net operating income per hectare of land, and the net operating income obtained from subtracting farm cash expenses from the gross agricultural output, operating income per net worth can be estimated. The three indicators are based on income relative to three factors of production, land, labour and own capital (*ibid*, 2013).

It is common practice that farm efficiency or performance is measured using Data Envelopment Analysis (DEA) or the Stochastic Frontier Analysis (SFA). The latter is a parametric approach used when several independent variables can be estimated (Buckley and Carney, 2013). The DEA is a non-parametric approach which enables the evaluation of relative efficiencies of a set of comparable outcomes and does not require that the explanatory variables be estimated (Tajbakhsh and Hassini, 2015).

2.10. Study analytical methods

The four objectives in the study were analyzed using a mix of qualitative and quantitative methods. In order to evaluate institutional integration in the governance of SIS, the Multidisciplinary Transition Framework (MTF) was adopted and adapted for the study. MTF is an interdisciplinary conceptual and methodological framework used to evaluate water systems, management processes and multi-level governance regimes (Pahl-Worstl *et al.*, 2014). Knieper *et al.* (2010) used it as a tool for the structural and comparative analysis of water resource management. The framework provides a comprehensive analysis of resource management, and as such was adopted to evaluate integration in the multifaceted and multi-stakeholder structure which exist in smallholder irrigation governance. Furthermore, Social Network Analysis (SNA) was employed to identify challenges in SIS from the perspective of primary water users and government officials. SNA provides a pattern of ties that exist between different entities, objects, or concepts (Wambeke *et al.*, 2011). Through these ties, it is possible to denote which core challenges exist and which challenges are linked to others.

Principal Components Analysis (PCA) was used to evaluate farmer's perceptions of governance within the schemes, including the satisfaction with formal and informal institutions and stakeholder engagement. PCA is a multivariate data analysis method used to reduce the dimensionality through the creation of new uncorrelated variables called Principle Components (PCs) (Jolliffe, 2002). Muchara *et al* (2014) used PCA to generate participation indexes or farmer's participation in water related activities. Chipfupa and Wale (2018) used

PCA to reduce the dimensionality of the variables measuring psychological capital. As such PCA was used to generate participation, governance and psychological capital indexes.

Structural Equation Modelling (SEM) models the determinants of farmer participation. SEM is a commonly used analytical tool in analyzing cause-effect relationships in behavioural studies (Toma and Mathijs, 2007). It determines a structure and relationships between both latent and observed variables. It is usually composed of two parts, namely the Structural and Measurement model (Menozzi *et al.*, 2015). Johnson *et al.* (2020) examined the nature and performance of participatory water institutions in eastern India using SEM. The use of SEM in this study was motivated by the need to evaluate the level of participation in management, made up of unobserved latent variables, using observed management activity questionnaire items. Additionally, it enables the evaluation of the relationship between the PCA generated Participation in Management Indexes (PMI) and observed socio-economic and institutional variables.

The Stochastic Meta-frontier Analysis (SMFA) can be used for evaluating water-use efficiency. Given differences in institutional arrangements and production systems, the technical efficiency of water-users is not comparable using a comprehensive production frontier (Huang *et al.* 2014; Melo-Becerra and Orozco 2017). Furthermore, the choice of production and input combinations may be affected by factors such as climatic conditions, institutional arrangements, land tenure and water availability, that are beyond the individual's control. Bravo-Ureta *et al.* (2020) used SMFA to model technical efficiency of dairy farmers operating on different irrigation infrastructure, and Akem *et al.* (2019) modeled farmer performance of farmers in different regions. Given the stochastic nature of agricultural production, and the differences in the SIS included in the study, SMFA has the necessary statistical properties to model farmer performance, taking into account the differences across the SIS in the analysis.

2.11. Summary

The review shows despite efforts to develop SIS; many still face problems. The challenges that smallholder farmers in irrigation schemes hinge on the institutions that govern them, nationally and locally. Governance in SIS is multi-faceted and include several stakeholders who all have a vested interest and objectives, and this has the potential to prevent the attainment of institutional integration. Furthermore, institutional ad social and physical factors affect farmer participation in SIS, and that farmers generally participate in one or

more ways in the schemes. The review also shows that farmer performance can be assessed in several ways, and that institutions and socioeconomic factors affect performance. The literature focuses less on the institutional integration at scheme level, farmers perceptions of governance, farmers participation, particularly in the management of the schemes, and the potential influence of institutions on farmer performance at scheme level, hence the analysis in the following four chapters. The following chapters present the empirical sections in the form of complete research manuscripts.

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CHAPTER 3: AN ASSESSMENT OF INSTITUTIONAL INTEGRATION IN WATER GOVERNANCE OF RURAL SMALLHOLDER IRRIGATION SCHEMES: EVIDENCE FROM KWAZULU-NATAL PROVINCE, SOUTH AFRICA

Abstract

Smallholder Irrigation Schemes (SIS) in South Africa continue to perform below expected levels despite governments' efforts to revitalize them. The beneficiaries of SIS are usually low-income farmers faced with various production constraints, whose success rests on the institutional environment within the schemes. The South African government adopted the Integrated Water Resource Management Framework, which amalgamates social equity, economic efficiency as well as environmental sustainability. Various stakeholders are involved in irrigation policy-making and collectively share the responsibility of implementing programmes. However, sector fragmentation, lack of coordination and shortcomings in policy enforcement contribute to the ineffectiveness of water policies with subsequent adverse effects on the welfare of scheme beneficiaries. This study evaluates institutional integration, mainly horizontal and vertical integration of water governance in rural SIS. The research focusses on four SIS in the KwaZulu-Natal Province of South Africa. The schemes have contrasting features such as institutional arrangements, farmer composition and production challenges. Stakeholder interactions in the schemes were assessed through Exploratory Social Network Analysis to identify, categorise, and investigate stakeholder challenges. The study utilized the social facets of the Management Transition Framework, an interdisciplinary framework for assessing water systems, management processes and multi-level governance regimes. The focus was placed on the regulatory elements in the water system, including both formal and informal institutions. The study found that information asymmetries hindered horizontal integration, while the fiscal and capacity challenges, low accountability and transparency amongst stakeholders lead to the lack of vertical integration. The study recommends that stakeholders need to understand the existing institutions and the roles of their counterparts to establish synergies and to improve coordination in the systems, to ensure effective governance. Additionally, transparency and accountability should be improved to attain vertical integration in the system. Furthermore, government official should strive to uphold the Batho-Pele principles.

Keywords: Vertical integration, Horizontal integration; Batho-Pele Principles; Management Transition Framework; Social Network Analysis; Water governance.

3.1. Introduction

The South African smallholder irrigation (SIS) sector is characterized by polycentric governance which involves various stakeholders. The sector requires that producers in irrigation schemes have secure land tenure, a mandate of the Department of Rural Development and Land Reform (DRDLR)¹. There is a need for water use and revitalization of irrigation schemes, an issue in the mandates of the Department of Water and Sanitation (DWAS) as well as those of the Department of Public Works, which is responsible for the construction of infrastructure. Farmers utilize schemes for agricultural production agricultural producers which is the mandate of the Department of Agriculture, Fisheries and Forestry. The schemes also require the support of local key players, such as district councils, municipalities, and traditional authorities (DAFF, 2011).

In South Africa, all the involved governmental departments have the responsibility of upholding the Batho Pele Principles, which were introduced in October 1997. Batho Pele translated from the Sesotho language, means “People First”. The principles advocated for the better delivery of goods and services to the public and were envisioned to promote efficiency and effectiveness in service provision by all sectors of government. Based on the South African constitution, they sought to ensure that public service delivery is accountable transparent and development-oriented (Nzimakwe and Mpehle, 2012). However, there is currently a lack of mechanisms to monitor the failure of upholding the principles when it comes to service delivery (Constable *et al.*, 2007).

Key players in SIS governance are the Catchment Management Agencies (CMA), Water User Associations (WUA), Department of Agriculture, Fisheries and Forestry (DAFF), Department of Water and Sanitation (DWS), The Department of Rural Development and Land Reform (DRDLR), Department of Environmental Affairs (DEA), Agricultural Research Council (ARC) and the Water Research Commission (WRC). The ARC provides agricultural research information while the WRC funds water-related research projects. The private sector is made up of financial institutions, non-governmental organizations (NGO’s) and local traditional authorities. Given the multiplicity of organizations, policies, acts and strategies involved in water management, it is crucial that there is an alignment of policies,

¹ As of June 2019, Department of Agriculture, Land Reform and Rural Development (DALRRD) was established by the merger of the Department of Agriculture, Forestry and Fisheries (DAFF) and the Department of Rural Development and Land Reform (DRDLR).

coordination of processes and cooperation of stakeholders, to ensure a successful integrated system (DAFF, 2011).

The Integrated Water Resource Management (IWRM) is a sustainable and balanced approach of water resource management adopted in South Africa. Informed by the 4 Dublin Principles, it amalgamates social equity, economic efficiency, as well as environmental sustainability, and is deemed an important tool that recognizes disciplinary linkages (GWP, 2000; Pradhan *et al.*, 2014). Mehta *et al.* (2016) highlight that IWRM emphasises decentralisation through new institutions, procedures, accountability standards and new planning processes. However, various problems hinder the success of IWRM implementation. Varis *et al.* (2014) noted the key elements contributing to the failure of water governance to include sector fragmentation, problems with the institutional set-up and coordination, shortcomings in law and policy enforcement, as well as a shortage of stakeholder involvement.

For IWRM to be successful and contribute to sustainable development, there is a need to address institutional challenges and encourage stakeholder coordination (Viesmann, 2011; Rahmawati *et al.*, 2014). The World Wide Fund for Nature (WWF, 2005:3) defined a stakeholder as “any individual, group, or institution who has a vested interest in a project area and/or who potentially will be affected by project activities and have something to gain or lose if conditions change or stay the same”. Due to the roles played by different stakeholders in water resource governance, the management thereof tends to be complex. The various stakeholders have their priorities and approaches to achieve their goals (Syafri, 2013), decreasing the likelihood of a well-coordinated system. Therefore, to minimize failure, it is vital to identify and understand the roles of the stakeholders within a system. This includes their interests, potential conflicts, and appropriate strategies (WWF, 2005). The identification of stakeholders and their objectives helps in evaluating coordination, collaboration as well as institutional integration, thus it is essential to analyse the stakeholder networks.

Stakeholder mapping or analysis defines social and natural dimensions affected by a decision and an action. It includes identifying persons, parties and organizations that are affected by decisions and actions and categorizes the different groups according to their involvement in the decision making and action implementation process (Reed, 2009). It is about identifying the actors, their connections, as well as their interests within the network (Newcombe, 2003). The coordination among public stakeholders at different government levels and across sectors enhances efficiency, equity, and sustainability of natural resource governance. It can further

be classified in sectoral, territorial, and organizational dimensions (Charbit, 2011). Gupta and Pahl-Wostl (2013) argue that effective water resource governance systems are those that have cross-level coordination. It has also been noted that integration across sectors and administrative levels are necessary for IWRM (Pahl-Wostl, 2009). Often, stakeholders in natural resource governance explicitly or implicitly share policy and implementation authority. They collectively share responsibility, development, and implementation across different sectors (horizontally), between different levels of government, from national to local (vertically), as well as between the public and private sector (Charbit, 2011).

Horizontal integration is often challenging to achieve due to the diverse interests of involved actors (Denby *et al.*, 2011). The challenges in attaining horizontal integration usually arise due to the presence of specific gaps, namely, information, capacity, funding, policy, administrative, objective and accountability (Charbit, 2011). There are four common causes of failure in terms of vertical integration exist. These are the 1) Fiscal challenge, characterized by a difficulty in funding or investing in projects; 2) Capacity challenge, which refers to the inadequate resources and human capital to carry out tasks transparently; 3) Policy challenge, characterized by challenges of taking advantage of any links or synergies across sectors; 4) Administrative challenge associated with fragmentation of projects at the local level (Charbit, 2011; Junghun and Camila, 2012). The concept of institutional integration includes both governance and management of SIS, as policy and its successful implementation on the ground indicates vertical integration. While the coordination of the different stakeholders and their actions to achieve set goals indicate horizontal integration (Kidd and Shaw, 2007; Denby *et al.*, 2011).

Varis *et al.* (2014) suggest the adoption of a Water-in-All Policies Approach (WIAP) that emphasises horizontal integration, which they deemed the weak point of IWRM. Without the involvement of other sectors, such as is the case with the water-food-energy nexus, water resource governance will remain weak. “WIAP could also bring more strategic thinking to the water sector, emphasizing the need to actively promote and lobby the importance of water issues in other sectors and recognizing impact pathways or streams to make this happen in practice” (Varis *et al.*, 2014; 442). However, the approach might be difficult to adopt as some sectors might deem their need for water use more than others.

Nielsen *et al.* (2013) explored the strengths and weaknesses of different institutional arrangements for river basin management in six countries. Using multi-level governance,

regime interplay and institutional effectiveness theories, the study found that central governments had the most influence in basin management plans, while local governments had limited roles. The study also found that norms and incentives promoted institutional integration and may help in overcoming coordination issues, resulting in more integrated management.

Denby *et al.* (2016) evaluated the integration between land and water reform processes in the Inkomati Irrigation Scheme in the Eastern Cape, South Africa. The study found discrepancies between the South African IWRM policy and the realities at the local level. They found that integration was not clear and that the failure to implement the National Water Act was due to policy not recognizing the complex historical context, and the inequalities in knowledge and resource access. Additionally, they highlighted that the lack of incentives or legislative enforcement plays a role in the failure of attaining the necessary integration in the Inkomati Irrigation Scheme and that the multi-actors had diverse interests and objectives.

The National Water Act (NWA) aims to manage water resources in an integrated way, boasting of interconnection between land and water institutions (Meinzen-Dick and Nkonya, 2007; Denby *et al.*, 2016). Meinzen-Dick and Nkonya (2007) however suggest that the NWA has found it challenging to integrate across sectors and to overcome the segmentation between two authorities responsible for land and water. They discovered that overlapping government mandates resulted in low participation of stakeholders (particularly at meetings), non-alignment of projects, lack of accountability and inadequate information flow. They further recommended that before new water institutions are formed, there are a couple of factors to be considered such as a good understanding of social institutions, a careful assessment and the willingness to learn, experiment and adapt to policy changes. Overall, the attainment of the different types of integration within a water resource system enables the flow of information, accountability, and transparency, all which consequently encourages farmer participation and performance (Herrfahrdt-Pähle, 2013; Muchara *et al.*, 2014). Furthermore, given the vast literature on performance, particularly from the technical point of view, an evaluation of institutional integration can provide a possible cause of the underperformance of schemes, from a social perspective. Therefore, this study uses qualitative methods to evaluate institutional integration and associated challenges in the governance of SIS in KwaZulu-Natal.

3.2. Methodology

3.2.1. Theoretical and Conceptual Framework

Given the multi-stakeholder nature and complexities of water resource management, institutional integration is often hard to achieve. This can also be due to fragmented institutional structures, poor relationships between stakeholders and poor coordination, which result in a lack of clarity about roles and responsibilities (Carlson and Stelfox, 2009). Evaluating institutional integration within the management or governance of water resources is important for sustaining stakeholder engagement. It helps identify gaps within the system, as well as any need for policy intervention (Smith *et al.*, 2015). Improved coordination, as well as the collaboration of institutions, enhances system efficiency (Viessmann, 2011). Institutions do not only refer to organizations but also the rules, regulations, and processes in SIS. Figure 3.1 depicts the social aspects of the Management Transition Framework (MTF), as well as the Organization for Economic Co-operation and Development (OECD) Governance Multi-level Framework and the South African government's Batho-Pele Principles. The administration gap, which represents the mismatch between hydrological and administration boundaries, was omitted as the study focusses on integration in the social elements of water management.

The MTF is an interdisciplinary conceptual and methodological framework used to evaluate water systems, management processes and multi-level governance regimes. MTF provides an interdisciplinary approach across social and natural science by integrating a range of concepts to enable the understanding of water management regimes (Pahl-Worstl *et al.*, 2014). It also provides a comprehensive analysis of resource management. It is an operational tool that can be used for structural and comparative analysis of water resource management (Knieper *et al.*, 2010) and gives practical guidance for the implementation of processes towards more adaptive resource systems.

For this study, the framework was adapted to focus on the social and regulative systems in water management. The social system consists of actors who participate in water management processes. These actors have roles and knowledge about the system and are affected by any policy gaps they may be faced with in water management (Charbit, 2011). The gaps are part of the OECD Governance Multi-level Framework, which has been used to evaluate co-ordination “gaps” in the water sector. The main idea behind the framework is to address the interdependencies across different levels in water management (Charbit, 2011).

The various sectors involved in water management set the primary conditions about the water management processes, and these processes influence the actions taken, the rules formed as well as the knowledge shared by different actors. Water policies and acts also guide these processes. The Batho-Pele Principles are aligned to the South African Constitution and include government departments consulting citizens about the services they receive, upholding service standards, treating civilians with courtesy and consideration, openness, and transparency, as well as redressing issues citizens raise.

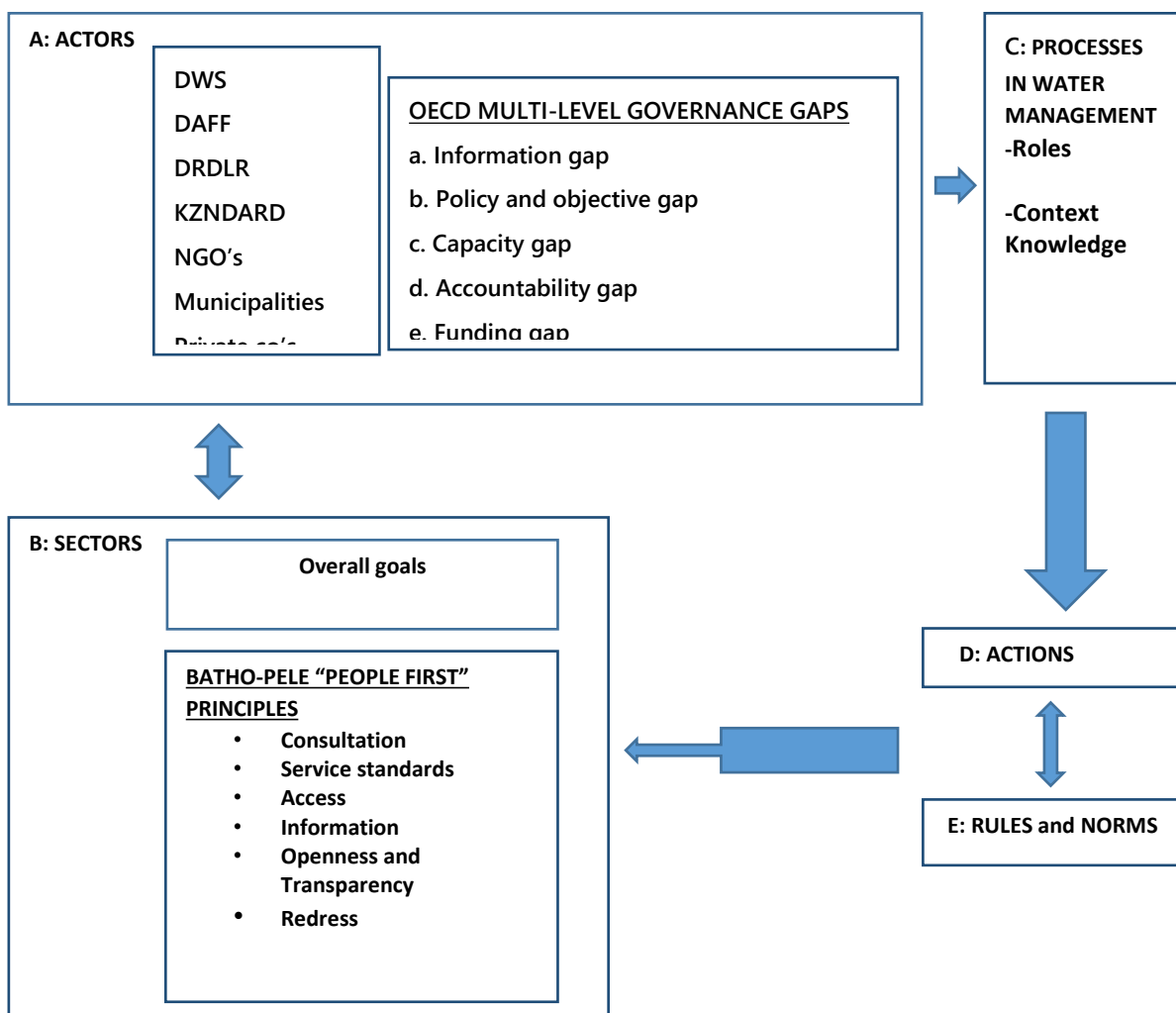


Figure 3.1: Social facets of the Management Transition Framework and OECD governance gaps showing linkages in smallholder irrigation scheme management
Source: Adapted from Pahl-Worstl *et al.*, (2014); Charbit, (2011).

3.2.2. Study Areas

The study focused on four irrigation schemes in KwaZulu-Natal (KZN) namely, Tugela Ferry, Ndumo, Mooi River and Makhathini Flats. The schemes were chosen due to their contrasting characteristics, including governance regimes, farmer compositions and scheme location. The

Makhathini Flats and Ndumo Irrigation Schemes are situated in the Umkhanyakude District, under the Jozini Local Municipality, north-eastern KZN. The Tugela Ferry and Mooi River Irrigation Schemes are situated in central KZN, under the uMzinyathi District, in the Msinga Local Municipality.

Makhathini Flats Irrigation Scheme (MFIS)

MFIS comprises of individual (mostly males) and cooperative irrigators (mostly women). The individual farmers produce sugarcane, while the cooperatives mostly produce vegetables. The individual irrigators operate on land provided by the land trusts (under traditional authorities), and the cooperative irrigators operate on state-supplied land.

The Ndumo Irrigation Scheme (NIS)

NIS is a 500-ha scheme where farmers produce a wide variety of commodities such as tomatoes, cabbage, and other cash crops. The farmers in the schemes are largely commercial farmers. The irrigators belong to two cooperatives, each representing the older and the newer block.

Mooi River Irrigation Schemes (MRIS)

The MRIS comprises of about 840 irrigators, drawing water from a 25km long canal. The scheme is currently undergoing maintenance, and water access is extremely variable due to the nature of water distribution, supply, and scheduling. T

Tugela Ferry Irrigation Scheme (TFIS)

TFIS comprises about 1500 farmers on 800 ha of land. The TFIS irrigators use various water transmission mechanisms (canal via gravity, diesel, and electric pumps) and farmer production is more for subsistence. The farmers operate on an average of 0.4 ha of land allocated by the local traditional authority.

3.2.3. Sampling and data collection

Data was collected through focus group discussions (FGD) as well as interviews with different stakeholders involved in the management of SIS in KwaZulu-Natal. A total of 102 farmers were available during the FGD across the schemes. The FGD and meetings with government stakeholders were held in two districts (Umkhanyakude and Umzinyathi)

between March 2017 and June 2018, and organized with the help of extension officers and farm scheme committee leaders. Meetings included a total of 30 respondents, including farmer representatives, steering committees (which are the executive members in the schemes), extension officers, local government officials, national government representatives as well as NGO representatives.

3.2.4.Data analysis

The Management Transition Framework (MTF) and the OECD governance gaps were adopted, and together with the South African Batho-Pele Principles, used to analyse the horizontal and vertical integration in water resource management. Stakeholder interaction in the four irrigation schemes was recorded from stakeholder meetings and FGD. Exploratory social network analysis was conducted using the Pajek Software to identify the pertinent issues that constrain the achievement of institutional integration in the schemes. Social network analysis enables the researcher to gain insights on issues affecting stakeholders, which influence either service delivery or the performance of water users.

3.2.4.1. Social Network Analysis

Respondents were asked to mention the challenges they face, which potentially affect the current state of institutional integration in the schemes. A social network is a pattern of ties that exist between different entities, objects, or concepts (Wambeke *et al.*, 2011). These ties are represented by a set of nodes that depict relationships or links to each other (Marin and Wellman, 2011). The Pajek software was used to produce a web of challenges that stakeholders and water users faced in the schemes. The challenges were ranked and visualized. Pajek is a software used in the analysis of large networks, for visualization and analytical purposes (Batagelj and Mrvar, 1998). The software produces a visualization of the network of challenges, which can be moved around to depict the parties represented in the data. Values of closeness of the highlighted challenges were estimated. A measure of closeness was computed to attach numerical values to the links between the pertinent issues in SIS governance. Closeness coefficients measure the sum of the length of paths in a network between a node and the rest. The higher the value, the higher a variable or theme is linked to others (Okamoto *et al.*, 2008). It gives a measure of the degree to which challenge is closely linked to and gives rise to others (Opsahl *et al.*, 2010). Mathematically,

$$\text{closeness}(v) = 1 / \sum d_{vi}$$

Where v is the vertex or node, and d is the distance between the vertex and other nodes. The coefficient can be regarded as a measure of how the connectivity of one node is to the other nodes. This gives a reflection of which core challenges need to be overcome, as they are related or may even give rise to other challenges. Understanding these challenges sheds light on which issues need to be addressed in efforts of attaining successful institutional integration in the governance of irrigation schemes. The next subsection presents the results of the analysis.

3.3. Results and Discussion

3.3.1. Application of the adapted Management Transition Framework to assess vertical and horizontal integration in SIS in KwaZulu-Natal

A. Actors

Water resource governance is characterized by different actors, across sectors and between administrative levels. The various actors have different roles (Table 3.1), objectives and knowledge about the system. In the four SIS included in the study, the Department of Agriculture, Fisheries and Forestry (DAFF) and Department of Water and Sanitation (DWS) were the key stakeholders involved in policy making regarding water management. DAFF was responsible for guiding irrigated agriculture. The department was responsible for developing guidelines for the revitalization of schemes, and through consulting with research institutions such as the WRC and ARC, fund research projects related to irrigation in South Africa (DAFF, 2015).

Other actors were the Department of Rural Development and Land Reform (DRDLR), KwaZulu-Natal Department of Agriculture and Rural Development (KZNDARD), Municipalities, Technoserve, traditional authorities, private consultants, academic institutions and most importantly, irrigators. All these actors play roles in the schemes and have some context knowledge about the processes in the schemes and the governance of irrigation water. Their roles in the four schemes are presented in Table 3.1, representing the interaction between actors and process management, as depicted in the adapted MT-framework.

Table 3.1. Interaction between actors and processes in water management and their roles

Actor	Role
DWS	Formulate water policy; Issue water licenses.
DAFF	Formulate agricultural policy, fund agrarian programmes, as well as scheme development.
DRDLR	Rehabilitate schemes, supply land to cooperatives, supply irrigators with farming equipment and infrastructure.
KZNDARD	Supply infrastructure, primary production inputs, and provide extension services.
Municipalities	Fund irrigation projects.
Extension Workers	Offer agricultural extension support.
traditional authorities	Allocate land, involved in conflict management in the schemes.
NGOs	Provide technical support, training, and micro-finance.
Research organizations	Conduct research on water and agricultural related issues.
Academic Institutions	Conduct research on water and agricultural related issues.
Private Consultants	Infrastructure maintenance and repair, Infrastructure design.
Steering Committees	Farmers who represent other farmers in the scheme, selected as executive members.
Farmers	Irrigate and produce agricultural commodities, formulate rules, engage stakeholders, elect committee members.

Evaluating institutional integration within the management or governance of water resource is important for sustaining stakeholder engagement and helps identify gaps within the system, as well as any need for policy intervention (Smith *et al.*, 2015). As given in the OECD Multi-level Framework, the following gaps, affecting actors and the processes in water management were identified in the schemes.

Aa: Information Gap

The information gap refers to information asymmetries between governmental departments or across the different levels of government (Charbit, 2011). In the planning stages on the national level, stakeholders know what is expected and how it should be executed, as well as

how much funding should be allocated. Members of the different national departments (DWS; DAFF; DEA; DRDLR) meet to coordinate plans and ideas. Additionally, projects are implemented by the various entities with the allocated funds in the provincial and local level. The case study revealed that not only do the local entities often not know what another's objective is, but they also do not understand the water or agricultural strategies which give rise to the implementation of the project. This is reportedly attributed to political changes in the province, as when a new member of the executive council (MEC) is elected, existing programmes stop being implemented, new strategies are followed, and therefore, certain projects do not get completed. The farmers are also not aware of the policies, strategies, rules, and procedures set by the government. The schemes are mostly governed by informal institutions, mainly being the rules and regulations, they have set locally.

Ab: Policy and Objective gap

Policies at the national level are somewhat aligned; however, entities often operate independently at the local level, thus missing opportunities to undertake cross-sectional activities, that would translate into cost-cutting in the long run (Akhmouch, 2012), as well as capacitating employees. The local entities have different rationale and objectives. An instance is where the department of environmental affairs would want to conserve a particular area, while the agricultural ministry would deem the area fit for agricultural production.

Ac: Capacity gap

There is a shortage of technical labour such as engineering personnel as well as economic advisors and extension workers in the local departments. The existing extension workers have to cater to a large number of irrigators in the schemes.

Ad: Funding and Accountability

Although the government has spent substantial amounts of money on rehabilitation and development of schemes, it is spent on a large number of schemes across the country. Due to limited funding locally, some projects do not reach completion, and hardly any entity is held accountable. Farmers complain that when infrastructure needs to be repaired, the agencies responsible always say there is not enough money in the budget. As such farmers do not perform to their fullest potential and do not know who to report to, who exactly is accountable. Lack of transparency makes it challenging to hold entities or individuals accountable. The governmental officials also feel that farmers should be accountable for the

damages to infrastructure and to be able to maintain the irrigation equipment as they are the resource users. They argue that most farmers expect to be given everything and are not willing to help themselves.

B: Sectors

The different sectors set the basic conditions for processes in water management, such as policymaking, funding and water-pricing. It is the responsibility of every department in South Africa, to uphold the “Batho-Pele (People First)” governance principles. It is through upholding these principles and setting basic conditions for the processes in water management that good water governance can be ensured.

The Batho-Pele principles require government entities to:

Consult citizens about the services they receive and be given a choice. Indeed, this has been a case with extension officers in the SIS. However, irrigators do not know the exact role of key players such as the DWS, who do not consult the water users directly, as regularly as expected.

Uphold service standards- Irrigators are often told what they will receive, and which processes they should go through, with no feedback or follow-up from entities.

Irrigators should receive equal access to services; however, they have voiced out that some block members and other schemes receive more governmental support.

Treat irrigators with courtesy and consideration- In most cases the irrigators are treated with courtesy but are not always considered. Farmers feel that there is a need for the DWS to finish the process of getting water licences for irrigators, for them to be secure with regards to water access.

The ministries should provide full information about the services available- Irrigators are not aware of the services most of the stakeholders involved in water resource management offer, and therefore do not know where to go for assistance.

Openness and Transparency- Citizens should be aware of how national and provincial departments are run. This is not the case in the schemes, as most farmers do not know which department is responsible for rendering which service.

Redress-Irrigators are not satisfied with the way their issues raised are addressed once reported, and the time they must wait until there is some redress. The results are consistent with the findings of Khoza and Du Toit (2011), who found that the Batho Pele Principles have not been effectively implemented in health service provision.

C-D-E: Processes in water management, actions and norms

Processes in water management are influenced by the actors, the roles they play, the knowledge they have, as well as the rules and norms with which they operate. The farmers in the scheme are governed by both informal and formal institutions. Although most irrigators are not aware of the policies and strategies, they try to work together for the greater good. Most of the farmers in the selected SIS are not generally willing to pay for water. They believe it is a natural resource, and therefore they should not pay for it. They also have their own processes of conflict management. The farmers are represented by executive committees which they elect. Each block has a chairperson that serves as part of the secondary committees, which are the link between other stakeholders and the farmers. The committee members report to the traditional authorities in cases of conflict and are usually the link between the farmers and extension officers. This was the case in all the schemes.

In the event of a conflict, the local committees attend to it and report to the traditional authorities, where penalties are levied. However, the penalties for rule-breaking are low, about R200 to R300, making rule compliance low. The DWS was responsible for the development and maintenance of irrigation infrastructure issuing of water licences and collecting water fees. It is expected that farmers are to have water-use licences. However, in the TFIS, MRIS and NIRS, the farmers allege that a representative from the DWS advised them to be part of cooperatives in order to access water licences, which the farmers did, but were not consulted again after that, indicating low involvement of the department on the ground. The case-study reflects a system where farmers are not particularly satisfied with the involvement of DWS and the formal institutions that govern the scheme.

The multi-stakeholder nature of water governance translates to a system characterized by various challenges that inhibit institutional integration in SIS. The challenges from both governmental stakeholders and farmers that constrain the attainment of institutional integration are highlighted in the next section.

3.3.2. Social network of issues and challenges affecting stakeholders in smallholder irrigation schemes in KwaZulu-Natal

Results from the Pajek Exploratory Social Network analysis (Figure 3.2) highlight some key issues which constrain institutional integration in water resource governance, as presented in. Government officials, particularly the DRDLR, DAFF, KZNDARD and farmers, highlighted the challenges. The pertinent issues farmers pointed out, as shown by the larger nodes, in the blue shaded domain on the left of Figure 3.2, were; lack of farmer training, high production costs, lack of awareness on policies and strategies in irrigation management, rule non-compliance, and low government response or interaction. The network links show that farmers are unwilling to pay for certain services, do not readily participate in irrigation management and are unaware of the formal institutions that govern the scheme.

The domain on the right shaded in orange represents views from government officials, steering committees (farmer representatives) as well as extension officers. The key issues highlighted were strong sector fragmentation, lack of accountability, miscommunication between entities, lack of transparency and high consultancy costs. The strong fragmentation is linked to lack of coordination, information asymmetry and leads to miscommunication between entities. The high consultancy costs are linked to delays in project completion. It was noted that engineering companies, often take on more work than they can implement, and therefore delay project completion. In cases where the project is not completed, another company takes over. The miscommunication and information asymmetry hinder project completion as some stakeholders may not be aware of the plans or objectives of the others and do not understand the strategies or programmes in place.

Consistent with the graphical representation in Figure 3.2, Table 3.2 shows the variables with the highest closeness coefficients, measuring the sum of the length of paths in a network between a node and the rest. Low farmer participation and lack of farmer training are close to a range of other issues. The results in Table 3.2 show that strong sector fragmentation and lack of transparency were the dominant issues stakeholders highlighted as inhibiting institutional integration in scheme governance. Figure 3.2 shows that poor response from the government is linked to low reliability, as well as delays in project completion, a challenge also noted by government officials. Lack of farmer training is linked to low farmer participation highlighted by government stakeholders, which is also linked to infrastructure damage. These are issues that, if addressed, could potentially curb other governance challenges in SIS.

Table 3.2. Closeness coefficient of challenges constraining institutional integration in SIS

Farmer challenges	Closeness Coefficients
Poor government response	0.7
Lack of farmer training	0.6
Low farmer participation in irrigation management	0.6
Lack of awareness of formal institutions	0.5
<hr/>	
Stakeholder challenges	
<hr/>	
Strong fragmentation	0.8
Lack of transparency	0.8
Low farmer participation	0.8
High consultancy costs	0.7

Source: Pajek Social Network Analysis output (2018).

The challenges or issues highlighted by stakeholders could potentially inhibit the attainment of horizontal and vertical integration. The problems affecting the national and local government, non-governmental organizations as well as farmers, affect how the scheme governance is integrated and consequently affects the overall performance of the scheme. These challenges also affect the effectiveness of both formal and informal institutions in water resource management.

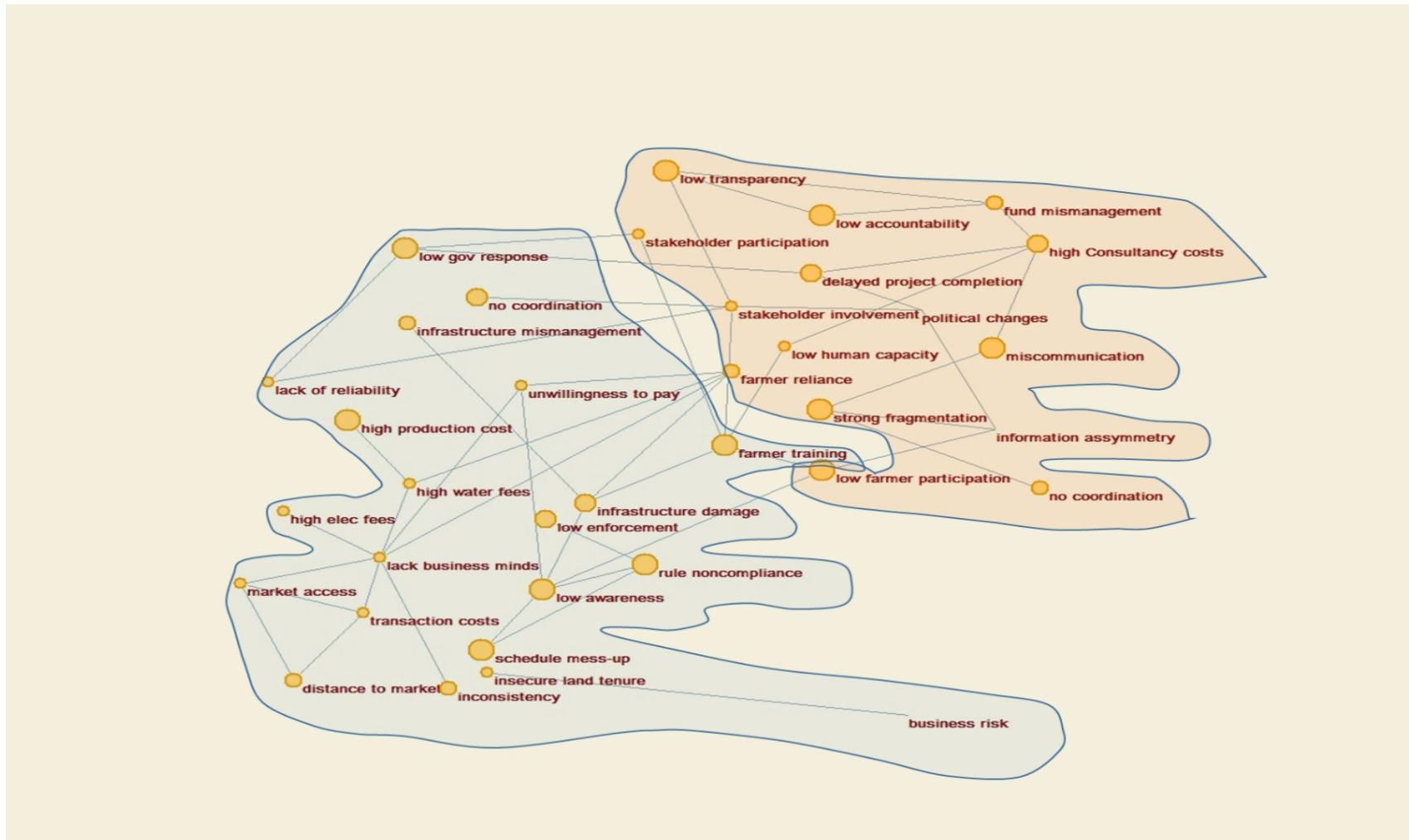


Figure 3.2. The social network of pertinent issues in SIS in KwaZulu-Natal.
 Source: Pajek Social Network Analysis Output (2018).

3.4. Conclusions and Recommendations

Although the Governmental Departments are coordinated, on the national level, the strong fragmentation on provincial and local levels results in information asymmetries. These asymmetries lead to incoordination across sectors, as each entity operates independently. Thus, there is a low level of horizontal integration locally. Lack of funds and shortages in human capacity result in projects not being fully implemented, and the strong sector fragmentation makes it challenging to hold entities accountable. Therefore, the strategies and programmes, meant to uplift and support farmers are not timeously implemented or completed, resulting in a lack of vertical integration in SIS. Issues that stand out that inhibit the successful implementation of projects by the government, are lack of transparency and accountability, farmers being too reliant on the government, as well as sector fragmentation.

One key challenge that government officials and farmers highlighted in the irrigation schemes are farmers' low participation, which stems from not being aware of the formal institutions in water governance. Therefore, it is recommended that focus be put on training farmers in irrigation and infrastructure management, as well as raise awareness about the existing institutional arrangements and roles of different entities. Farmers also need to be capacitated to not entirely rely on governmental support. This can be achieved through education programs to strengthen the capacity of farmers. Governmental entities and other stakeholders need to understand the existing institutions and the roles of their counterparts to establish synergies and to improve coordination in the systems, to ensure effective governance. More skilled labour is needed at the local level, to ensure successful implementation of projects, while creating employment. Moreover, mechanisms should be adopted to monitor and evaluate if the Batho-Pele principles are upheld by government officials to ensure good governance.

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CHAPTER 4. HOUSEHOLD-LEVEL PERCEPTIONS OF GOVERNANCE IN SMALLHOLDER IRRIGATION SCHEMES IN KWAZULU-NATAL PROVINCE

Abstract

Good governance is a prerequisite of better management of common-use resources. Awareness of institutions, the inclusion of members in decision-making processes, stakeholder engagement and transparency are needed for good governance, which enhances sustainable use of pooled water resources. This paper, therefore, considers perceptions of farmers about irrigation scheme governance in its various dimensions. The study uses household data of 341 farmers drawn from four irrigation schemes in KwaZulu-Natal. The results show that farmers that are satisfied with the informal institutions, being the rules and norms set locally to govern the scheme farmers, also value the involvement of the traditional authorities in scheme management, including their contribution in rule enforcement. Age, agricultural training, water adequacy, participation in scheme activities, psychological capital and land tenure have a positive effect on perceptions of governance constructs. Farmers are satisfied with the informal institutions governing the schemes. Therefore, the study recommends the inclusion of informal institutions in policy formulation. Farmers should be empowered through training and be made aware of formal institutions applicable to their irrigation scheme. Furthermore, stakeholder engagement in the schemes should be strengthened.

Keywords: Perceptions of Governance; Smallholder Irrigation Schemes; Principal Components Analysis; KwaZulu-Natal

4.1. Introduction

The increasing frequency of droughts have negatively affected agriculture in South Africa and has resulted in the increased demand for irrigation (Sinyolo *et al.*, 2014). Smallholder irrigation schemes (SIS) have become an important water source for agriculture among smallholder farmers, and thus plays a key role in poverty reduction (Muchara *et al.*, 2014). In the South African context, an SIS is defined as a multi-farmer irrigation project larger than five hectares in size, used mainly for agricultural production (Perret & Geyser, 2007, Van Averbek, 2012). SIS have the potential to alleviate poverty and improve household food security in rural areas in South Africa (Sinyolo *et al.*, 2014). However, many of them continue to face technical challenges such as inadequate water supply and dilapidated infrastructure (Dirwai

et al., 2019). To address these issues, the government introduced a process to rehabilitate the schemes, which is an engineering-centred concept, involving the restructuring of infrastructure to ensure adequate water supply and the redesigning of systems (DAFF, 2012).

Despite the rehabilitation process, SIS continued to underperform (Gomo *et al.*, 2014). As such, social dynamics were then included in the development of SIS, which resulted in a process called revitalization, a philosophy that provides for both the re-design of existing infrastructure and engagement with the organizational and social dynamics of water distribution and allocation (*ibid*). It was through this revitalization process that the Irrigation Management Transfer (IMT) was introduced in South Africa in 1996. IMT sought to decentralize the management of the schemes. Two years later, Participatory Irrigation Management (PIM) was introduced under the National Water Act of 1998. PIM is a philosophy that is centred on involving farmers or water users in the operation, management, and maintenance of irrigation systems in tertiary and secondary levels (Kulkarni and Tyagi, 2012). In essence, this involves transforming the farmer into the “water manager” (Gomo *et al.*, 2014) and involving them in the governance of the scheme.

Water governance refers to ‘all those interactive arrangements in which public, as well as private actors, participate, aimed at solving problems or creating opportunities, attending to the institutions within which these governing activities take place’ (Hassenforder and Barone, 2019:783). Institutions provide a basis for human cooperation and enhance stable interactions (Nielsen *et al.*, 2013), while also shaping water-related decision making, including behaviours, and drive behaviours associated with activities such as water sharing and use (Hassenforder and Barone, 2019). Institutions can either be formal or informal, with formal institutions representing the policies, strategies, organizations formed by the government. In contrast, informal institutions refer to the rules and norms that are usually set locally (Muchara *et al.*, 2014). In the context of irrigation systems, “institutions generally include the rules applied to operation and maintenance of the systems, designing cropping patterns, allocation and scheduling of water, conflict resolution, and to maintain a coordinated flow of action and transactions in the society” (McKay and Keremane, 2006; 206).

Several studies have evaluated the success of IMT and PIM in irrigation schemes across the world and have shown that farmers’ involvement in scheme management contributes to improved scheme performance (Meinzen-Dick *et al.*, 2000; Khalkheili and Zamani, 2009; McKay and Keremane, 2006; Muchara *et al.*, 2014). Given that farmers are actively involved

in scheme management, it then becomes imperative that they are aware of the institutional arrangements in irrigation management. Awareness and understanding of institutions and inclusion of members in decision-making processes and transparency of governance are needed for improved scheme management (McKay and Keremane, 2006; Hassenforder and Barone, 2019).

Meizen-Dick *et al.* (2002) found that the involvement of traditional leaders reduced the transaction costs of organizing people and makes users more willing to take part in scheme governance. Khalkheili and Zamani (2009) found that good relationships between farmers and other involved stakeholders are important for farmers participation. The overarching of the findings of these studies is that the success of management transfer ultimately depends on a set of institutional arrangements and the understanding and or farmers' satisfaction with these institutional arrangements. Typically, institutional analysis of the water sector focuses on the formal aspects of law, policy, and administration (McKay and Keremane, 2006) and hardly on the informal institutions governing the schemes.

Most studies have considered the impact of IMT and PIM on the performance of the SIS. They have also focussed on how institutional arrangements can be adapted to improve scheme management. However, Shar (2005) and McKay and Keremane (2006) note that these types of analysis are not complete if they do not include the understanding of the institutional arrangements and the “working rules/rules in use” which are deemed as the informal institutions in scheme governance. Governance and management of schemes are in the hands of the local farmers and assessing their perceptions is important as they possess knowledge that is holistic and critical in evaluating local scheme governance (Cookey *et al.*, 2016). As such, this study aims to add to the literature by evaluating the perceptions of governance at the household level in SIS. It also assesses the determinants of the governance perceptions of farmers in SIS. To the knowledge of the authors, this is the first study to investigate perceptions of both formal and informal institutions at household level in KwaZulu-Natal irrigation schemes, the first to also introduce household-level SIS governance using indices. This paper has five sections; the second part presents the conceptual framework, followed by the third section of the paper explaining the methods adopted for the study. The fourth part disseminates the results on the perceptions of governance by farmers in

SIS, and the determinants of the computed governance indices, the fifth section puts forward the conclusions and recommendations of the study.

4.2. Methodology

4.2.1. Conceptual Framework

Water governance in South Africa is a multifaceted, interdisciplinary concept involving various institutional arrangements and stakeholders. This study considers the Management Transition Framework (MTF), which is an interdisciplinary conceptual and methodological framework used for evaluating water systems, management processes and multi-level governance regimes (Pahl-Worst *et al.*, 2014). MTF provides an interdisciplinary approach across social and natural science by integrating a range of concepts to enable the understanding of water management regime (*ibid*, 2014). It also provides a comprehensive analysis of resource management. It is an operational tool that can be used for structural and comparative analysis of water resource management (Knieper *et al.*, 2010) and gives practical guidance for the implementation of processes towards more adaptive resource systems.

The framework considers various facets of water resources, but for this study, the framework is adapted to focus on the social and regulative systems in water management. The social system consists of formal institutions such as national water policies and strategies, which stipulate the use and management of water resources.

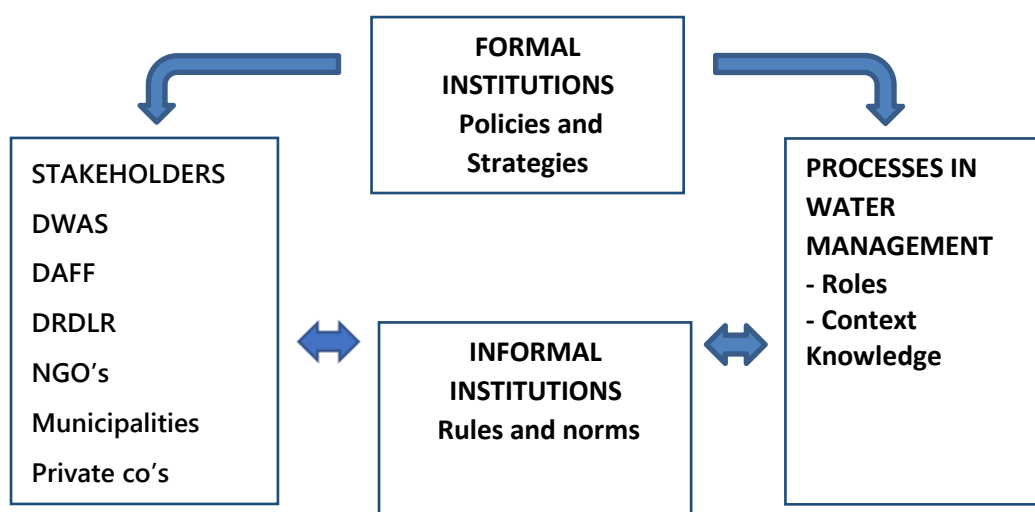


Figure 4.1. Linkages in the social facets of SIS management
Source: Adapted from Pahl-Worstl *et al.*, (2014); Charbit, (2011).

The relevant stakeholders, who each have roles to play in water management, carry out the stipulated guidelines. The stakeholders include the Department of Water and Sanitation (DWAS), The Department Agriculture, Fisheries and Forestry (DAFF), the Department of Rural Development and Land Reform (DRDLR), NGOs, traditional authorities, and farmers. The processes in water management, guided by the formal institutions, include roles of stakeholders and context knowledge of the dynamics of water resources. The functions of the stakeholders are aligned to their respective goals and responsibilities, as governmental ministries, traditional authorities, and farmers. The processes in water management also include the context knowledge of the dynamics of water resource management, such as conflict management, irrigation scheduling and the election of committee members. The stakeholders, particularly farmers and traditional authorities, often devise rules and mechanisms to govern irrigation schemes, which form the informal institutions. These rules are also guided by the different roles and knowledge of the dynamics in scheme management. The informal institutions set primary conditions about the water management processes and drive the involvement of local stakeholders. The components of the social aspects of MTF are used in the study to gather information about farmers perceptions of SIS governance, incorporating formal and informal institutions, processes in management and stakeholder engagement.

4.2.2. Study area

The MFIS comprises of individual (mostly males) and cooperative irrigators (mostly women). The individual farmers produce sugarcane, while the cooperatives mostly produce vegetables. The individual irrigators operate on land provided by the land trusts (under traditional authorities), and the cooperative irrigators operate on state-supplied land. The NIS is a 500-ha scheme operated by 50 farmers. The farmers produce a variety of commodities commercially. The irrigators belong to two cooperatives, representing the older and the newer block (Dlangalala *et al.*, 2020). The MRIS comprises of about 842 irrigators, drawing water from a 25km scheme. It is undergoing rehabilitation, and water access is extremely variable (Dirwai *et al.*, 2019). The TFIS comprises about 1500 farmers on 800 ha of land. The TFIS irrigators use various water transmission mechanisms (canal via gravity, diesel, and electric pumps) and farmer production is more for subsistence. The farmers operate on an average of 0.4 ha of land allocated by the local traditional authority.

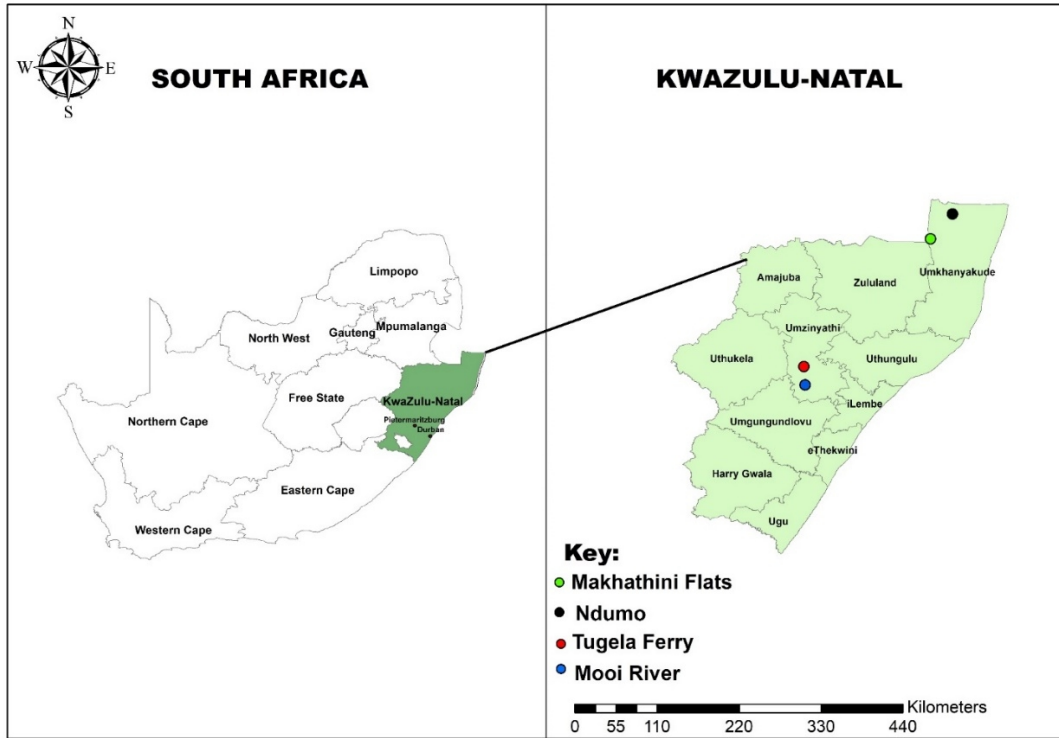


Figure 4.2. Map of the KwaZulu-Natal Province showing locations of the SIS

4.2.3. Data collection and sampling

The study focused on four irrigation schemes in two local municipalities in the KwaZulu-Natal Province in South Africa, namely, Jozini Local Municipality (JLM) in Umkhanyakude and the Msinga Local Municipality (MLM) in Umzinyathi District. The four schemes selected for the study are representative of the characteristics of other irrigation schemes in South Africa. The systematic random sampling was employed to select 341 farmers across the schemes. The total number was fixed to capture a representative sample according to the number of farmers operational within the schemes. In MRIS and TFIS, irrigation farmers were proportionately selected, there are about 1500 and 825 plot holders in the scheme, respectively. In total, 120 farmers were selected in both the MRIS and TFIS located in the MLM. The same sampling procedure was used in the JLM, where 60 farmers from the MFIS and 41 from the NIS were selected from a total of about 603 and 50, respectively. In MFIS every second farmer was selected. In TFIS, every 12th farmer was selected, and every sixth farmer was selected in MRIS. A questionnaire including information on irrigation activities, institutional arrangements, demographic, agricultural production, and related information was administered to farmers who source water from the schemes. Furthermore, Focus Group Discussions (FGDs) with farmers and committee members of the schemes, were held in the

schemes, where issues regarding scheme governance, the role of farmers and institutional arrangements in the schemes were discussed. Information was captured using audio-recording and scripts. Data was collected over a period of three months, from September to November 2017. Although only four schemes were selected, they are representative of the characteristics of other irrigation schemes in South Africa (Dirwai *et al.*, 2019; Dlangalala *et al.*, 2019).

4.2.4. Empirical Methods

4.2.4.1. Principal Components Analysis (PCA)

Principal Components Analysis (PCA) was used to evaluate farmer's perceptions of governance within the schemes, including the satisfaction with formal and informal institutions and stakeholder engagement. PCA is a multivariate data analysis method to reduce the dimensionality of many interrelated variables, while retaining as much as variation in the data as possible (Jolliffe, (2002); Muchara *et al.*, 2014). The dimension reduction is attained by the creation of new variables (Principal Components), that are uncorrelated. The new retained variables explain the variation present in all the variables and can explain certain phenomenon within the data (Jolliffe, 2002). Study participants ranked their understanding and perceptions of governance. A total of 18 governance items were included. Their perceptions and understanding were ranked using a 5-point Likert scale from zero (0) if a farmer strongly disagrees, to five (5) if he/she strongly agrees. Farmers were asked to rank their perceptions of formal institutions, the satisfaction of stakeholder engagement, informal institutions. Ranking perceptions is important as water-users may not have the same level of satisfaction for every item. For instance, a farmer might be satisfied with the involvement of the traditional authorities in rule enforcement, but not be happy with the election process of committee members. PCA was also used to generate household governance indices (HGI) for different facets based on farmers' awareness and perceptions governance in the schemes. The indices were then used as a dependent variables in multiple regressions to evaluate their determinants. The indices were formulated using the commonly used Bartlett OLS estimation.

4.2.4.2. Multiple Regression Model

The PCA-derived composite index of perceptions of governance at the household level, i.e., HGI was used as the dependent variable (Y) in a regression specified in equation 1 as:

$$Y^*_i = \beta_1 + \beta_2 X_i + \dots + \beta_j X_i + u_i \quad (1)$$

$$E(u_i | X_i) = 0 \quad (2)$$

where Y^*_i is a latent variable representing HGI index, X is the vector of explanatory variables, β is a vector of estimated parameter coefficients and u_i is the vector of independently and normally distributed residuals with a common variance (Greene, 2003). The variables included as covariates in the regression are described in Table 4.1.

Table 4.1. Description of explanatory variables

Variable Name	Description	Exp sign
Age	Age of a water user (years)	+/-
Gender	The gender of the water user (1=Male; 0=Female)	+/-
Total farming Income	A continuous variable which is the amount of income received from irrigated agriculture (Rands)	+
Cooperative Member	A binary variable representing whether a water-user is part of an agricultural cooperative (1=Yes; 0=No)	+
Credit access	A binary variable which represents whether a farmer has access to credit or not (1=Yes; 0=No)	+
Land tenure security	A binary variable, representing whether a farmer is satisfied with the existing land tenure or not (1=Yes; 0=No)	+/-
Agricultural Training	A binary variable indicating whether a farmer has received agricultural training (1=Yes; 0=No)	+
Irrigation Training	A binary variable that captures whether a water user has undergone irrigation and water training (1=Yes; 0=No)	+
Psychological capital	PCA derived composite score which represents the self-efficacy, hope and resilience of a water-user	+
Water Adequacy	A binary variable which indicates whether a water-users considers irrigation water they have access to adequate for their cropping requirements (1=Yes; 0=No)	+
Participation in management index	PCA derived composite score, which represents participation in the management activities in the schemes.	+

4.3. Results and discussion

4.3.1. Descriptive Statistics

Table 4.2 presents descriptive statistics of farmer characteristics across the schemes. As is the case with many rural settings, there are more female water users, accounting for about 77% of the sample. This is expected as smallholder crop farming in the rural areas of KZN is dominated by females (Muchara *et al.* (2014); Sinyolo *et al.* 2014). The average age of the farmers is 54 showing that relatively older people are part of the schemes, which is consistent with Dlangalala *et al.* (2020) who found an average age of 55 amongst farmers in the SIS

Table 4.2. Descriptive statistics of explanatory variables

Variables	Percentage % (n=341)
Categorical variables	
Gender: Male=1	1=22.62
Female=0	0=77.38
Agricultural training: Yes=1	1= 54.43
No=0	0=45.57
Irrigation training: Yes=1	1=29.51
No=0	0=70.49
Land tenure security: Yes=1	1=74.59
No=0	0=25.41
Credit access: Yes=1	1=60.19
No=0	0=39.81
Cooperative membership: Yes=1	1=36.39
No=0	0= 63.61
Irrigation water adequacy: Yes=1	1= 37.21
No=0	0=62.79
Continuous variables	
Age:	Mean= 54 Standard Deviation= 13.95 Min=20 Max=88
Total farming income (ZAR):	Mean=18 823 Standard Deviation= 50 066 Min=600 Max= 502 740
Participation in management index:	Mean 5.12e-09 Standard Deviation= 2.01 Min=-5.24 Max= 3.02
Psychological Capital index:	Mean 2.15e-09 Standard Deviation= 2.2 Min=-6.93 Max= 4.85

Source: Survey Data (2018)

Most of the water-users consider themselves secure in terms of land tenure, with about 54% having received agricultural training. About 63% feel that irrigation water is inadequate for their cropping requirements while only 29.5% of the farmers noted that they received irrigation training. Only about 36% of the farmers are members of agricultural co-operatives, while 60% have access to credit.

4.3.2. Principal components analysis of farmers' understanding and perceptions of governance of SIS in KZN

Farmer's perceptions and understanding of governance in the schemes were evaluated using PCA. Table 4.3 presents the PCA results which show that the Kaiser-Meyer-Olkin (KMO), the measure of sampling adequacy yielded a value 0.75, implying that PCA can be performed on the data. The Bartlett's test of sphericity, which is used to check whether the observed correlation matrix diverges significantly from the identity matrix was statistically significant, showing that the included variables are not perfectly correlated. Due to the complex nature of the perceptions of the variables, the cut-off point chosen was 0.3. Using the Kaiser criterion, five principal components that had eigenvalues greater than one were retained. The results showed that the first principal component (PC1) named Informal institutions has the highest explanatory power, accounting for 24.75% of the variation in farmer's perceptions of governance in the schemes. PC1 together with principal components (PC2)-Stakeholder engagement, (PC3)- Formal institutions, (PC4)-Scheme management, and (PC5)-Youth involvement cumulatively account for 68.5% of the variation in the data.

PC1, named "Informal institutions" is dominated by variables which represent informal institutions, which are the norms and rules set locally to govern the schemes. The results show that farmers who are satisfied with the involvement of traditional authorities satisfied with the informal institutions are also satisfied with how farmers work together with the local traditional councils. Farmers feel that penalties within the schemes are fair and are satisfied with conflict management in the schemes. PC2 labeled "Stakeholder involvement", is dominated by variables which rank farmers' perceptions of governmental stakeholders' involvement in the scheme. The results show that farmers who are satisfied with the involvement of Departments of Agriculture, Forestry and Fisheries (DAFF), are also satisfied with the involvement of other stakeholders such as Department of Rural Development Land Reform (DRDLR), Department of Water and Sanitation (DWAS) as well as non-governmental organizations such as Lima and Technoserve.

PC3 named “Formal institutions”, dominated by farmer’s awareness of the National Water Act of 1998 (NWA), the Natural Water Resource Strategy, and government’s aims in SIS, which form part of the formal institutions in place in governing schemes in the country. Farmers that are aware of the NWA are also aware of the NWRS. PC4 named “Scheme management” is dominated by variables ranking farmers’ perceptions of local scheme management such as farmers’ involvement in formulating scheme rules, the process of electing scheme committee members and satisfaction with the current committee, consistent with the findings of Dlangalala *et al.* 2020). PC5 labeled “Youth involvement” shows that farmers who are satisfaction with the youth’s involvement in scheme management are also satisfied with the youth’s understanding of scheme rules.

Table 4.3. Principal Components Analysis of farmers' perceptions of SIS governance

Variables	Principal Components				
	PC1- Informal institutions	PC2-Stakeholder engagement	PC3-Formal institutions	PC4-Scheme management	PC5-Youth involvement
Awareness of National Water Act	0.04	0.001	0.585	0.159	0.218
Awareness of Natural Water Resource Strategy	0.048	-0.023	0.568	0.185	0.234
Knowledge of government's aims in SIS	0.024	0.118	0.421	-0.085	-0.015
Satisfaction with fairness of penalties in SIS	0.224	-0.014	0.036	0.128	0.043
Satisfaction with conflict management in SIS	0.215	0.052	0.042	0.337	-0.075
Satisfaction with the involvement of traditional authorities	0.326	-0.124	0.069	-0.226	-0.063
Satisfaction with involvement of DAFF	0.163	0.464	0.079	-0.185	-0.134
Satisfaction with involvement of DRDLR	0.181	0.422	0.072	-0.282	-0.095
Satisfaction with involvement of DWAS	0.116	0.346	0.044	0.001	-0.204
Satisfaction with involvement of NGOs	0.029	0.346	0.034	-0.305	-0.081
Satisfaction with the involvement of farmers in making rules	0.198	0.131	-0.067	0.382	-0.012

Satisfied with the current executive committee	0.228	0.142	-0.0902	0.4202	-0.214
Satisfied with the process of electing the executive committee	0.206	0.134	-0.134	0.398	-0.2003
Satisfied with the contribution of the traditional council in irrigation management	0.374	-0.198	0.0102	-0.141	-0.072
Satisfied with the traditional council's understanding of scheme rules	0.366	-0.238	0.019	-0.112	-0.021
Satisfied with how farmers and traditional councils work together	0.367	-0.239	0.019	-0.112	-0.021
Satisfaction with the youth's involvement in SIS management	0.141	0.219	-0.243	0.011	0.586
Satisfied with the youth understanding of scheme dynamics	0.146	0.202	-0.204	0.0202	0.606
<hr/>					
Eigenvalue	4.7	2.68	2.1	1.87	1.66
Variance explained	24.75%	14.11%	11.07%	9.87%	8.75%
Cumulative Variance explained	24.75%	38.86%	49.93%	59.79%	68.54%
Keiser-Meyer-Olkin (KMO)	0.75				

Bartlett's test of Sphericity: Chi-square = 3078.366; Degrees of freedom = 171; p-value = 0.00001

Source: Survey Data (2018)

Notes: Dominant variables are highlighted in bold

The five retained PC representing the aggregate farmers' perception of governance in the scheme were used to compute indices, which are proxies of perceptions of the different governance facets.

4.3.3. Results of the determinants of farmers' perceptions of governance.

Table 4.4 presents the multiple regression results of determinants of the PCA-derived composite indices of perceptions of governance at the household level. The five retained PCs gave rise to indices which proxy perceptions of informal institutions, stakeholder engagement, formal institutions, local scheme management and youth involvement. The mean Variance Inflation Factor 1.25 indicate that multicollinearity is not a problem in the data. The results are mostly in line with a priori expectations and discussed below. The results show that factors that determine perceptions of the governance indices in SIS are age, gender, co-operative membership, credit access, agricultural training, land tenure, irrigation water adequacy, participation index, income, and psychological capital.

The results indicate that older farmers are satisfied with informal institutions and local scheme management. The informal institutions PC includes the satisfaction of local rules and traditional authority engagement. It is plausible that the older farmers would, therefore have better perceptions of scheme governance. This is also because the schemes are based in rural settings, where traditional authorities play a key role in the management of resources (Muchara *et al.*, 2014) and due to older farmers being more inclined to respect and uphold tradition, they are likely to be satisfied with the local institutions which are largely enforced by traditional authorities. Older farmers, however, show not to be satisfied with stakeholder engagement in the schemes and are not aware of the formal institutions governing the schemes. This finding is consistent with Duhan and Singh (2017), who found that younger farmers accumulate information from different sources and are willing to adopt and adhere to formal policies. Therefore, younger farmers are more likely to be aware of current policies and strategies in water resource management. The negative gender coefficient estimate shows that female farmers have better perceptions of informal institutions. Most of the farmers in the schemes are female and would likely be satisfied with the government of the schemes, as they would be part of the rule-setting, decision-making, and engaging with other stakeholders such as the traditional authorities and governmental ministries.

Table 4.4. Multiple regression model of the determinants of HGI's

Variables	PC1	PC2	PC3	PC4	PC5
	Informal Institutions	Stakeholder Engagement	Formal Institutions	Local scheme management	Youth Involvement
Age	0.015*(0.01)	-0.01**(0.01)	-0.01*(0.01)	-0.01(0.01)	-0.05(0.01)
Gender	-0.57*(0.3)	0.2 (0.22)	1.22*** (0.22)	0.26(0.19)	0.05(0.19)
Cooperative membership	-0.63** (0.26)	1.11*** (1.98)	0.02(0.19)	-0.28*(0.16)	0.22(0.17)
Access to Credit	0.17(0.22)	-0.21(1.64)	-0.03(0.16)	-0.58*** (0.14)	-0.29** (0.14)
Agricultural Training	0.51** (0.25)	0.27(0.19)	0.08(0.18)	0.17(0.16)	-0.24(0.16)
Irrigation Training	-0.19(0.27)	0.12(0.21)	0.37*(0.2)	0.12(0.17)	-0.54(0.18)
Land tenure	0.60** (0.27)	-0.47** (0.2)	0.07(0.19)	0.78*** (0.17)	0.23(0.17)
Irrigation water adequacy	0.61** (0.25)	0.92*** (0.18)	-0.18(0.17)	0.07(0.15)	0.21(0.16)
Participation index	0.11*(0.06)	-0.01(0.04)	-0.01(0.04)	0.2*** (0.04)	-0.16*** (0.04)
Psychological capital	0.104*(0.06)	-0.01(0.04)	-0.05(0.04)	0.02(0.04)	0.09** (0.04)
Total income	2.31e-06(2.95e-06)	-1.08e-06(2.22e-06)	1.81e-06(2.16e-06)	-4.16e-06**(1.89e-06)	1.27e-06(1.92e-06)

Mean VIF=1.25

Obs=341

Notes: ***, **, * = Statistical significance at 1%, 5%, and 10% level, respectively. Robust Standard errors in parenthesis, Obs=observation

Source: Survey Data (2018)

The results suggest that male farmers are more aware of formal institutions, consistent with the findings of Muatha (2014) and Dlangalala (2020). This could be attributed to male farmers being active in executive management of the schemes, and therefore engaging more with governmental entities and other stakeholders.

Findings also indicate that farmers who are not part of co-operatives have better perceptions of informal institutions and scheme management. During FGDs, farmers highlighted that co-operative membership does not mean that farmers operate as co-operatives, and due to this, may not fully benefit from the rules set within the schemes. Farmers who are part of co-operatives showed to have better perceptions of stakeholder engagement, inconsistent with the findings of Tshishonga and Bandyambona (2016) who found that co-operatives lack the support of institutions such as government. Co-operatives are usually registered entities and benefit from the support of government through extension services and NGOs, as such would have good perceptions in terms of stakeholder engagement. Farmers who have received agricultural and irrigation training perceive informal institutions and formal institutions scheme in a good light. This could be because most training and support is provided by entities such as the government and NGO's, and through the training, could be made aware of policies and strategies relating to water resource management.

Farmers who are secure in terms of their land tenure have good perceptions of informal institutions and local scheme management. This is plausible as the traditional authorities are usually responsible for land allocations and are also involved in scheme management (Muchara *et al.*, 2016). However, farmers with secure land tenure are less satisfied with stakeholder engagement. During FGD's farmers highlighted that they hardly interact with other stakeholders either than the traditional authorities and elected committee members in the schemes.

Farmers that feel that irrigation water is adequate for their cropping needs have better perceptions of governance. Irrigation water adequacy is dependent on the rules in terms of water access and irrigation infrastructure supply, which involves the support of stakeholders. Therefore, farmers who have adequate water would most likely have good perceptions about the governance of the scheme, particularly the engagement of stakeholders and the informal institutions governing the scheme.

The participation index is a PCA derived composite score which represents participation in the management activities in the schemes. These include decision-making, financial contribution, information dissemination and regulation and control. Consistent with *a priori* expectations Farmers who therefore have a higher participation index are most likely to have better perceptions of governance because to participate in the schemes, a farmer would have to be satisfied with the informal institutions and local scheme management. Similarly, psychological capital index, a higher-order construct, which captures self-efficacy, hope and resilience of a farmer positively affects the HGI. This indicates that farmers with a higher psychological index are more likely to have positive perceptions of governance, as farmers with a higher psychological capital have a mindset and attitude that enables them to take initiative and would most likely be involved and satisfied with scheme governance.

4.4. Conclusions and recommendations

Although it is important to evaluate the formal institutions, being the law, policy, and administration in water management, it is equally important to analyse governance issues taking into consideration the on the informal institutions governing the schemes. This study evaluated farmer's perceptions of governance and their determinants at the household level in four SIS in the KwaZulu-Natal Province. This included a holistic view of governance, including both formal and informal institutions in the schemes. The study found that farmers are generally satisfied with the informal institutions, being the "rules in use", they have set for themselves in the schemes. Furthermore, they are satisfied with the involvement of traditional authorities in schemes governance, including conflict resolutions and rule enforcement.

The study recommends that informal institutions be at the forefront in policy formulation as farmers are comfortable and are satisfied with the rules they devise to govern the schemes. Furthermore, the involvement of traditional authorities in formulating policies should be considered. Failure of which could lead to unsuccessful decentralization of the management of and in compliance of formal arrangements formed outside the schemes. The study found that several factors such as gender, cooperative membership, and agricultural and irrigation training determine farmer's perceptions of governance. Male farmers should be encouraged to participate in the schemes, to get involved in the formulation of rules, while female farmers should be made aware of the formal institutions of scheme governance.

The training of farmers results in farmers having good perceptions of informal institutions and being aware of formal institutions. Better land agreements and water supply arrangements should be promoted as farmers who are secure in terms of land tenure and feel that they have adequate irrigation water supply, have better perceptions of scheme governance. The inclusion of informal institutions in policy formulation and improved stakeholder engagement is encouraged to ensure the successful governance of the schemes. This will also strengthen the participation of farmers in the management of schemes, thus making Irrigation Management Transfer and other policy imperatives a reality at local level.

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CHAPTER 5: DETERMINANTS OF FARMERS' PARTICIPATION IN THE MANAGEMENT OF SMALLHOLDER IRRIGATION SCHEMES IN KWAZULU-NATAL PROVINCE, SOUTH AFRICA

Abstract

Participatory Irrigation Management is an important concept in the management of water resources. It fosters collective responsibility and rule compliance, the lack of which, creates a weakened environment for sustainable water use. This study adopted Principal Components Analysis (PCA) and Structural Equation Modelling (SEM) to evaluate the determinants of farmer's participation in the management of four smallholder irrigations schemes (SIS) in KwaZulu-Natal Province, South Africa. The selected schemes, Ndumo, Makhathini Flats, Mooi River and Tugela Ferry, are representative of the general management and farmer activities in smallholder irrigation schemes in the country. The study considered household data from 341 irrigators and found that those who participated in regulation and control management activities of SIS also participate in information sharing activities. Farmer's participation in the four identified management constructs has different determinants. The study agricultural training, land tenure security, credit access and co-operative membership positively influence farmers' participation in decision making. Additionally, irrigation water adequacy positively influences farmers' participation in making financial contributions in the schemes. The study recommends that better land agreements that would improve the security of tenure should be put in place to foster farmer participation. Farmers should receive and participate in agricultural and irrigation training to increase the likelihood of participating in the management of irrigation schemes, which in turn fosters the sustainable use of the water resource.

Keywords: Farmer participation in management; Smallholder Irrigation Schemes; Structural Equation Modelling; KwaZulu-Natal Province

5.1. Introduction

An irrigation scheme is defined as “an agricultural project involving multiple holdings that depend on a shared distribution system for access to irrigation water and, in some cases, on a shared water storage or diversion facility” (Van Averberke *et al.*, 2011, pg 797). In the South African context, a smallholder irrigation scheme (SIS) is defined as a multi-farmer irrigation project larger than five hectares in size, for the use of plot holders in rural or resource-poor

areas (Perret and Geysler, 2007). SIS play a key role in ensuring food security, particularly in rural areas, where most households rely on agriculture for food production (Muchara *et al.*, 2014; Sinyolo *et al.*, 2014). For this reason, the government has made efforts to include farmers in the management of SIS, through the adoption of the Irrigation Management Transfer (IMT) programme and the Participatory Irrigation Management (PIM) (Van Averberke, 2012) which are concepts that are focussed on involving the farmer in the management of scheme (*ibid*, 2012). The schemes have struggled to keep afloat despite the decentralization of their management (Cousins, 2013). Furthermore, weak institutions, lack of information, low levels of stakeholder participation, are problems that persist in SIS (Perret, 2002; Muchara *et al.*, 2014; Denby *et al.*, 2016). These problems, primarily related to the governance of the schemes, warrant the exploration of governance and other key associated factors in determining farmer participation in scheme management.

In recent decades, it has been widely accepted that public participation, that is, the involvement of individual and/or organised public members in the decision-making processes improves natural resource management by incorporating public knowledge, values, and perspectives (Özerol, 2012; Muchara *et al.*, 2014). In participation, stakeholders influence policy formulation and management decisions affecting their communities and establish a sense of ownership (Khalkheili and Zamani, 2009). Although the objectives of farmer participation vary between areas, they are generally directed at improving the operation and maintenance of the irrigation system, thus increasing the efficiency of resource use. Due to farmers being the major users of irrigation systems (Özerol, 2013), their collective action is required to ensure scheme sustainability (Muchara *et al.*, 2014; Özerol, 2013). This includes, but is not limited to, farmers establishing institutions for sustainable water management, hence the adoption of PIM in South Africa. PIM is a philosophy centred on involving farmers or water users² in the operation, management, and maintenance of irrigation systems (Kulkarni and Tyagi, 2012). This translates to the farmer being a “water manager” (Gomo *et al.*, 2014). It refers to farmer involvement in policy and decision making, planning, designing, construction and supervision, operation, and maintenance (O and M) and performance evaluation of irrigation systems.

Farmers involved in the management of SIS, build a sense of ownership, achieve collective action and benefit from improved rule compliance (Ostrom 1999; Özerol, 2012).

² The words “farmers” and “water-user” are used interchangeably throughout the manuscript.

Participation enables water users to learn from each other and ascertain the impacts of their individual and collective actions on resource sustainability. It also validates that users have a stake and a responsibility on the state and sustainability of the resource and increases the likelihood of water users adhering to the rules. In terms of institutions, it enables farmers to realize and understand the consequences of breaking the rules, and the benefits of complying with them (Muchara *et al.*, 2014). It improves compliance in that water users can “keep an eye” on each other’s actions and that everyone adheres to collective commitments, such as attending meetings (Ostrom, 1990; Özerol, 2012; Muchara *et al.*, 2014). The lack of farmer participation in the management of SIS has the potential of destabilizing the environment for sustainable water use and could lead to what Hardin (1968) termed the “tragedy of the commons”. The “tragedy of the commons” is an economic ideology based on individuals maximizing private utility from a given resource. In this case, water-users abstract water from a shared-resource system for their self-interest, while depleting or spoiling that resource through their unsustainable use. The lack of participation in management adversely affects positive collective action and subsequently, the sustainable use of a resource.

Literature highlights several factors that affect farmer participation in the management of SIS (Hayami and Kikuchi, 1999; Meinzen-Dick *et al.*, 2002; Muchara *et al.*, 2014) which may depend on geographical area, cultural norms, and institutional set-ups. The factors include social, economic as well as institutional. Meinzen-Dick *et al.* (2002) highlight that the presence of organizations such as co-operatives can play a unifying role in fostering of farmer participation. Evidence from India showed that the presence of social capital in the form of co-operatives, temples and other organizations tend to make farmers participate more in canal irrigation schemes. Meinzen-Dick *et al.* (2002) showed that the involvement of traditional leaders or trusted individuals also reduced the transaction costs of organizing people and makes users more willing to participate in collective action. Additionally, good relationships between users and other involved stakeholders, such as extension officers, have been shown to improve farmer participation (Khalkheili and Zamani, 2009).

Hayami and Kikuchi (1999) noted that heterogeneity among users might affect farmer participation. Farmers from different villages that share a resource may be unwilling to work together, and cooperation may be difficult. In comparison, people from the same community may generally be willing to work together, which in turn makes rule enforcement easy. A study in the Greek agri-environmental schemes suggested that agricultural training of the

farmers, farm economic performance, participation by neighbours or relatives, age, and basic education of a farmer influence farmer participation (Damianos and Giannakopoulos, 2002). Other factors include farm labour, family size and income, which all positively influence farmer participation in irrigation management. Families that have a large, irrigated portion of land are more likely to participate (Damianos and Giannakopoulos, 2002; Karli *et al.*, 2006; Muchara *et al.*, 2014). Furthermore, a large family has more labour and has a higher likelihood to attend meetings and other participatory activities (Khalkheili and Zamani, 2009).

Given its broad complex nature, participation in SIS has been analysed using various methods (Khalkheili and Zamani, 2009; Fischer and Qaim, 2012; Muchara *et al.*, 2014; Adekunle *et al.*, 2015). Khalkheili and Zamani (2009) evaluated the relationship between farmer participation in irrigation management and selected independent variables in the Doroodzan Dam Irrigation Network, Iran, using a Spearman correlation test. The study found that farmer attitudes toward participation in irrigation management had the highest correlation with farmers' active participation. The study also found a high correlation between irrigated farm size and farmer participation, and that on-going support and follow-up from government entities encourage farmer participation.

Muchara *et al.* (2014) used a Tobit regression model to evaluate the factors affecting farmer participation in irrigation water management in the Mooi River Irrigation Scheme, South Africa. The study found that financial contribution towards infrastructure maintenance, income from irrigation farming, frequency of attending irrigation management meetings, training in irrigation management determine farmer participation in collective activities. In some cases, binary choice models such as the Probit model are adopted to analyse the determinants of participation (Fischer and Qaim, 2012; Adekunle *et al.*, 2015), this dichotomous variable is used when participation is considered a choice, where farmers participate or not. Adekunle *et al.* (2015) used the logistic regression model to identify factors that affect participation in the Lower Niger River Basin Development Authority in Nigeria. The study found that knowledge of irrigation techniques, water supply in the dry season, as well as relationships between the authorities and irrigators influence farmer participation.

Participation, especially in irrigation scheme management, is important as it fosters collective responsibility, rule compliance, and importantly, positively influences scheme and farmer performance (Khalkheili and Zamani, 2009; Özerol, 2012; Muchara *et al.*, 2014). As such, this study seeks to evaluate the determinants of farmer's participation in the management of

four irrigation schemes in KwaZulu-Natal, representative of an average scheme in South Africa. It considers four facets of management, namely regulation and control, administration, information sharing and financial contributions. The analysis in this study differs from other participation studies as firstly it considers the relationships between various management activities in SIS. These relationships are vital in framing policy interventions in irrigation management, as well as informing which management activities can be improved in SIS. Secondly, it considers the determinants of farmers' participation in management. The research questions addressed are: i) Is there a relationship between management activities in which farmers participate in SIS and are the management activities divergent? ii) What are the determinants of farmers' participation in the management of SIS. The paper is composed of five main sections. The following section presents the conceptual framework, followed by Section 3, which describes the data collection, study sites and analytical methods. The subsequent section presents the findings of the study, followed by conclusions and recommendations.

5.2. Methodology

5.2.1. Conceptual Framework

PIM is an important concept in the management of water resources. It fosters the involvement of farmers in different aspects of resource management, such as planning, maintenance as well as financing (Kulkarni *et al.*, 2011). Participation in management activities such as decision-making, financial contribution, information dissemination as well as regulation and control, all depend on an individual's rational behaviour, as well as the attributes of the water use as shown in Figure 5.1. The attributes include the institutional setting, individual's socioeconomic and financial circumstances, and physical resource factors. Participation in management activities differs between water users. One water user could participate more in one activity over the other, and as such a holistic participation measure should be derived.

The framework includes the possible outcomes of participation. Participation in management encourages good governance, where issues such as rule compliance, conflict management and accountability are improved. It has the potential of promoting better utilization of water resources, as such, increasing the sustainability of the scheme (Kulkarni *et al.*, 2011). It also provides an incentive to manage water and use it efficiently, which then enhances agricultural production, subsequently improving welfare, including food security (Muchara *et al.*, 2014).

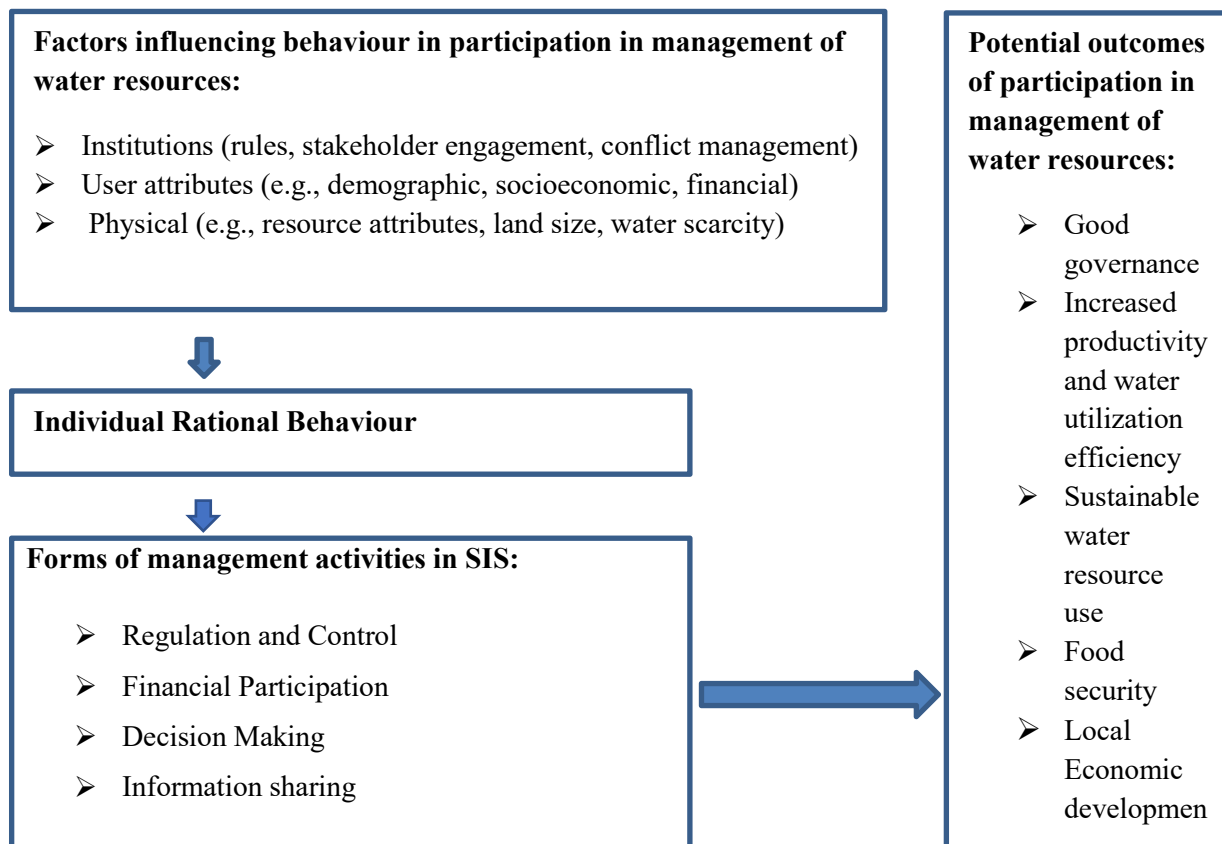


Figure 5.1. Framework for analysing participation in the management of SIS
 Source: Adapted from Muchara *et al.* (2014).

Furthermore, when farmers participate in the management of the scheme, collective economic activities such as group purchasing of inputs, development of agribusinesses are probable. This, in turn stimulates economic development in the communities (Garces-Restrepo *et al.*, 2007).

5.2.2. Empirical methods of data analysis

The study employed Structural Equation Modelling (SEM) and Principal Component Analysis (PCA). The SEM includes both the Confirmatory Factor Analysis (CFA) and multiple regression to observe the relationship between management constructs and evaluate the determinants of participation, respectively. PCA was used to generate the Participation in Management Indices (PIM).

Respondents ranked twelve irrigation management activities using a 3-point Likert scale from 1-if a water-users never participate to 3-if they always do. Although a larger scale such as a 5-point scale is recommended, the choice of the 3-point Likert was motivated by the type of

management activities, as an irrigator either never, sometimes, or always participated. The 12 management activities were grouped into four main themes, namely (1) **Participation in regulation and control** (Reporting unlawful behaviour (unauthorised handling, theft etc.); Engaging authorities regarding water issues; Reporting leakages along canals); (2) **Financial participation** (Contributing finance towards infrastructure; Contributing finances towards irrigation infrastructure maintenance, e.g. buying material, paying the maintenance people); (3) **Participation in decision making** (Electing/removing committee members; Formulating rules in the scheme; Irrigation water scheduling; Attending irrigation meetings); (4) **Participation in information sharing** (Distributing information about water issues (written or verbal); Helping other water-users manage/conservate water; Attending irrigation/water-related training). The activities are assumed to have equal weights; however, water-users may value them differently due to preference and the water resource system in place. Together, the activities give rise to the generation of Participation in Management Indices (PMI), which are used as proxies for participation in the management of the schemes. The different management activities were then used as observed variables to formulate a Structural Equation Model (SEM).

5.2.2.1. Structural Equation Modelling

SEM is a commonly used analytical tool in analysing cause-effect relationships in behavioural studies (Toma and Mathijs, 2007). It has grown popular due to its ability to combine exploratory factor analysis with multiple regression models. It determines a structure and relationships between both latent and observed variables. Latent variables are abstract variables that cannot be directly measured, as in the case of participation in management. However, several observed variables, such as questionnaire items that hypothetically measure latent variables are included in SEM models (Pradhananga *et al.*, 2015; Menozzi *et al.*, 2015). It is usually composed of two parts, namely the Structural and Measurement model. The structural model presents the part of the model that focusses on the relationship between the latent, unobserved variables. While the measurement model deals with the relationship between the observed and latent variables (Toma and Mathijs, 2007; Menozzi *et al.*, 2015). The use of SEM in this study was motivated by the need to evaluate the level of participation in management, made up of unobserved latent variables, using observed management activity questionnaire items. Additionally, it enables the evaluation of the relationship between the PCA generated Participation in Management Indexes (PMI) and

observed socio-economic and institutional variables. Within the SEM, this study employs Confirmatory Factor Analysis (CFA) and multiple regression.

5.2.2.2. Confirmatory Factor Analysis

CFA is a statistical technique used to confirm or verify the factor structure of a group of observed variables (Gallagher and Brown, 2013) and thus models the relationship between observed and latent variables. It is mainly used when there is some knowledge of what the observed variables represent, unlike Exploratory Factor Analysis, which is data-driven. CFA thus indicates which observable variables best represent the latent constructs and can therefore help determine whether all the variables or certain aspects of the latent constructs should be emphasized or improved (Gallagher and Brown, 2013; Menozzi *et al.*, 2015; Pradhananga *et al.*, 2015). For the study, CFA was used to address the first research question of determining the relationship between management activities which farmers participate in, to identify if farmers choose to equally participate in the four management themes/constructs. Furthermore, CFA was used to confirm whether the management constructs are statistically different, which validates constructing different proxies for each and running separate regression models. The Goodness of Fit test was assessed using the Root Mean-Square Error of Approximation (RMSEA). Cronbach's alpha was used to test the internal consistency of the latent variables in the model. Convergent and Discriminant Validity of the variables was also evaluated using factor loadings of the variables.

5.2.2.3. Principal Components Analysis

Due to the multidimensional nature of participation considered in this study, a binary method of accounting for participation could not be adopted (Muchara *et al.*, 2014). As such, PCA was used to generate composite PMI to account for the various activities in management that water-users could partake. PCA's dimension reduction attribute helps in capturing the multiple activities that are considered within the four facets of management, namely, financial, information-sharing, decision-making as well as regulation and control.

5.2.2.4. Multiple regression in SEM

The multiple regression was used to address the second research question and evaluate the role of governance and the determinants of participation in management.

The multiple regression in the SEM is represented by Equation 5.1:

$$Y_i = b_0 + b_1X_1 + b_2X_2 + \dots + b_{13}X_{13} + u_i \dots \dots \dots (1)$$

Where Y_i represents the PMI of a water-user, b_0 represents the constant term, X 's represent the socio-economic and institutional independent variables and u_i , the error term. The explanatory variables are presented and described in Table 5.1. All but the gender variables are expected to influence farmers' participation in scheme management positively. In most rural settings in South Africa, females participate more in farming activities (Murugani and Thamaga-Chitja 2018) and would most likely participate more in the schemes, than their male counterparts.

Table 5.1. Description of explanatory variables

Variable Name	Description	Exp sign
Age	Age of a water user (years)	+
Gender	The gender of the water user (1=Male; 0=Female)	-
Cooperative Member	A binary variable representing whether a water-user is part of an agricultural cooperative (1=Yes; 0=No)	+
Credit access	A binary variable which represents whether a farmer has access to credit or not (1=Yes; 0=No)	+
Land tenure security	A binary variable, representing whether a farmer is satisfied with the existing land tenure or not (1=Satisfied; 0=Not Satisfied)	+
Water Adequacy	A binary variable which indicates whether a water-users considers irrigation water they have access to adequate for their cropping requirements (1=Adequate; 0=Not adequate)	+
Household Governance index	A PCA derived composite score of water-users' perceptions of governance. Includes perceptions, understanding, and awareness of institutions and governance in smallholder irrigation schemes, at the household level.	+
Psychological capital	A PCA derived composite score which represents the self-efficacy, hope and resilience of a water-user	+

Using a Likert-scale, farmers' satisfaction of 25 governance issues were ranked. The household governance index considers the understanding of formal institutions governing irrigation schemes, as well as farmers' satisfaction of stakeholders' (governmental institutions, traditional authorities, non-governmental organizations) involvement. It also includes informal institutions set by the farmers to govern the scheme, and their satisfaction with the decision-making processes and committees of the schemes. It paints a picture of governance in the farmer's view, with a higher index indicating the farmer's satisfaction with how the scheme is governed. PCA was also used to derive a psychological capital variable which represents the confidence self-efficacy, hope and resilience of a water-user. Variables included in constructing this variable included whether the farmer is business-oriented, willing to take risks and invest in farming activities, optimistic about opportunities, resilient during duress, and able to adopt adaptation strategies. A higher index indicates positive psychological capital, which can be considered an important characteristic which enables farmers to manage resources effectively and sustainably (Chipfupa and Wale, 2018).

5.3. Results and Discussion

5.3.1. Descriptive Statistics

Table 5.2 presents descriptive statistics of water-user characteristics. The results indicate that most of the farmers have no formal education, with only about 4% having received tertiary education. Most of the water-users consider themselves secure in terms of land tenure.

Table 5.2. Descriptive Statistics of water-users in SIS

Variables	Percentage % (N=341)
Categorical variables	
Gender	
Male=1	1=22.62
Female=0	0=77.38
Education	
No formal=1	1 = 50.66
Primary=2	2= 27.30
High School=3	3=17.76
Formal=4	4=4.28
Occupation	
Farmer=1	1=75.66
Other=0	0=24.34
Agricultural Training	
Yes=1	1= 54.43
No=0	0=45.57
Irrigation training	
Yes=1	1=29.51
No=0	0=70.49
Land tenure security	
Yes=1	1=74.59
No=0	0=25.41
Willing to participate in executive management	
Yes=1	1=67.05
No=0	0=32.95
Credit access	
Yes=1	1=60.19
No=0	0=39.81

Cooperative membership	Yes=1	1=36.39
	No=0	0= 63.61
Irrigation water adequacy	Yes=1	1= 37.21
	No=0	0=62.79

Continuous variables	
Age (years):	Mean= 54 Standard Deviation= 13.95
Total Income (ZAR):	Mean=18 823 Standard Deviation= 50 066

Source: Survey data (2018)

About 63% of the farmers feel that irrigation water is inadequate for their cropping requirements and 67% are willing to take up executive roles in local scheme management. Although the farmers use irrigation water, only 30% have received irrigation training. As is the case with many rural settings, there are more female water users, accounting for about 77% of the sample. About 36% of the farmers are members of agricultural co-operatives, while 60% have access to credit.

The following subsection presents the empirical results. Firstly, the SEM analysis results are presented, addressing the objective of evaluating the relationship between management constructs in which farmers participate, followed by the regression results of the determinants of farmer's participation in the management of SIS

5.3.2. Structural Equation Model Analysis Results

Confirmatory Factor Analysis (CFA)

To successfully run a CFA model, it is important that the observed and latent variables meet certain criteria, and that model fit is achieved. The Goodness of Fit test was assessed using the Root Mean-Square Error of Approximation (RMSEA). The RMSEA value of 0.04 for the model was statistically significant at 1% level, and being below 0.07, indicates a significant , good model fit (Steiger, 2007). Cronbach's alpha was used to test the internal consistency of the latent variables in the model. Convergent and Discriminant Validity of the variables was also evaluated using factor loadings of the variables. Table 5.3 shows the results of the internal consistency of the latent and observed variables. The latent variables showed internal consistency ranging from 0.57 to 0.91. Although the latent constructs of "participation in the distribution of information" and "regulation and control" are lower, based on Pradhananga *et*

al. (2015), the overall measure of 0.81 shows acceptable internal consistency, given by a value that is $\alpha \geq 0.74$.

Table 5.3. Reliability analysis of participation in management constructs

Latent constructs	Conbrach's Alpha α^a
Participation in regulation and control	0.57
Participation in management decision making	0.84
Participation in the distribution of information	0.57
Participation in financing	0.91
Overall model	0.81

^a Scale reliability coefficient

For discriminant validity, the correlations between latent variables should be less than 0.9 (Gallagher and Brown, 2013). This indicates that the latent variables included in the model are divergent or distinct management constructs. As shown in Table 5.4, the correlations range from 0.56 to 0.88, which are below 0.9, as such, proving discriminant validity (Gallagher and Brown, 2013). Therefore, the management constructs are different, and separate focus should be emphasized in interventions to improve them. Varying factors could also determine the constructs. Apart from discriminant validity, the correlation between constructs also gives an indication of where improvements can be made in terms of water-users management activities.

For instance, water-users who are involved in making management decisions should be encouraged to distribute water information, attend irrigation training as well as help other farmers conserve water. There is a strong relationship between Regulation and Control, and Information Sharing ($r=0.88$), Information Sharing and Finance ($r=0.81$), as well as Regulation Control and Finance ($r=0.69$). This is an indication that farmers who are active in the observed activities of one latent construct are also active in the other. The correlation between Decision Making and Finance ($r=0.56$), shows that a strong relationship does not exist between the two. This shows that farmers that participate in financing activities do not necessarily participate in decision-making activities.

Table 5.4. Covariances and correlations between latent management constructs

Latent Constructs	Covariances	Correlation coefficient
Regulation and Control-Information sharing	0.15	0.88
Regulation and Control-Management decision-making	1.53	0.58
Regulation and Control-Finance	0.18	0.69
Management decision making- Information sharing	0.12	0.59
Management decision making- Finance	0.18	0.56
Information sharing and-Finance	0.16	0.81

Source: Survey data (2018)

5.3.4. Principal Components results of contributors to participation in management indices

Participation in the management of the schemes is not one-dimensional as it is characterized by different facets. Therefore, the PCA was employed to group the dominant activities that determine the participation in management and to develop proxies of participation. The results are presented in Table 5.5. For model diagnostics, the study used Bartlett's sphericity test to check if the observed correlation matrix diverges significantly from the identity matrix (theoretical matrix under H0: the variables are orthogonal). It further applied the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, an indicator of the appropriateness of the use of PCA on the data. The Bartlett's test was significant ($P < 0.001$) and therefore rejects the null hypothesis that variables are not inter-correlated. The KMO value of 0.77 is middling, and a good indicator that overall, the variables have a lot in common, and the use of PCA is justified (Kaiser 1974). Applying the Kaiser criterion and a scree plot, four PCs were retained. The four retained PCs cumulatively explained 69% of the variation and were named based on the dominant management activities.

Table 5.5. Principal component analysis of the participation in management activities

Variables	Principal Components			
	PC1-Decision making	PC2-Financial contribution	PC3-Information distribution	PC4-Stakeholder engagement
Finance irrigation maintenance	0.177	0.564	-0.317	-0.004
Contribute finance for irrigation	0.194	0.569	-0.289	-0.104
Attend management meetings	0.321	-0.179	0.001	0.115
Attend irrigation related training	0.282	-0.153	-0.201	0.559
Engage authorities	0.302	0.086	0.018	0.490
Distribute irrigation information	0.082	0.307	0.659	0.178
Help other farmers conserve water	0.259	0.054	0.497	0.090
Election of committee members	0.375	-0.226	-0.073	-0.095
Formulation of scheme rules	0.398	-0.237	-0.064	-0.222
Formulation of irrigation schedule	0.353	-0.214	-0.054	-0.325
Report unlawful behaviour	0.313	0.128	-0.051	-0.018
Report leakages along canals	0.245	0.162	0.280	-0.467
Eigenvalues	4.065	1.92	1.3	1.01
Variance explained	34%	16%	11%	8%
Cumulative Variance explained	34%	50%	61%	69%
Keiser-Meyer-Olkin (KMO)	0.77			
Bartlett's test of Sphericity	Chi-Square = 1381.24			
	Degrees of Freedom = 66			
	P-value = 0.0001			

Notes: Component loadings greater than |0.30| are highlighted in bold print

Source: Survey data (2018).

The first PC, Decision-making, explained 34% of the variation, and dominated by the election of committees, formulating scheme rules and irrigation schedule, and engaging authorities. The second PC, named Financial contribution, is dominated by irrigator's financial contribution to irrigation activities, maintaining infrastructure, distributing irrigation

information and accounts for 16% of the variation. The third PC- named Distribution of information, accounts for 11 % of the variation and is dominated by irrigators' activities of distributing irrigation information and helping other farmers conserve water. The last PC- Stakeholder engagement, accounts for 8% of the variation and is dominated by farmers' participation in engaging with authorities and attending water-related training.

5.3.5. Multiple regression results of the determinants of farmer's participation in the management of SIS

Using the multiple regression model, four models were estimated, using PCA derived participation indices as dependent variables. The results yielded a mean Variance Inflation Factor of 1.26, indicating a low level of multicollinearity between the independent variables. The results presented in Table 5.6 suggest that independent variables have varying effects on the different management constructs.

Decision Making

The results show that the Household Governance Index (HGI) positively affects farmers' participation in decision-making activities. The index includes awareness of formal and institutions, understanding of rules and satisfaction with stakeholder involvement in the schemes. This shows that farmers who generally know the institutions, formal and informal, would be more inclined to participate in formulating rules, schedules, and electing committee members. A key aspect of Participatory Irrigation Management is the farmer being the manager of the resource and building a sense of ownership (Gomo *et al.* 2014; Muchara *et al.* 2014). It is therefore vital that farmers are satisfied with the institutional arrangements, to participate in making decisions in the schemes.

Land tenure security is also a statistically significant predictor of participation in decision making. Farmers who are satisfied with their land tenure, are more likely to invest efforts in irrigation activities and would want to hold a stake in the decision making within the scheme. Hence are more likely to participate more in the management of the scheme. The cooperative membership variable was found to be a statistically significant determinant of participation in decision-making activities. This is consistent with the findings of Meinzen-Dick *et al.* (2002), who found that farmers who are part of cooperatives tend to participate more in the schemes. Co-operatives play a unifying role in terms of participation in the schemes. Agricultural training significantly affects farmer participation in decision making. When farmers know the

value of irrigated agriculture and how to manage and conserve water, they gain the propensity to maintain the resource, as such will most likely participate in management activities to ensure the sustainable use of the scheme.

Table 5.6. Determinants of farmer's participation in the management of SIS

Independent Variables	PC1-Decision making	PC2-Financial contribution	PC3-Information distribution	PC4-Stakeholder engagement	V.I.F
Age	0.01 (0.01)	-0.001 (0.006)	0.01 (0.01)	0.01*** (0.01)	1.11
Gender	0.38 (0.29)	0.27(0.23)	-0.33**(0.17)	0.32***(0.16)	1.25
Governance Index	0.12** (0.05)	0.033 (0.03)	0.04 (0.03)	0.02 (0.03)	1.29
Water Adequacy	0.37 (0.244)	0.69***(0.18)	-0.23(0.14)	0.22*(0.13)	1.19
Land security	0.71*** (0.28)	-0.66(0.2)	0.05 (0.15)	-0.29**(0.41)	1.17
Credit access	-0.35 (0.21)	0.19 (0.16)	0.79***(0.12)	0.28**(0.11)	1.11
Agricultural training	0.66***(0.25)	-0.3 (0.18)	-0.08(0.14)	0.23*(0.13)	1.36
Irrigation training	-0.11 (0.26)	0.29 (0.2)	-0.06(0.15)	0.09 (0.14)	1.3
Household income	2.81e-06 (2.89e-06)	3.4e-06(2.9e-06)	9.44e-06(1.62e-06)	-3.03e-06(1.53e-06)	1.25
Co-operative membership	0.66**(0.261)	0.39*(0.21)	-0.22(0.14)	0.1(0.14)	1.29
Psychological capital	0.08 (0.06)	0.0988(0.04)	0.13*** (0.33)	-0.13***(0.03)	1.46

Note: ***,**,*; significant at 1%, 5% and 10%, respectively. Mean VIF= 1.25

Source: Survey Data (2018).

Financial Contributions

The results in Table 5.6 show that farmers who feel that the water they receive from irrigation is adequate for the cropping needs tend to participate more in financial contribution. This is logical sense, as farmers would financially contribute towards the maintenance of infrastructure and other irrigation related activities to ensure that they still receive an adequate supply of irrigation water. Water adequacy has a positive effect on participation. Consistent with the findings of Muchara *et al.* (2014), when farmers feel that their water is adequate for their cropping requirements, they will tend to participate in irrigation activities. Farmers who are part of co-operatives participate more in the finance manage construct. This is consistent with the findings of Meinen-Dick *et al.* (2002), who found that farmers who are part of cooperatives tend to participate more. Co-operatives play a unifying role in terms

of participation; information is easily distributed, and members would more likely make financial contributions like their counterparts.

Information Distribution

The results show that female farmers participate more in disseminating information amongst their peers, during Focus Group Discussions, farmers noted that they receive most of the information regarding the schemes come from fellow farmers, particularly in cooperative meetings. Consistent with *a priori* expectations, females make the bulk of farmers in rural areas. Therefore, it is expected that they would be more involved in distributing information. This is consistent with the findings of Katungi *et al.* (2008) who although found that females are disadvantaged in accessing information about technologies in agriculture, they participate more in sharing information locally. Farmers with higher psychological capital, are those that are confident in themselves as commercial farmers, resilient, self-reliant and are hopeful in terms of governing the schemes and improving their communities, as such they are more likely to share information with other farmers. Consistent with *a priori* expectations, access to credit has a positive effect on participation in information sharing. Farmers who have access to credit are more likely to have better access to information and therefore would participate in distributing it to other farmers.

Stakeholder engagement

Farmers who have higher psychological capital tend to more self-reliant, are business-oriented and resilient, and as such, they would be less inclined to engage with authorities, particularly for support. The stakeholder engagement management construct also includes engaging authorities through attending irrigation training. The results show that male farmers tend to participate more in engaging authorities and that indeed, farmers who have received agricultural training, would also participate more in irrigation training. Consistent with Damianos and Giannakopoulos (2002), who found that age positively influences water users' participation in management, the age coefficient estimate shows that older farmers participate more in engaging with stakeholders. With the average age of 54 years, it is highly likely that members who participate in scheme management are in the older age groups. During FGDs, farmers indicated that young people are less involved in scheme management and not interested in agriculture. The positive coefficient estimate of the age variable shows that the propensity for farmers to participate in engaging authorities increases with age. Possibly

because the elderly regard the schemes as their lifeline. It further motivates why stakeholder engagement should be improved, as it is crucial in the sound management of water resources (Ricart *et al.* 2019).

5.4. Conclusions and Recommendations

Evaluating and understanding the determinants of participation in irrigation management is key to establishing interventions in water resource management. When farmers do not participate in the management of schemes, the unsustainable use of the resource is highly likely. Therefore, the study employed econometric models to evaluate the role of governance and other determinants of water-users' participation in the management of irrigation schemes. The study concludes that varying factors drive farmers' participation in different management constructs. A combination of institutional and socio-economic variables also influences participation in management. It also notes that water-users participation in one management activity does not translate to the full involvement in other activities.

Governance index is a multi-dimensional composite value which positively affects scheme management. Farmers who are satisfied with stakeholder engagement, the involvement of traditional authorities and current informal institutions governing the scheme (higher Governance index), participate more in the schemes. The results suggest that farmers should be made aware of the formal institutions and improve their engagement with relevant stakeholders (vice versa) as this affects their propensity to want to take part in irrigation management activities. Therefore, efforts should be put in strengthening the formal and informal institutions in irrigation schemes. A better understanding of institutions and support from relevant officials would encourage farmers to participate, as when needed, farmers know who to consult for support.

Agricultural training should be improved as this will expose farmers to methods and understanding of sustainable use of water and water resources. Additionally, training should include awareness of strategies such as PIM, which will give farmers the understanding of how each management activity is important as the other, and how the successful management of the scheme will yield better outcomes. Through this, trained farmers will most likely be inclined to participate in the management of the schemes. Irrigators that feel that water is adequate for their crop production participate in scheme management, therefore, access to

water should be improved throughout the schemes. This can be achieved through better water scheduling arrangements and proper rule enforcement. Furthermore, policy interventions should also be focussed on establishing ways of ensuring that farmers have secure land tenure. This provides incentives and encourages participation in management, through irrigators' need to produce, irrigate, and manage water resources.

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CHAPTER 6: EVALUATION OF WATER-USER PERFORMANCE IN SMALLHOLDER IRRIGATION SCHEMES IN KWAZULU-NATAL PROVINCE, SOUTH AFRICA: A STOCHASTIC META-FRONTIER ANALYSIS

Abstract

Smallholder Irrigation Schemes (SIS) are pivotal in sustaining livelihoods and creating employment in rural communities of South Africa. However, despite the revitalization and rehabilitation of SIS by the government, the performance of farmers is still below par. This study evaluates the performance of water-users across four SIS in KwaZulu-Natal Province namely, Mooi River, Makhathini Flats, Tugela Ferry and Ndumo. The schemes have contrasting institutional arrangements, irrigation technology and other characteristics such as plot sizes and water extraction methods. Data were collected using questionnaires from 306 randomly sampled households across the four schemes. Technical Efficiency (TE) was used as a proxy for water-user performance and was measured using Cobb-Douglas and Translog production functions. A Stochastic Meta-Frontier Analysis (SMFA) method was employed to measure the overall efficiency of water-users across the schemes and to determine the technical gap ratios. The SMFA results show that the overall average meta-efficiency is 0.85, while the group-specific Stochastic Frontiers (SF) yielded mean TE scores of 0.51, 0.71, 0.56 for MRIS, TFIS, MFIS-NIS, respectively, placing water-users in MRIS on the lowest productivity frontier. The efficiency model results showed that governance index, farmer psychological capital, land tenure security, credit access, cooperative membership, and gender, significantly affect water-users' technical efficiency. The study concludes that interventions should be geared towards strengthening institutions, empowerment of farmers through relevant training and access to credit. Furthermore, adequacy of water and its availability in the schemes should be improved as both are key in ensuring profitability and productivity of water.

Keywords: Smallholder Irrigation Scheme, Stochastic Meta-Frontier Analysis, Technical Efficiency.

6.1. Introduction

Over the years, climate change has impacted South African agriculture as evident in rapid changes in temperatures and rainfall, which subsequently is putting pressure on the demand for water in agricultural production (Bernstein, 2013). As such, irrigation is increasingly

becoming a critical factor in enhancing agricultural productivity and consequently alleviating poverty in rural areas (Sinyolo *et al.*, 2014). It is estimated that about 1.3 million hectares of land in South Africa are under irrigation; of which about 0.1 million hectares are under smallholder irrigation schemes (SIS) (Van Averbeke, 2008). SIS are defined as “agricultural projects that involve multiple holdings, which depend on a shared distribution system for access to irrigation water” (Van Averbeke 2012, 413). In South Africa, SIS were mainly put in place with the primary focus of food security of the irrigators (Van Averbeke, 2012), however, an increasing number of smallholder farmers are gradually shifting from subsistence to commercial production.

In general, SISs in the country are underperforming due to a combination of infrastructural and economic factors (Van Averberke *et al.*, 2011; Muchara *et al.*, 2014; Sinyolo *et al.*, 2014). However, often overlooked, is the potential effect of institutional arrangements on farmers’ performance in SISs. Institutions are defined in several ways in different schools of thought. In water resource management, institutions are ground rules for resource use, and can either be formal or informal. The former includes policies, rules, regulations, organizations, plans, procedures, while the latter represents norms, traditions, practices and customs (Bandaragoda, 2001; Muller, 2012; Muchara, 2014). Institutions have the potential to affect the costs of exchange and production, as well as the behaviour of decision-making entities. Apart from institutions, agricultural, social, and economic factors affect the performance of water-users³ in SIS

Factors affecting farm performance

Land is a key input in agricultural production whose size and tenure have been highlighted as factors that either positively or negatively affect farm performance (Manjunatha *et al.*, 2013; Dlamini and Masuku, 2013; Rajendran *et al.*, 2015). Manjunatha *et al.* (2013) analysed the impact of land fragmentation, land ownership and farm size on farm technical efficiency. The study found that smaller farms have lower inefficiencies, this was consistent with Debebe *et al.* (2015) who found that smallholding size of land yield better crop efficiencies due to lower transaction costs and easier management compared to larger farms. In contrast, Rios and Shively (2016) found that small farms were less efficient than larger farms due to scale investments in irrigation infrastructure. Land ownership was also found to positively affect farm performance (Manjunatha *et al.*, 2013; Ebarle *et al.*, 2015). A study conducted in

³ Water-users and farmers are used interchangeably throughout the manuscript.

Southern Philippines on the profitability of vegetable farmers suggested that farmers that owned land had a higher probability of running profitable farm businesses (Ebarle *et al.*, 2015), which was also found to be the case in India (Manjunatha *et al.*, 2013).

Literature highlights several economic factors that affect farm performance, and these include low production costs, high agricultural yields and prices, as well low marketing costs (Dlamini and Masuku, 2013; Ebarle *et al.*, 2015; Mushi and Ngaruko, 2015). Dlamini and Masuku (2013) found that farming experience has a positive influence on farm profitability amongst sugarcane farmers in Swaziland. Social factors such as farmer groups and cooperatives have been found to improve farm performance (Debebe *et al.*, 2015; Herbert, 2015). A study conducted in the Democratic Republic of Congo, Burundi and Rwanda showed that farmers who were members of farmer groups performed better than those that were not and had a higher probability of being economically or financially efficient in their agricultural production (Herbert, 2015). This was due to the sharing of valuable information.

Debebe *et al.* (2015) found that access to extension services is an important factor that affects farm performance because extension services provide farmers with new information and provide recommendations on agricultural activities and market access. Mumba *et al.* (2012) found that the closer the farm is to the market, the higher the probabilities of farm profitability as shorter distances to markets usually translate into lower transaction costs. Previous studies have adopted several proxies and measures of performance; this has also resulted in the use of techniques used to analyse the factors which affect performance (Speelman *et al.*, 2008; Ojo, 2006; Verhofstadt and Maertens, 2014; Tajbakhsh and Hassini, 2015).

Methods used in farm performance evaluation

Different methods, including but not limited to accounting, economic, agricultural, and environmental (performance) indicators have been used to evaluate factors affecting farmer performance (Speelman *et al.*, 2008; Verhofstadt and Maertens, 2014). The performance of a farm can be assessed by estimating its efficiency and productivity. Technical Efficiency (TE) can be estimated by comparing the observed output to the potential maximum optimum output, given the total inputs used. TE is attained when a farm can produce the maximum feasible output from a given bundle of inputs, or by using the minimum feasible amounts of

inputs to produce a certain level of outputs, using a particular technology (Ojo, 2006; Speelman *et al.*, 2008).

TE is generally measured using Data Envelopment Analysis (DEA) or the Stochastic Frontier Analysis (SFA). The latter is a parametric approach used when several independent variables can be estimated (Buckley and Carney, 2013). The DEA is a non-parametric approach which enables the evaluation of relative efficiencies of a set of comparable outcomes and does not require that the explanatory variables be estimated (Tajbakhsh and Hassini, 2015). This study considers the Cobb-Douglas and Translog production functions to estimate technical efficiencies of irrigators in four irrigation schemes using the SFA.

The schemes have different methods of irrigation, which constitutes technology. The method of irrigation affects water access, availability, which consequently affects the productivity of the farmers. The study differs from other performance studies conducted in irrigation as it considers the performance of water-users in four SISs with varying irrigation systems and institutional arrangements in KwaZulu-Natal. The estimation of measures of technical efficiency, including exogenous variables enables policy recommendations to be made, not only to improve technical efficiency but also to provide an opportunity to enhance performance through improved institutional arrangements, subject to technical agri-production constraints. The study aims to provide empirical evidence of the technical efficiency of water-users as well as the inefficiency effects in SIS in KwaZulu-Natal, South Africa. The following section outlines the conceptual framework adopted and is followed by the methodology, presentation and discussion of results, conclusions, and recommendations.

6.2. Methodology

6.2.1. Theoretical Framework

A farmer uses various inputs to yield a quantity of produce that is sold to generate a certain amount of revenue. Assuming that an i^{th} farmer belonging to j^{th} irrigation scheme combines a number of X_i inputs, to attain a Y_i in sales, technical efficiency can be associated with a set of group and farm-specific exogenous variables. Technical efficiency is the maximization of output given a certain number of inputs and can be outlined on a production frontier. A meta-frontier envelopes the group-specific efficiencies and helps with the derivation of the technology gap ratio (TGR), which indicates the distance between farms in a certain group to the most efficient in the sample. A meta-frontier is represented in Figure 6.1, enveloping the group-specific Frontiers 1, 2, 3 and 4. At any given input x_i , a water-user's given output

relative to the meta-frontier, $F^M(x_{ji})$ includes the technology gap-ratio, the water-users' technical efficiency ($F^i(x_{ji})$), as well as the random noise term (e^{-ujt}) (Huang *et al.*, 2014).

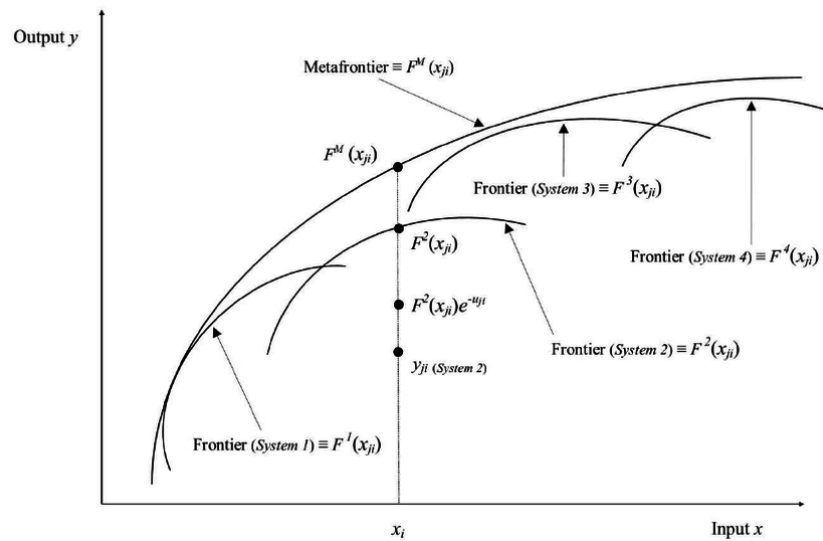


Figure 6.1. Concept of a Stochastic meta-frontier
Source: Melo-Becerra and Orozco (2017)

6.2.2. Study Sites and Data Collection

The study is focused on four irrigation schemes in KwaZulu-Natal Province, namely Tugela Ferry, Ndumo, Mooi River and Makhathini Flats. The schemes were chosen due to their contrasting characteristics, including governance regimes, farmer compositions, irrigation type and region. Makhathini Flats (MFIS) and Ndumo (NIS) Irrigation Schemes are situated in the Umkhanyakude District, under the Jozini Local Municipality, north-eastern KZN. The Makhathini Flats Irrigation Scheme comprises of individual (mostly males) and cooperative irrigators (mostly women). The individual farmers produce sugarcane, while the cooperatives mostly produce vegetables. The individual irrigators operate on land provided by the land trusts (under traditional authorities), and the cooperative irrigators operate on state-owned land. The Ndumo B Irrigation scheme is a 500ha scheme operated by 50 farmers. The farmers produce a wide variety of commodities and production is more commercially oriented. The irrigators belong to two cooperatives, one representing the older and the other, newer block.

The Tugela Ferry (TFIS) and Mooi River Irrigation Schemes (MRIS) are situated in central KZN, under the uMzinyathi District, in the Msinga Local Municipality. The MRIS comprises of about 840 irrigators, drawing water from a 25km scheme. It is undergoing rehabilitation, and water access is extremely variable. TFIS comprises about 1500 farmers on 800 ha of land.

The TFIS irrigators use various water transmission mechanisms (canal via gravity, diesel and electric pumps) and farmer production is more for subsistence. The farmers operate on an average of 0.4ha of land allocated through the local traditional authority. Figure 2 shows the location of the irrigation schemes across the province.

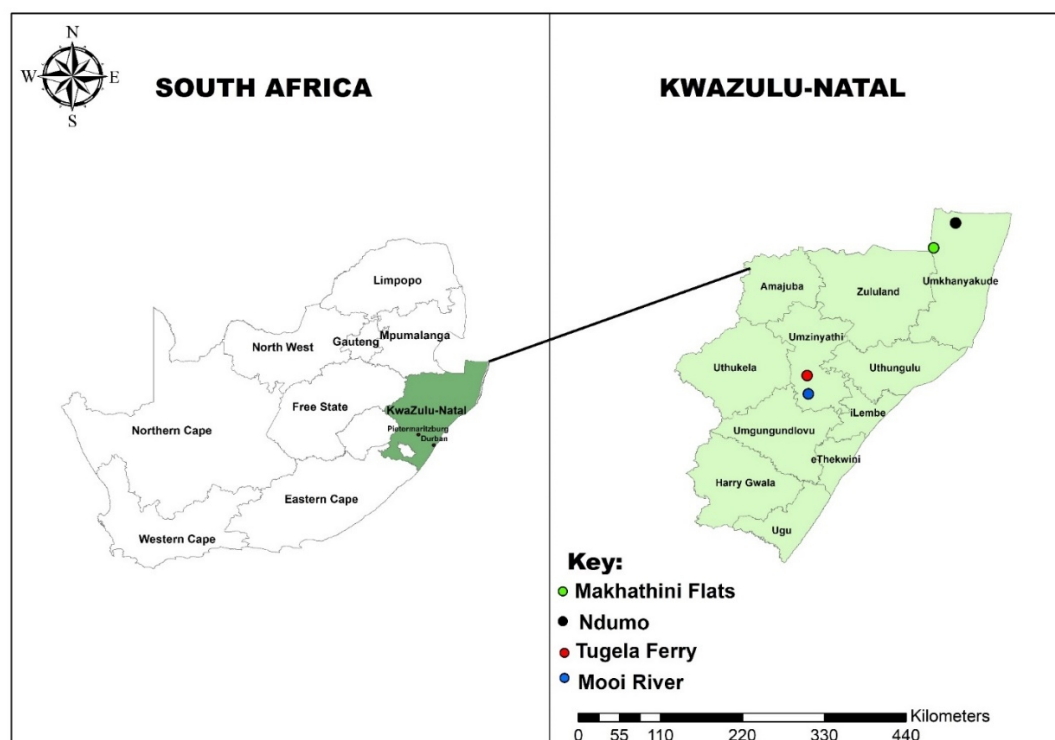


Figure 6.2: Map of KwaZulu-Natal Province, South Africa

The systematic random sampling was employed, 306 farmers were selected. Due to the different sizes of the scheme, 100 farmers were selected in the MRIS and TFIS, located in the Msinga Local Municipality. The same sampling procedure was used in the Jozini local municipality, where 66 farmers from the MFIS and 40 from the NIS were selected. Focus group discussions (FGD) were also held in each of the schemes.

Irrigation technology and key contrasting characteristics of the schemes:

Mooi River Irrigation Scheme

MRIS is situated in the Msinga Local Municipality. Irrigation water flows through a gravity flow canal from the Mooi River. The scheme is divided into three parts, the upper, middle, and lower tail of the canal, comprising fifteen blocks in total. Farmers get water through distribution canals on specifically scheduled days. The schedule is set by farmers and block

committees. The land is allocated by the local traditional authority, and farmers are part of agricultural cooperatives.

Tugela Ferry Irrigation Scheme

TFIS is also situated in the Msinga Local Municipality, and farmers irrigate through a short-furrow system. It is an older irrigation scheme that spans across 540 hectares with about 1500 water-users. Plots in the scheme are allocated by the local traditional authority. Most of the farmers are not part of cooperatives, and water access is subject to fee payment.

Makhathini Flats Irrigation Scheme

MFIS is situated in the Jozini Local Municipality, and irrigation water is extracted through a main canal, conveying water to the plots. The scheme has about 538 hectares in use by 600 plot holders. The land is allocated through trusts, and a monthly fee must be paid to the local managing agency for water access. Some farmers in the scheme occupy about 10 hectares of land, while the rest, who are part of cooperatives produce on smaller plots.

Ndumo Irrigation Scheme

NIS is situated in the Jozini Local Municipality, is about 500 hectares occupied by about 50 farmers. An underground water conveyance system is used for the extraction of water and diverted into the plots through pipes. Farmers do not pay for water but pay for electricity pro-rata. There are two main cooperatives that farmers belong to the scheme. Land is allocated through the local traditional authority.

6.2.3. Empirical method of evaluating technical efficiency of water-users in SIS

Water-users maximize output using a combination of inputs. Given the differences in institutional arrangements and production systems, the technical efficiency of water-users is not comparable using a comprehensive production frontier (Huang *et al.* 2014; Melo-Becerra and Orozco 2017). In maximizing output, the choice of production and input combinations may be affected by factors such as climatic conditions, institutional arrangements, land tenure and water availability, that are beyond the individual's control. Battese and Rao (2002) introduced the application of a meta-frontier to estimate technical efficiencies across different groups. Battese *et al.* (2004) and O'Donnell *et al.* (2008) later introduced a two-step method of estimating technical efficiencies of decision-making units. The first step involves the calculation of efficiencies using stochastic frontiers, while the second stage is composed of

linear programming methods to estimate the meta-frontiers. Huang *et al.* (2014) proposed a new technique that considers a stochastic meta-frontier instead of a mathematical linear programming approach. The advantage of a stochastic meta-frontier method is that statistical properties of the frontier are ensured in the second stage, thus controlling for white noise, as opposed to the mathematical model. As such, this study adopts a Stochastic Meta-frontier Analysis to estimate the technical efficiencies of water-users in the four irrigation schemes.

Suppose for the j^{th} irrigation scheme, the i^{th} water-user's stochastic frontier at a certain period is modelled as:

$$Y_{jit} = f_{jt}(x_{jit})e^{v_{jit}-u_{jit}} \quad j=1,2,3,\dots,J; i=1,2,3,\dots,N_j \quad (1)$$

Where Y_{ji} denotes the scalar output at time t , and x_{jit} denotes the scalar inputs of the i^{th} water user in the j^{th} irrigation scheme. The random errors v_{jit} represent statistical noise; a normally distributed error term that captures noise with the notion that deviations from the frontier are due to variables beyond the control of the water-user. u_{jit} are non-zero error terms which represent technical inefficiency. The assumption is that the v_{ji} 's are distributed independently and are independent of the U_{ji} 's (Melo-Becerra and Orozco, 2017). The technical efficiency in production is then given by Equation 2:

$$TE_{ji}^j = Y_{ji} / f(X_{ji})e^{v_j} \quad (2)$$

The technical efficiency is associated with a set of farm-specific exogenous variables within the irrigation schemes. The meta-frontier production function for all water-users in the schemes is defined as $f^M(x_{ji})$, where the function is the same for all irrigation schemes. The meta-frontier $f^M(x_{ji})$, envelopes scheme production frontiers $f(x_{ji})$, in the following relationship.

$$f(X_{ji}) = f^M(X_{ji})e^{-u_{ji}^M} \quad (3)$$

where $-u_{ji}^M$ is ≥ 0 , therefore at any given period, $f^M(\cdot) > f(\cdot)$ and the ratio between the j^{th} irrigation scheme production frontier and the meta-production frontier gives the Technology Gap Ratio (TGR);

$$TGR = f^j(X_{ji}) / f^M(X_{ji}) = e^{-u_{ji}^M} \leq 1 \quad (4)$$

Thus, at any given input level, a water-user's observed output Y_{ji} , relative to the meta-frontier ($f^M(X_{ji})$) consists of three components, the TGR = $e^{-u_{ji}^M}$; the water-user's TE = $e^{-u_{ji}^U}$; and the random noise term $e^{v_{ji}}$.

Therefore, at a period of time;

$$Y_{ji}/f^M(X_{ji}) = \text{TGR} \times \text{TE} \times e^{v_{ji}} \quad (5)$$

Following the approach by Huang *et al.* (2014), the meta-frontier estimation is summarized in Equations 6 and 7.

$$\ln Y_{ji} = \ln f_j(X_{ji}) + V_{ji} - U_{ji}, \quad i=1,2,\dots,n \quad (6)$$

$$\ln f_j^*(X_{ji}) = \ln f^M(X_{ji}) + V_{ji}^M - U_{ji}^M \quad (7)$$

where $\ln f_j^*(X_{ji})$ represents the estimates of the irrigation scheme-specific frontier, which should be estimated j times. The estimates $\ln f_j(X_{ji})$ from all the schemes are then pooled to estimate the meta-frontier (equation 7). To ensure that the estimated meta-frontier is greater or equal to the scheme frontiers, the TGR is always less or equal to unity. The model was estimated using the Cobb-Douglas and Translog production functions as they are commonly used in efficiency studies in agriculture (Ghoshal and Goswami 2017; Sujan *et al.* 2017; Njuki and Bravo-Ureta 2018, Makombe *et al.* 2017). The estimated inefficiency models are given by equation 8, as:

$$U_{ji} = \sigma_0 + \sigma_1^j W_{j1}^j + \dots + \sigma_i^j W_{ji}^j \quad (8)$$

Where U_{ji} represents the inefficiency of a water-user in the j th irrigation scheme, σ_0 represents the constant term, W^j represent the exogenous variables in the model and σ_i represents unknown parameter estimates. The choice of functional form to be used in estimating a stochastic production function is important. The Translog and Cobb-Douglas production functions are commonly used in efficiency studies (Ghoshal and Goswami 2017; Sujan *et al.* 2017; Makombe *et al.* 2017). Cobb-Douglas is usually tested against a relatively flexible function form, such as the Translog function (Bezat 2011; Makombe *et al.* 2017). The two forms yield partial elasticities of inputs. Additionally, a test to determine whether inefficiency effects need to be included in the model is performed. This indicates whether non-production or exogenous variables should be included in the model. As such two

hypotheses are tested, i.e., that the Cobb-Douglas is more appropriate than the Translog production function, and that inefficiency effects should be included in the model.

6.3. Results and Discussion

6.3.1. Description of explanatory variables and descriptive statistics

The study estimated the models with a mix of continuous and categorical socio-economic and production variables. Three input variables were used for the estimation of the production function as determinants of efficiency, while ten exogenous variables were used for the inefficiency model. The variables with their expected regression signs are presented in Table 6.1. The output variable is presented by the product of the quantity produced and price. The number of irrigation hours was used as a proxy for irrigation due to the challenge of measuring the water used, as there are no water meters in the irrigation systems. On the day or the period farmers irrigate, water supply is invariable. All the production variables⁴ were entered in the TE model in logarithmic form. The tenure security variable presents whether an irrigator feels satisfied with the security of land or not. The Governance index is a composite household-level index, generated through Principal Components Analysis (PCA), which includes dimensions such as awareness of policies, perceptions towards stakeholder involvement as well as informal institutions in the schemes. Psychological capital is an index which considers how the water user perceives themselves, in terms of their confidence, resilience and hope.

Table 6.1 also presents the descriptive statistics of variables used in the model. The results show that the average household size in the schemes is four. It is also evident that water-users in NIS utilize more land than farmers in the other SISs. With an average of 8 hectares, the farmers are more commercially oriented. This is also evident from the average revenues gained in the scheme, which are about tenfold than what water users in the other schemes generate. Water users in the TFIS utilize about 50% less land than MFIS and generate on average 52% of the average farm incomes realized in MRIS. Water users in the schemes also irrigate for relatively similar hours, apart from farmers in NIS who irrigate an average of 11 hours per day. Water users in the MRIS have the lowest number of water users that have access to credit (46%) as compared to the other schemes (62%, 52% and 72%, for TFIS, MFIS and NIS, respectively). Most of the water-users are co-operative members; however,

⁴ Labour was omitted from the production function due to the invariability across the schemes. Most farmers reported only 1 labourer hired, which yielded infeasible solutions in the estimation of the production functions. Soil quality is more or less homogeneous across the schemes.

only 24% of the TFIS farmers are part of cooperatives. In general, most of the sampled water-users feel secure in terms of land tenure, and the schemes are dominated by women, apart from NIS, characterized by only 32.5% of female farmers.

Table 6.1. Description and descriptive statistics of explanatory variables

Variable	Description	MRIS	TFIS	MFIS	NIS	Hypothesized effect on efficiency
<i>Production Variables</i>		<i>Average</i>				
Farm revenue	Farm revenue (ZAR)	8551 (14029)	4515 (4925)	8400 (10535)	80 262 (86503)	
Irrigation hours	Number of hours irrigating per day	7 (7.3)	9 (4.3)	8 (4.6)	11 (5.92)	+
Area utilized	Area utilized for production (ha)	0.5 (0.8)	0.25 (0.22)	0.9 (1.7)	8 (10.2)	+
Fertilizer	Amount of fertilizer used for production (kgs)	176 (557.2)	83 (78.05)	204 (315.6)	608 (1035.7)	+
<i>Inefficiency Determinants</i>						
<i>Continuous Variables</i>						
Age	Age of a water user	57 (14.12)	55 (12.29)	52 (13.7)	47 (15.5)	+/-
Household members	Number of household members	4 (2.3)	3 (2.3)	4 (2.3)	4 (2.9)	-
Governance Index	Composite score of farmer's awareness of institutions and perception of governance in the scheme	0.14(2.2)	1.13 (1.7)	-0.93 (2.9)	-0.98 (2.3)	-
Psychological Capital	Composite score of a farmer's psychological capital	-0.86 (2.5)	0.31 (1.78)	0.92 (1.7)	0.9 (1.77)	-
<i>Categorical Variables</i>		<i>Percentage</i>				
Gender	Male =1	16	14	33	67.5	+/-
	Female=0	84	86	67	32.5	
Water Adequacy	Whether or not the farmer perceives their water supply adequate for the cropping needs					-
	Water adequate=1	23	93	71	72.73	
	Water not adequate =0	77	7	29	27.27	
Credit Access	Whether a farmer has access to credit					-
	Access to credit=1	46	62	52	72.5	
	No access to credit=0	52	38	48	27.5	
Cooperative membership	If a farmer is part of a co-operative					-
	If part of=1	86	24	73	15	

	If not a part=0	14	76	27	85	
Tenure Security	Whether or not a farmer is satisfied with land tenure					-
	If satisfied=1	81	72	58	87.5	
	If not satisfied=0	19	28	42	12.5	
Agricultural Training	Whether or not a farmer has received agricultural training					-
	If received=1	45	50.48	79.07	73.53	
	If not=0	55	49.52	20.93	26.47	
Total observations		100	100	66	40	

Key: MRIS= Mooi River Irrigation Scheme (MRIS); TFIS=Tugela Ferry Irrigation Scheme; MFIS= Mahlathini Flats Irrigation Scheme; NIS=Ndumo Irrigation Scheme

Note: The exogenous determinant variables included in the 'inefficiency' estimation would bear a negative sign to show that they have a positive effect on efficiency

Standard Deviation in parenthesis

Source: Survey analysis output (2018)

6.3.2. Technical Efficiency estimations of water-users in SIS

To test whether the farmers in the schemes belong to the same population, the likelihood ratio test for pooling was conducted through imposing elasticities of land cultivated, fertilizer, and irrigation on other scheme data. The results showed that the MRIS and TFIS belong to two different populations (LR=19.3, $p>0.05$) and as such, two separate production frontiers were estimated. This was further tested by including a dummy variable in the pooled model, which was significant at 5% level, indicating that indeed the two schemes are different. In contrast, the results showed that the NIS was a subset of the MFIS population (LR=25.2, $p<0.01$) and as such, the data was pooled to estimate one frontier for both groups. Henceforth results will be presented for three groups, MRIS, TFIS, and MFIS-NIS.

Table 6.2 presents the technical efficiency score distribution amongst water-users in KZN. The results indicate that most water-users in the schemes fall in the highest range of efficiency. Only 5% of water-users in TFIS fall in the lowest range of technical efficiency, while MRIS have the highest numbers of water-users in the lowest efficiency range. In general, results indicate a higher percentage of water-users from the TFIS in the highest range of technical efficiency distributions. This is also accompanied by relatively higher percentages of water-users in the lowest efficiency range, for farmers in the MRIS and MFIS-NIS.

Table 6.2. Efficiency score distribution of water-users in SIS in KZN

Efficiency group	MRIS (%)	TFIS (%)	MFIS-NIS (%)	Total (%)
0-0.2	21	5	13	12.4
0.2-0.4	21	20	28	21.8
0.4-0.6	21	32	24	24.7
0.6-0.8	37	53	35	41.1
Total water-users	100	100	106	100%

Key: MRIS= Mooi River Irrigation Scheme (MRIS); TFIS=Tugela Ferry Irrigation Scheme; MFIS= Mahlathini Flats Irrigation Scheme; NIS=Ndumo Irrigation Scheme

Table 6.3 presents the Technological Gap Ratios, as well as the average and maximum technical efficiency scores in each SIS. Consistent with the technical efficiency distribution results, the average technical efficiency score in the TFIS is around 0.56, which is higher than the average scores in the MFIS-NIS and MRIS, showing that water-users in the former scheme are more technically efficient. The differences in the mean efficiency scores across

the schemes indicate differences in conditions in the schemes, which possibly include, institutional arrangements, production orientation and market access, amongst other factors. The TGR indicate the distance between the scheme frontiers and the meta-frontier. The results indicate that water-users in TFIS are not too far off from the meta-frontier. The average water user in TFIS would have to increase output by 33% using the same combination of inputs if they were to achieve the technical efficiency of their most efficient counterpart. Water-users in the MRIS and MFIS-NIS must increase their output by 57% and 45% using the same combination of inputs, respectively, to attain the technical efficiency of the most efficient farmer.

Table 6.3. Technology Gap Ratios and average Technical Efficiency scores in KZN SIS

Irrigation Schemes	MRIS	TFIS	MFIS-NIS
Average TE	0.37	0.56	0.45
Max TE	0.86	0.84	0.83
Technological Gap Ratios	0.51	0.71	0.56

Key: MRIS= Mooi River Irrigation Scheme (MRIS); TFIS=Tugela Ferry Irrigation Scheme; MFIS= Mahlathini Flats Irrigation Scheme; NIS=Ndumo Irrigation Scheme

Considering the presence of differences across the schemes, when estimating efficiency across the schemes, it cannot be assumed that the same production functional form is appropriate for all the groups (Makombe *et al.*, 2017). Therefore, the Translog production function is estimated for each of the three groups schemes. The F-statistic is then used to determine the suitability of the Translog, which if not statistically significant, is reduced to Cobb-Douglas form specifications. The results indicate that the Translog model estimated for the TFIS is not statistically significant (p-value=0.64), showing that the six coefficients on the squared and interaction terms are zero. Therefore the frontier was estimated using the Cobb-Douglas specifications. The Translog function for both the MRIS and MFIS-NIS yielded F-stats that are statistically significant at the 1% level, showing that the interaction and square terms should be included in the models, and as such, were specified in Translog form.

The second test performed was to determine whether the inefficiency effects need to be included in the model. Also presented in Table 4 are gamma (γ) values for each of the schemes. The γ values are derived from the SigmaU and SigmaV in the model. If $\gamma = 0$, the technical inefficiency is not present and therefore, the stochastic frontier model does not need

to be estimated. The closer γ is to unity, the more likely it is that the frontier model is appropriate, and the higher the contribution of the explanatory variables to the inefficiency in the model. A lower gamma value indicates that inefficiencies are mainly caused by factors beyond the control of the water user. The TFIS and MRIS have gamma values close to one, 0.8 and 0.9, respectively. The rejection of the null-hypothesis of the absence of gamma, shows that external shocks affect water-users' inefficiency, and possible errors of measurement.

The stochastic frontier estimated for irrigation schemes yielded maximum likelihood estimates of σ^2_u that are statistically significant, indicating that the technical inefficiency effects are significant in explaining the variability of total revenue generated in the schemes. Table 6.4 presents the maximum likelihood results of the frontier models estimated. The elasticities in the meta-frontier model are statistically significant, indicating that an increase in area, labour and fertilizer utilized can significantly increase mean agricultural revenue generated from irrigated crop production. Although the production input estimates are all significant in the meta-model, they differ in the level of significance across the schemes.

In MRIS, only area, and fertilizer utilised are statistically significant. The elasticities suggest that *ceteris paribus*, a 1% increase in land and fertilizer used increases mean farm revenue by 0.532% and 0.123%, respectively. Although irrigation and fertilizer utilized increase mean farm incomes in TFIS, only the land elasticity of 0.021 is statistically significant. The irrigation hours elasticities are statistically significant in the MFIS-NIS model, indicating irrigation's contribution to the mean incomes in the schemes. The fertilizer elasticity in the NIS model is statistically significant, showing that a 1% increase in fertilizer increases mean revenue by 0.33%. This is as expected, due to the production orientation of farmers in the schemes who produce on a larger scale and use more fertilizer. The interaction and the squared variables in the MRIS are all statistically significant.

Increasing returns to scale are evident in the MRIS for area utilized, irrigation hours, as well as the interaction variable of area and irrigation, and fertilizer and irrigation hours. This is a strong indicator of the importance of irrigation water on farm revenue. It shows that water-users should have water available for irrigation when needed. This is particularly key in MRIS, where, during focus group discussions, farmers mentioned that water access for crop production is challenging, mostly due to users on the upper end of the canal extracting water

outside their scheduled irrigation days. Increasing returns to scale are also evident in the MFIS-NIS group for irrigation. In MFIS, farmers must pay a monthly fee for water, which they at times cannot afford. Infrastructure problems such as lack of maintenance of irrigation equipment also prevent water-users from accessing adequate water in the NIS. Therefore, efforts to increase irrigation access and reliability in both schemes should be prioritized.

Technical Inefficiency effects

Table 6.4 also presents technical inefficiency effects. The dependent variable in the model, represented by $Lnsig2u$, is technical inefficiency; therefore, a negative sign on the coefficient estimate in the model indicates that the variable improves technical efficiency. Overall, most of the resulting parameter estimates make economic sense. The results show that female water-users are more likely to be efficient as compared to their counterparts in the MFIS-NIS group. Apart from most of the farmers being female, most rural women lack resources and therefore would be more judicious with the use of their resources. This is in contrast with the findings of Gwebu and Matthews (2018), who found male farmers more efficient than female ones in smallholder tomato production in South Africa.

Most of the male farmers in the schemes are more business-oriented and usually have better access to markets, compared to the female farmers, who generally produce for subsistence. However, the results suggest that female farmers are more efficient in their production. Therefore, to enhance their efficiency further and to improve the efficiency of the male farmers, empowerment through better access to markets, institutional support, as well as credit access, is needed to improve their efficiency. The results indicate that age has a positive effect on technical inefficiency in the MFIS-NIS model, showing that younger farmers perform better. This finding is consistent with Duhan and Singh (2017), who found that younger farmers accumulate information from different sources. Younger farmers are more willing to adopt new technologies and find new markets and are therefore more likely to perform better than older farmers. Water users that have access to credit are more efficient in the MRIS, as shown by the statistically significant coefficient estimate. During FDGs, farmers indicated their lack of access to credit, which inhibits them from purchasing production inputs, whose increase would improve mean outputs and consequently, revenue. Farmers also noted that the lack of collateral and ownership of land plays a role in their failure to secure credit. As such, micro-finance institutions should consider terms in which

producers who do not own land or have less surety can be provided with necessary financial assistance.

The coefficient estimate of water adequacy shows that water-users across the schemes who perceive that irrigation water is adequate for their cropping requirements tend to be more efficient. Availability of irrigation water plays a significant role in determining the production approach a farmer adopts. The model results show that farmers that are satisfied with their water supply are most likely to be efficient in their combination of inputs. Cooperative membership improves efficiency in all the schemes; however, the variable is statistically significant in the MRIS. This could be because most of the water users in the TFIS included in the study (76%) are not cooperative members, and although farmers in MFIS-NIS are officially part of co-operatives, they do not operate as such (most farmers are individualistic in their production). The coefficient estimate is particularly statistically significant in the MFIS where most farmers are part of cooperatives. This is consistent with Debebe *et al.* (2015) and Herbert (2015), who noted that membership of social groups has a positive impact on resource management and performance. This could be attributed to the information sharing that takes place in most agricultural cooperatives. Cooperatives can be efficient institutions to foster development and productivity of farmers (Chagwiza and Muradian, 2016) and as such water-users should be encouraged to be part of social groups, provided the groups are well managed and operated.

Water-users that have secure land tenure tend to be more efficient than those that do not, as shown by the negative parameter estimates. The coefficient estimate is statistically significant at the 5% level in the MRIS. The finding is consistent with Manjunatha *et al.* (2013), Ebarle *et al.* (2015) and Lawin and Tamini (2018), who found that land ownership is also positively related to farm performance. Although the farmers do not own the land, the mere feeling of security encourages investment in the land and the confidence to produce with minimal risk of land being confiscated. Therefore, arrangements such as long-term lease agreements and purchasing of the land should be encouraged, as it might have a positive impact on technical efficiency.

Table 6.4. Stochastic Frontier estimates of technical inefficiency in SIS

Irrigation Schemes								
Variables		MRIS		TFIS		MFIS/NIS		Meta-Model
Ln	Farm	Coefficient	Std	Coefficient	Std	Coefficient	Std	Coefficient
Income		Estimate	Error.	Estimate	Error.	Estimate	Error.	Estimate
Ln area		0.532***	0.090	0.021**	0.003	0.412	0.299	0.001*** (0.005)
Ln fertilizer		0.123***	0.060	0.05	0.001	0.329***	0.409	0.100*** (0.044)
Ln Irrigation		0.03	0.050	0.008	0.002	0.795*	0.984	0.301*** (0.048)
Ln area ²		0.009***	0.001			-0.176**	0.091	
Ln fertilizer ²		-0.015***	0.002			-0.179***	0.035	
Ln irrigation ²		0.0565***	0.001			0.198*	0.165	
Lnarea*fert		-0.019***	0.004			-0.072	0.044	
Lnarea*irrig		0.029***	0.001			0.043***	0.133	
Lnfert*irrig		0.062***	0.0001			-0.335***	0.167**	
Lnsig2v		-27.931***	22.638	-8.367***	0.198	-0.499**	0.233	
constant								
Gender		1.698	0.66	-0.252	1.82	4.189**	2.34	
Age		0.064	0.017	0.094	0.04	0.314*	0.141	
Credit access		-0.834**	0.381	0.908	1.04	0.03	0.08	
Water Adequacy		-0.734	0.52	-1.336***	1.52	-0.320***	0.908	
Cooperative member		-2.73***	0.71	-0.206	1.46	-0.015	0.09	
Tenure security		-1.71***	0.653	-1.21	-1.22	-0.138	0.071	
Agricultural Training		-0.771*	0.44	-3.75***	1.269	-0.001	0.084	
Household members		0.07	0.06	0.215	1.829	0.01	0.01	
Governance index		-2.356**	0.11	0.981***	0.23	-0.049**	0.017	
Psychological capital		-0.154*	0.101	-0.762*	0.421	-0.002	0.025	
Sigma v		0.241	0.14	0.52	0.091	0.091	0.255	
Gamma		0.9		0.8		0.58		

Note: ***, **, *; significant at 1%, 5% and 10%, respectively.

The results indicate that farmers that have undergone agricultural training are more efficient than those who have not. The variable is statistically significant in all but the MFIS-NIS.

Farmers who have received agricultural training have a better understanding of input combination and therefore, are most likely to maximise their revenue. The coefficient is not statistically significant in the MFIS-NIS because even though farmers in the scheme have received training, they emphasized that they require training on how to penetrate the value chain, rather than being trained for agricultural production only. Although farm valued the training on how and when to plant, they indicated that they would also like to get training on marketing, financial management and pricing, all which influence revenue. Therefore, agricultural training should be offered to water-users and needs to be broadened to include other aspects like marketing and pricing.

Psychological capital, which involves an individual's resilience, hope and confidence in themselves, makes economic sense in the MRIS, TFIS and MFIS-NIS models. The results show that water-users with higher psychological capital are likely to be more efficient. The results suggest that farmers that are confident in themselves as business owners, who do not lose hope, are resilient and willing to take risks are more likely to be more efficient (Chipfupa and Wale 2018). As such, policy should be focused on developing the entrepreneurial spirit and independence of farmers through business training and extension services. Incentivized programs and sustainable access to markets could also encourage farmers to be more business-oriented and confident in their enterprises.

The results show that governance index does not improve efficiency in the TFIS. However, the results also show that water-users with higher governance index in the MRIS and MFIS-NIS are likely to be more efficient. A higher governance index indicates a better understanding and perception of policies and strategies. They have a more enlightened perception of the governance and management of the scheme and are also satisfied with the involvement of governmental stakeholder involvement in the scheme. Therefore, farmers should be made aware of policies and even the roles of various stakeholders in the scheme, for them to seek the necessary support when needed. It also shows that if farmers understand and are satisfied with how the scheme is governed, they are more likely to perform better.

6.4. Conclusions and Policy Recommendations

Evaluating the factors that influence the performance of water-users is crucial for the development of smallholder irrigation policies and interventions. This is particularly important given the increased reliability of production on irrigation water usage and the contribution of smallholder production to rural food security. Using production economic

methods to evaluate performance of water-users, the study concludes that the increase in production outputs, land, fertilizer and labour, positively impacts agricultural revenue, and thus the performance of an agricultural producer. A combination of socio-economic, institutional, and social factors influences water-users' efficiency in SISs. Therefore, there is a need for a balanced approach when devising ways of improving the performance of SISs. Interventions should consider both technical factors in performance analysis and institutional arrangements that impact the schemes.

Considering that land tenure, credit access, psychological capital, governance index, cooperative membership positively affects water-user efficiency, interventions should be directed to these factors. Better land leasing arrangements, such as long-term lease agreements should be encouraged. This could encourage on-farm investments by farmers, thus improving performance. Improved management and operation of cooperatives would encourage information sharing and make participating farmers improve efficiency. Better terms for low-collateral farmers should be considered in financial institutions, as credit access enhances farmer efficiency. An improvement on better access to markets and water adequacy should be emphasized in policy interventions, as these are key to profitability and productivity in smallholder irrigation schemes. Land tenure security, governance index, water adequacy and cooperative membership are variables which are directly or indirectly affected by institutional arrangements in the schemes.

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CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1. Purpose of the study

SIS are pivotal in sustaining rural livelihoods in South Africa. As such, there has been a growing focus on institutional reform and making arrangements to improve their governance, improve the performance of the water users, and subsequently, achieve sustainable use of water resources and improved farmers' welfare. This focus on institutional arrangements has yielded suggestions on the implementation of appropriate policies, particularly, an enabling: a) social and institutional environment, b) farmer participation, and c) improvement of farmer performance. This study evaluated institutional integration, farmer participation and water-user performance in SIS, using qualitative and quantitative techniques to address the specific objectives. The study used data from a total of 341 households across four SIS in KZN, namely MRIS, TFIS, MFIS, and NIS. The schemes have contrasting features such as institutional arrangements, farmer composition and production challenges.

An enabling social and institutional environment is characterized by coordination between stakeholders, transparency, and the efficient implementation of the policies. Various stakeholders are involved in irrigation policy-making and collectively share the responsibility of program implementation. However, sector fragmentation, lack of coordination and other shortcomings in rule enforcement contribute to the ineffectiveness of water policies, hindering SIS success. The third chapter of the study evaluated the horizontal and vertical institutional integration of water governance in SIS. Stakeholder interactions in the schemes were assessed using Exploratory Social Network Analysis to identify, categorize, and investigate stakeholder challenges. The study employed the MTF, an interdisciplinary framework, for evaluating water systems, management processes and multi-level governance regimes. In general, good governance is a prerequisite for effective management of common-use resources. Awareness of institutions, the inclusion of members in decision-making processes and transparency of governance are needed for social participation, which enhances sustainable use of common-pool water resources. The fourth chapter of the study evaluated the determinants of household perceptions of governance using multiple regression models.

Farmers' collective action and participation in SIS provide a sense of ownership and leads to the responsible use of the resources, the lack of which creates a weak environment for

sustainable water use. As such, the fifth chapter of this study evaluated the role of governance on farmers' participation in the management of SIS. The study adopted PCA and SEM to evaluate the determinants of water users' participation in the management of SIS.

Improving performance in the schemes is a policy target that ensures the sustainable use of the schemes and enhances the welfare of farmers as well as provides opportunities for the broader community. Therefore, the sixth chapter of the study adopts production economics theory and production functions to evaluate the performance of water-users across the four SISs, given the varying institutional arrangements. TE was used as a proxy for water-user performance and was measured using Cobb-Douglas and Translog production functions. SMFA method was employed to measure the overall efficiency of water-users across schemes and to determine technical gap ratios.

7.2. Conclusions

An evaluation of institutional integration using horizontal and vertical integration found that the governmental departments are coordinated at the national level. However, there is a strong fragmentation at provincial and local levels, which has resulted in information asymmetries among stakeholders, particularly among farmers. These asymmetries have led to the lack of coordination across sectors, as each entity operates independently. Thus, there is limited local horizontal integration. Lack of funds and shortages in human capacity resulted in projects not being fully implemented, and the strong sector fragmentation makes it challenging to hold entities accountable. Therefore, the strategies and programmes, meant to uplift and support farmers are not timeously implemented or completed, resulting in a lack of vertical integration in SIS. Issues that stand out that inhibit successful program and project implementation are lack of transparency and accountability, as well as sector fragmentation. Government officials and farmers highlighted that farmers' low participation in the irrigation schemes stems from the lack of awareness of the formal institutions in water governance.

Perceptions of governance and their determinants at the farm household level were evaluated using Principal Components Analysis and a multiple regression model. This included a holistic view of governance, including both formal and informal institutions in the schemes. The study concluded that farmers are generally satisfied with the informal institutions, being the "rules in use", which they have set for themselves in the schemes. In this regard, they are satisfied with the involvement of traditional authorities in scheme governance, including during conflict resolutions and rule enforcement. The results suggest that male farmers are

more aware of formal institutions, consistent with the findings of Muatha (2014) and Dlangalala (2020). This could be attributed to male farmers being active in executive management of the schemes, and therefore engaging more with governmental entities and other stakeholders. Farmers who are male and have received agricultural and irrigation training perceive formal institutions scheme in a good light. Land tenure, water adequacy, gender, psychological capital, and participation determine the farmers' perceptions of governance in the schemes.

PIM is an important concept which fosters collective responsibility and rule compliance, the lack of which, creates a weak environment for sustainable water resource use. This study adopted PCA and SEM to evaluate the role of governance on water users' participation in the management of SIS in KwaZulu-Natal. A combination of institutional and socio-economic variables influence participation in management. It also notes that a water user's participation in one management activity does not translate to full participation in another. The study concluded that irrigators who participated in the regulation and control of SIS also participate in information sharing activities. HGI, land tenure security, credit access and household income were found to influence participation in the management of irrigation schemes positively.

A SMFA method was employed to measure the overall efficiency of water-users across schemes and to determine the technical gap ratios. The SMFA results show that the overall average meta-efficiency was 0.85. At the same time, the group-specific stochastic frontiers yielded mean TE scores which ranged from 0.51 to 0.71, placing water-users in MRIS on the lowest productivity frontier. The study concluded that the increase in production outputs, land, fertilizer, and labour, positively impact agricultural revenue, and thus the performance of an agricultural producer. The efficiency model results showed that governance index, farmer psychological capital, land tenure security, credit access, cooperative membership, and gender, significantly affect water-users' technical efficiency.

7.3. Recommendations

A combination of socio-economic, institutional, and social factors influences affect integration, farmer participation in management, and performance in SIS. Therefore, a balanced approach is needed when devising ways of improving the governance and performance of SISs.

Local government coordination

Governmental entities and other stakeholders need to understand the existing institutions and the roles of their counterparts to establish synergies and to improve coordination in the systems, to ensure effective governance and policy implementation. Skilled labour is needed at the local level, such as engineers and technical extension services, to ensure successful project implementation. Farmers in the schemes need improved access to extension services.

Informal institutions and policy formulation

Informal institutions should be an integral part in policy formulation as farmers are comfortable and satisfied with the rules they devise to govern the schemes. Furthermore, traditional authorities should be integrated in formulating policies. The proposed approach can ensure farmer compliance with both formal and informal arrangements as SIS farmers tend to adhere to the decisions of traditional authorities and are satisfied with their involvement.

Farmer Training

The study recommends that farmers be put trained in irrigation and infrastructure management, as well as raise awareness about the existing institutional arrangements and roles of different entities. Farmer training can be facilitated through farmer workshops by various stakeholders such as academic institutions and non-governmental organizations. Farmers also need to be capacitated not to entirely rely on government support for scheme management. Reliance on government can be minimized by enhancing their psychological capital through the provision of training in water and infrastructure management, as well as general business training. Agricultural and irrigation training should be improved to expose farmers to methods of sustainable use of water and water resources. Additionally, training should include awareness of strategies such as PIM, which will give farmers the knowledge of how each management activity is as vital as the other, and how the successful management of the scheme will yield better outcomes.

Market and credit access

Financial institutions should consider better terms for farmers with limited collateral as credit access enhances farmer efficiency. Furthermore, better access to markets, for example, through marketing cooperatives, is needed to ensure that farmers are economically active.

Improved management and operation of cooperatives would encourage information sharing and make participating farmers improve efficiency.

Land tenure and irrigation water adequacy

Farmers that feel that water is adequate for their crop production, participate in scheme management and have secure land tenure are more likely to participate in scheme management and to be more efficient. These two factors also positively affect the household governance index. Therefore, water access should be improved throughout the schemes. This can be done through better water scheduling arrangements and proper rule enforcement. Furthermore, policy interventions should also be focussed on establishing ways of ensuring that farmers have secure land tenure. This provides incentives and encourages participation in management, through irrigators' need to produce, irrigate, and manage water resources.

7.4. Study limitations

The study only considered schemes in KwaZulu-Natal. As such, stakeholder interactions and involvement were only recorded for the schemes included and could be different in other parts of the country. The data was collected over one year, at a time where administrative changes were made in the local departments. These changes could have subsequently affected the management of departments, as well as the operations in the departments.

7.5. Areas for further research

Given the findings of the studies, future research can adopt panel data to capture the dynamics of scheme governance. This data presents information about schemes in one province. Therefore, a comparative study, at the national level, would help provide further evidence of the included dynamics and concepts.

Studies focusing on the impact of informal institutions in the governance of schemes would also help in providing more evidence of their importance and how they can be incorporated into formal policy formulation.

Research on the role of female leadership and psychological capital concerning governance would help in identifying what needs to be improved, to obtain the successful management transfer of the schemes, as most schemes have a large percentage of female farmers.

Appendix 1. Questionnaire

UNIVERSITY OF KWAZULU-NATAL

SCHOOL OF AGRICULTURAL, EARTH AND ENVIRONMENTAL SCIENCES

ASSESSMENT OF THE EFFECTS OF THE INTERACTIONS BETWEEN INTERGENERATIONAL AND GENDER DIMENSION WITH GOVERNANCE ON THE PERFORMANCE OF IRRIGATORS IN SMALLHOLDER IRRIGATION SCHEMES.

Note: All the information provided in this questionnaire is STRICTLY CONFIDENTIAL and will be used for research purposes by staff and students at the University of KwaZulu Natal and Water Research Commission. There is no right or wrong answer to these questions. Moreover, participation in the survey is VOLUNTARY and NO FINANCIAL BENEFITS are paid during or after participation.

Household name	Municipality	District	Date
Irrigation scheme	Block	Interviewer's name	Name of Respondent

*Municipality: 1= Jozini Local, 2= Msinga Local

*District: 1= Umzinyathi, 2= Umkhanyakude

*Irrigation scheme: 1=Mooi River, 2= Tugela Ferry, 3=Makhathini, 4= Ndumo

A: HOUSEHOLD DEMOGRAPHICS (INFORMATION ABOUT THE IRRIGATOR TO BE ENTERED BELOW) (circle the appropriate)

A1. Age Gender: 1=M 0=F Marital status: 1=Single 2=Married 3=Divorced 4=Widowed

A2. Education 1=No formal 2=Primary 3=High School 4= Tertiary

A3. Main occupation 1=Farmer 2=Regular salaried job 3=Temporary job 4=Unemployed 5=Self employed 6=Student 7=Retired 8=Other (Specify)

A4.Total number of household members

A5. How many of the household members are adults/children?

A6. How many of the household members work on the farm?

A7 . Do you hire labour to work on the farm? 1= Yes, 0= No

* Household head refers to the household head that stays in the household for 4 or more days per week

** Please include only those who stay in the household for 3 or more days per week

B: SKILLS AND TRAINING

B1. What training have you had?

Skill	1=Yes; 0=No	Training provider
Agriculture		
Irrigation		
Water management		

B2. Which training did you find most useful on the farm?.....

B3. If no in any of the above, do you need training? 1=Yes; 0=No

C. ASSET OWNERSHIP

C1. Household asset: Indicate agricultural production assets that you have access to:

Asset	Quantity/ Number of items owned	Do you consider the production assets you have to be adequate for your Agricultural Activities: 1= Yes ; 0=No
Water Pump		
Ox-drawn plough		
Wheelbarrow		
Trailer		
Tractor		
Tractor-drawn plough		
Vehicle		
Cattle		
Goats		
Other		

C2. Are there any production assets supplied by the government? 1= Yes, 0= No

C2.1 If yes which ones:.....

D. LAND OWNERSHIP AND UTILIZATION

Land type	Ownership	Estimated area utilized	Proportion of area not utilized
Homestead garden			
Dry-land fields			
Irrigation plots inside the scheme			

Irrigation plots outside the scheme			
* <i>ownership</i> :1=Traditional allocation; 2=Rented; 3=State supplied/owned; 4=Inherited 5=Owned 6=Given by relative 7= Other			
Is it in your name? 1= Yes; 0= No			
D1.How far is your homestead from the irrigation scheme?			
D2. Do you pay for land (if leased)? Yes=1 No=0 (Rands)			
D2.1. Are you satisfied with the fees you pay for land? Yes=1; No=0			
D3 .How do you feel about your land size? 1=Too small 2=Just right 3=Too large			
D4 Rate the quality of your land for crop production 0=Poor 1=Average 2=Good			
• Water holding capacity			
• Drainage capacity			
• Resilience to degradation and unfavourable conditions			
• Low weed pressure			
• Sufficient nutrient supply			
• Salinity problems			
D5.Are you satisfied with the tenure security of your land? Yes=1 No=0			
D5.1.Are you permitted to sell land? Yes=1 No=0			
D5.2 Are you permitted to rent your irrigated piece of land? Yes=1 No=0			

E. SCHEME GOVERNANCE

E1. Please answer the following questions regarding the governance of SIS

1=Strongly Disagree; 2= Disagree; 3= Neutral; 4=Agree; 5=Strongly Agree

I am aware of the National Water Act of South Africa	
I am aware or have heard of the Natural Water Resource Strategy of SA	
I know what the government aims to achieve in SIS	
I know that I have to have a water licence to use irrigation water	
I am satisfied with how the land is allocated in SIS	

The terms of land allocation should change to suit farmer needs	
The rules regarding water allocation in the scheme are fair	
The rules set within the irrigation scheme are fair	
The rules in the scheme are hard to enforce	
Penalties for failure to comply with the rules are fair	
I am satisfied with the cooperation between blocks and farmers in the irrigation scheme	
Water users are always willing to contribute to the maintenance of infrastructure and equipment in the scheme	
I am satisfied with how water conflicts are managed in the scheme	
I am satisfied with the involvement of the traditional authority in the irrigation scheme	
I am satisfied with the involvement of the DAFF in the scheme	
I am satisfied with the involvement of the DRDLR in the scheme	
I am satisfied with the involvement of the DWAS in the scheme	
I am satisfied with the involvement of the government departments in the scheme	
I am satisfied with the involvement of NGOs in the scheme	
I am satisfied with the involvement of Farmers in making the rules	
I am satisfied with the current executive committee	
The election process of the executive committee is fair	
I am satisfied with the contribution of the traditional council in irrigation management	
I am satisfied with the traditional council's level of understanding of the rule in the irrigations scheme	
I am satisfied with the level of contribution of the traditional council in rule enforcement	
I am satisfied with the way that the farmers and traditional authorities work in the scheme	
I am satisfied with the youth's involvement in irrigation scheme management	
I am satisfied with the youths level of understanding of the schemes rules	
In your opinion, why is the youth not actively participating in farming	

E3. IRRIGATION WATER LAW	
Questions	Response
1. Do you have water rights? 1= Yes 0= No 2= I do not know	
2. If Yes, in what form? 1= Water Licence; 2= Water permit; 3=Other, Specify.....	
3. Do you have any constraints with due to the current irrigation water law(s)? 1=Yes 0= No 3.1.If Yes, what	
4. My access to water is secure 1=Strongly Disagree; 2= Disagree; 3= Neutral; 4=Agree; 5=Strongly Agree	
5. Have you experienced water conflicts in the past 12 months? 1= Yes 0= No	
5.1. Between farmers	
5.2. Between blocks	
5.3. Between cooperatives	
5.4 If Yes above, what were the causes? 5.5 If Yes in 5 were the problems solved? 5.6 If Yes how?.....	
6. Do you pay for use of water? 1=Yes; 0=No. How much? <ul style="list-style-type: none"> • 6.1 . If not paying, would you be willing to pay for water in the irrigation scheme? 1=Yes; 0=No • 6.2 If Yes much how much per month? • 6.3 If No why?..... 	
7. Who do you think has the responsibility to ensure water availability Why?.....	
8. Do you belong to Water Users Associations (WUAs)? 1= Yes 0= No <ul style="list-style-type: none"> • 8.1 If no to 8 do you know any Water Users Associations (WUAs)? 1= Yes 0= No 	
<i>1=Strongly Disagree; 2= Disagree; 3= Neutral; 4=Agree; 5=Strongly Agree</i>	

• 8.2 If Yes in 8.1, the WUAs has improved water access in your irrigation scheme	
9. You are satisfied with the irrigation schedule	
10. Government participation in irrigation water management increases your feeling of responsibility to manage water.	
11. Private sector and NGO's participation in irrigation water management increase your feeling of responsibility to manage water	
12. Irrigation water laws are effective in the management of water resources	
13. Irrigation laws influence your decisions on resource allocation.	
14. Irrigation water laws influence your economic performance	
15. Irrigation water laws influence your cropping patterns.	
E4. INFORMAL WATER MANAGEMENT INSTITUTIONS	
<i>1=Strongly Disagree; 2= Disagree; 3= Neutral; 4=Agree; 5=Strongly Agree</i>	Response
16. Are there appropriate rules existing in irrigation water management	
17. Mechanisms e.g. constitutions, to assist irrigation water management at scheme level exist	
18. The constitution is effective in the management of water resources	
19. Irrigation water policies are effective in the management of water resources.	
20. Informal water institutions are effective in the management of water resources.	
21. Informal water institutions affect your daily operation in the scheme.	
22. Informal water institutions influence your economic performance.	
23. You comply to the rules of the scheme	
24. The existing committee is effective in ensuring compliance to regulation on water uses	
25. Other water users understand the consequences of their actions in the irrigation scheme	

F. FARMER PARTICIPATION

Question	Response
F1. What role do you play in the scheme management? <i>1= ordinary member, 2= committee member, 3=Executive member, 4=Other;</i>	

Specify.....	
F2. If not participating: are you willing to participate in the scheme management? <i>1=Yes; 0=No</i>	
F3.If not participating, give your reasons?	

F4.What has been your level of involvement in the following activities for the past year (June 2016 – June 2017): *0=None (never involved); 1=Sometimes; 2=Always*

Activities	Rank
1. Financial based participation	
Contributing finance towards irrigation pump maintenance	
Contributing finance towards irrigation maintenance (buying material, paying the maintenance people, etc.)	
Contributing finances towards the Water Users` Association (WUA)	
2. Participation in decision making processes	
Attending irrigation meetings	
Attending irrigation/water related training	
Engaging authorities regarding water issues in the area	
Distributing information about water issues (written or verbal)	
Helping other farmers to manage/conserve water	
In electing/removing committee members	
In formulating rules in the scheme	
In irrigation water scheduling	
Other (specify)	
3. Participation in regulation and control	
Reporting unlawful behaviour (unauthorised handling etc.) Where do you report to ?.....	
Reporting leakages along the canal for repairs	
How often do you attend water related meetings (e.g. weekly, monthly, none, etc.):	

--	--	--	--	--	--	--	--	--

Key

Crops	Market Outlet	Inputs used
1=Maize; 2=Tomatoes	1=Local shop	1=Fertilizers; 2=Herbicides
3=Potatoes; 4=Sugarcane	2=Neighbours	3=Labor; 4=Transport
5= Spinach; 6=Cabbage	3=Contractor; 4=Hawkers	5=Marketing; 6=Seeds
7=Beans; 8=Onions	5=Shops in town	7=Pesticides; 8=Tillage
9=Butternut; 10=Other (specify)	6=Other (specify)	9=Packaging; 10=Other
		(Specify)

G2.How often do you fail to sell your farm produce? (*Never=0 Sometimes=1 Always=2*)

.....

G3. How much do you make from your crops? R.....

G4. What cropping method do you use in your plot 1=Mono-cropping; 2= Inter-cropping; 3= Crop rotation; 5= Other

H. WATER AVAILABILITY AND IRRIGATION

H1.How many times per week do you have access to water in your plot(s)?	days
<ul style="list-style-type: none"> H1.1.It is adequate? Yes=1; No=0 H1.2 How many minutes/hours do you let water into your plot on your irrigation day? 	hr/mins

H2..Please rate the extent to which you agree with the following statements pertaining to water access to your irrigation plot(s). (*1=Strongly Disagree; 2= Disagree; 3= Neutral; 4=Agree; 5=Strongly Agree*)

Water is reliable	
I always get water in my plot(s)	
Water is sufficient for my cropping requirements	
I have the ability to pay for water and water-related services	
Water distribution/sharing at farm level is fair	

H3.Rate the amount of water you have received over the past 12 months. (1=less; 2=same; 3=more)

H4.1 If changed what is the reason for this?

.....

J: HOUSEHOLD INCOME AND EXPENDITURE INFORMATION

J1. Please indicate the amount spent per month on:

- i. Food items R.....

ii. Non-food items (Electricity bill, toiletries eg soap, utility bills etc.)
R.....

J2.What were the sources of your household income in the last 12 months? (Indicate approximately how much each source contributed and how often).

Household Income Source		Total amount (Rands)	Frequency (how often?)
Remittances			
Agri activities	Irrigation Farming		
	Dry land farming		
	Livestock production		
Permanent Employment			
Temporary Employment			
Welfare grants	Disability grant		
	Child grant		
	Pensioners grant		
Other (Specify)			

J3.Please answer the following questions

Questions

Response

Do you have access to credit? 1=Yes 0=No

Have you taken credit or used any loan facility in the past 12 months? 1=Yes 0=No

If Yes, what was the main source of credit? 1= Relative/ friend; 2= Money lender; 3= Stokvel; 4= Input supplier; 5= Output buyer; 6= Financial institution (specify name)

If No to 4, please specify the reason(s). 1= Loan not required; 2= Interest rate is high; 3= I couldn't secure the collateral; 4= I have got my own sufficient capital; 5= It is not easily accessible; 6= I am risk averse

If you took credit, were you able to pay back? 1=Yes 0=No

If No, please specify the reason

K.PSYCHOLOGICAL CAPITAL

K1. What is your main reason for farming? (1=Income 2=Extra food 3=Employment 4=Other)

K2. You consider farming as a business and can be managed as such? (1= Strongly agree 2= Agree 3= Neutral 4=Disagree 5= Strongly disagree)

K3a.You are interested in expanding your farming operations (including increasing plots). (1= Strongly agree 2= Agree 3= Neutral 4=Disagree 5 = Strongly disagree).....

K3b.Why? _____

K4.Do you see yourself as a potential commercial farmer one day? 1=Yes 0=No

K5. You feel confident to contribute to discussions about the irrigation scheme strategy. (1= Strongly agree 2= Agree 3= Neutral 4=Disagree 5 = Strongly disagree)

K6. How satisfied are you with the performance of the scheme? (1=Very satisfied 2=Satisfied 3= Neutral 4= Dissatisfied 5= Very Dissatisfied)

K7. How interested are you in being a scheme committee member? (1= Very interested 2= Interested 3=Neutral 4= Slightly disinterested 5= Not interested at all)

K8. How interested are you in taking part in training in collective management of irrigation scheme? (1= Very interested 2= Interested 3=Neutral 4= Slightly disinterested 5= Not interested at all)

K9. When working in a group securing a sustainable use of resources for the future is important? (Yes=1; No=0).

K10. How high is your confidence in farming as a means to a sustainable livelihood? (1 =Very high 2= High 3= Neutral 4= Low 5= Very low)

K11. How high is your confidence in yourself as a farmer? (1 =Very high 2= High 3= Average 4= Low 5= Very low)

K12. Please indicate the extent to which you agree with following statements (1=Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly agree=5)

The government is not doing enough for the wellbeing of farmers	
I am optimistic about the future of farming in my area	
I am able to cope with natural shocks such as drought	
I am willing to go find a market if there aren't any available in my area	
I enjoy new opportunities	
I do not give up easily	
I am willing to take business risks	
I am willing to invest in farming and make a loss in the short-run in order to benefit in the long-run	
I have the power to affect the outcome of my farming	
I hope the quality of life will be better	
I trust other farmers	
I would not be farming If I had a better source of income	

L. SOCIAL CAPITAL

L1.Are you a member of any of the following groups

Group	Membership (Yes=1; No=0)	Function
Cooperative		
Social group (church, stokvel, burial society)		
Other (specify)		

L2. Please rank the following sources of information relevant to your farming activities based on how you have used them in the past year (eg, market prices, when to grow, where to sell).

1=Unimportant 2=Neutral 3= Important

Extension Officers

NGO's

Media

Private organizations

Internet

Academic institutions

Fellow Farmer

Traditional Leaders

Community meetings

Cooperative

Irrigation committees

Other (specify)

M. CHALLENGES IN SIS

(1=Strongly Disagree; 2= Disagree; 3= Neutral; 4=Agree; 5=Strongly Agree)

There are not enough plots available in the scheme

Irrigation scheme is too far from the homestead

People use water illegally in the scheme

There is a lack of market access for farm produce

Farmers are not willing to pay for water use

People benefit from irrigation water but do not participate in the scheme

Infrastructure is in poor condition

There is inadequate water supply in the scheme

There is unauthorised handling of water control infrastructure

I am not satisfied with the condition of the infrastructure

Management does not commit to infrastructure upgrade, rehabilitation and maintenance

In your opinion, what causes infrastructure damage?

.....

THANK YOU/SIYABONGA

Appendix 2: Ethical Clearance-Declaration of Consent

CONSENT FORM/IFOMU LEMVUMELO

PROJECT TITLE: Evaluation of institutional integration, farmer participation and performance in Smallholder Irrigation Schemes in KwaZulu-Natal, South Africa.

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I, Lerato Phali, Student no. 208518288, am PhD candidate, at the School of Agricultural, Earth and Environmental Sciences, at the University of KwaZulu-Natal (*Mina, Lerato Phali, ngingumfundi kuzinga lePhD, eSikole seSayensi yezoLimo neMvelo, eNyuvesi yaKwaZulu eNatali*). You are invited to participate in a research project entitled: Evaluation of institutional integration, farmer participation and performance in Smallholder Irrigation Schemes in KwaZulu-Natal, South Africa. (Uyamenywa ukuba ingxa yocwaningo ebizwa Evaluation of institutional integration, farmer participation and performance in Smallholder Irrigation Schemes in KwaZulu-Natal, South Africa. This study seeks to find out about farmer participation in management and performance in irrigation schemes, and to evaluate institutional integration in the scheme governance. This will enable recommendations to be put forward as to how can scheme governance be improved. Leli cwano ifuna ukuphenya ukuthi abalimi abasebenzisa amanzi emseleni bayalibamba iqhaza nokuthi basebenza kanjani. Ucwano futhi itholisisa ukuthi imethetho ebewke phezulu nguhulumente iyasebenza yini emseleni. Lokhu kuzosiza ngokuthi izincomo zibekwe maelana nokuphathwa nokubusa kwe hlelo lokunisela

I guarantee that your responses will not be identified with you personally (*Ngithanda ukuqinisekisa ukuthi izimpendulo zakho ngeke zabizwa nawe uqobo*). Your participation is voluntary and there is no penalty if you do not participate in the study (*Ukubamba kwakho iqhaza kulolucwano yikuzithandela futhi akukho isijeziso uma unguthandi*). Please sign on the dotted line to show that you have read and understood the contents of this letter (*Sicela usayine emzileni ukukhombisa ukuthi ufundile futhi uyaqonda okuqukethwe kule ncwadi*). The questionnaire will take approximate 45 minutes to complete (Lemibuzo iyothatha imizuzu engu 45 ukuqedela).

DECLARATION OF CONSENT (ISIFUNGO SEMVUMO)

I (*Mina, u*)..... (Full Name/ *Igama ngokugcweleyo*)
hereby confirm that I have read and understand the contents of this letter and the nature of the research project has been clearly defined prior to participating in this research project (*ngiyafunga ukuthi ngifundile futhi ngiyaqonda okuqukethwe kule ncwadi kanye nohlobo locwaningo lucacisiwe ngaphambi kokubamba iqhaza kulolucwaningo*).

I understand that I am at liberty to withdraw from the project at any time, should I so desire (*Ngiyaqonda ukuthi ngikhululekile ukuhoxa kulolu cwaningo nganoma yisiphi isikhathi, uma ngithanda*).

Participants Signature (*Sayina lapha*).....

Date (*Usuku*).....