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# Determinants of Farmers' Participation in the Management of Smallholder Irrigation Schemes in Kwazulu-Natal Province, South Africa

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**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 weak environment for sustainable water use. This study adopted Principal Components Analysis and Structural Equation Modelling to evaluate the determinants of farmer's participation in the management of four smallholder irrigations schemes 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. The results show that agricultural training, land tenure security, credit access and co-operative membership positively influence farmers' participation in decision making. Additionally, irrigation water adequacy positively influences farmer's 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 agricultural and irrigation training to increase the likelihood of participating in the management of irrigation schemes.

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

## 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 shared water storage or diversion facility. 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 & Geyser, 2007). SIS plays 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 Averbeke, 2012) which are concepts that are focussed on involving the farmers 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 (Perrett, 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 & 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 users[1] in the operation, management, and maintenance of irrigation systems (Kulkarni & Tyagi, 2012).

This translates to the farmer being a “water manager” (Gomo et al., 2014). It refers to farmers’ 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, 1990; Özerol, 2012). 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, 1999; 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 & Kikuchi, 1999; Meinzen-Dick et al., 2002; Muchara et al., 2014). These factors may include geographical area, cultural norms, and institutional set-ups, as well as those that are social and economic. Meinzen-Dick et al. (2002) highlight that the presence of organizations such as co-operatives can play a unifying role in fostering 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 & Zamani, 2009). Hayami & 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 farmer influence farmer participation (Damianos & 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 & Giannakopoulos, 2002; Karlı 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 & Zamani, 2009). Given its broad complex nature, participation in SIS has been analysed using various methods (Khalkheili & Zamani, 2009; Fischer & Qaim, 2012; Muchara et al., 2014; Adekunle et al., 2015).

Khalkheili & 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

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

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 & 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 & Zamani, 2009; Özerol, 2012; Muchara et al., 2014). As such, this study seeks to evaluate the determinants of farmers' participation in the management of four irrigation schemes in KwaZulu-Natal, representative of an average scheme in South Africa. The operational status of selected SIS across South Africa is presented in Table 1. The study 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.

**Table 1: Operational Status of Selected Smallholder Irrigation Schemes in South Africa**

| Irrigation Scheme | Plot Size | Irrigated Area | No. of Farmers | Irrigation System |
|---|---|---|---|---|
| Zanyokwe | 0.2 | 439 | 61 | Sprinkler |
| Tyefu | 0.16-0.25 | 641 | 1678 | Sprinkler/drag |
| Keiskammahoek | 0.25 | 744 | 147 | Sprinkler |
| Shioh | 0.25 | 455 | 278 | Centre pivot/sprinkler |
| Qamata | 1.28 | 1959 | 1000 | Flood |
| Ncora | 0.2 | 2490 | 272 | Sprinkler/drag |
| Tugela Ferry | 0.1-0.2 | 540 | 1500 | Short-furrow |
| Makhathini Flats | 0.1-10 | 538 | 600 | Short-furrow/sprinkler |
| Ndumo | 10 | 500 | 50 | Underground water conveyance |
| Mooi-River | 0.1-5 | 25km | 540 | Gravity flow canal |

**Source:** Van Averberke et al. (2011)

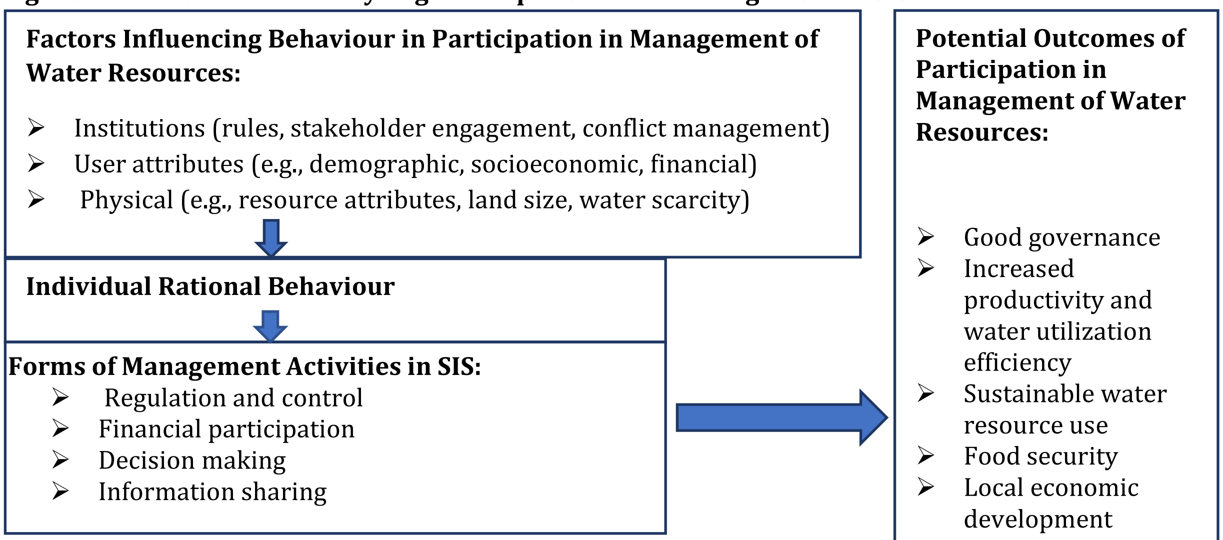
The following section presents the conceptual framework, followed by Section 3, which describes the data collection, study sites and analytical methods. The subsequent section presents the findings of the study, followed by conclusions and recommendations.

## 2. Methodology

**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 of 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 users as shown in Figure 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). 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, 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).

**Figure 1: Framework for Analysing Participation in the Management of SIS**




**Source:** Adapted from Muchara et al. (2014).

**Empirical Methods of Data Analysis:** The study employed Principal Component Analysis (PCA) and Structural Equation Modelling (SEM). PCA was used to generate the Participation in Management Indices (PIM). 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. 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 Likert scale such as a 5-point scale is recommended, the type of management activities, as an irrigator either never, sometimes, or always participated motivated the choice of the 3-point Likert. 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/conserve 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), which is a commonly used analytical tool in analysing cause-effect relationships in behavioural studies (Toma & Mathijs, 2007). 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. CFA is a statistical technique used to confirm or verify the factor structure of a group of observed variables (Gallagher & Brown, 2013) and thus models the relationship between observed and latent variables. 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. 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.

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 1:

$Y_i = b_0 + b_1X_1 + b_2X_2 + \ldots\ldots\ldots + b_{13}X_{13} + u_i$………… (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 2. 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 & Thamaga-Chitja, 2018) and would most likely participate more in the schemes, than their male counterparts.

**Table 2: 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 a 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 ranked their satisfaction of 25 governance issues. The household governance index considers the understanding of formal institutions governing irrigation schemes, as well as farmers' satisfaction of stakeholders' involvement in governmental institutions, tribal authorities, and non-governmental organizations. 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 & Wale, 2018).

## 3. Results and Discussion

**Descriptive Statistics:** Table 3 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 3: Descriptive Statistics of Water-Users in SIS**

| Variables | | Percentage % (n=341) |
|---|---|---|
| **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 adequate 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. This is expected as females dominate smallholder crop farming in the rural areas of KZN by (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) and Sithole et al. (2014) who found an average age of 55 and 54 amongst farmers in SIS in KwaZulu-Natal and Swaziland, respectively. About 36% of the farmers are members of agricultural co-operatives, while 60% have access to credit, similar to the findings of Sinyolo et al. (2014) who found that

65.8% farmers in SIS had 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.

**Structural Equation Model Analysis Results**

**Confirmatory Factor Analysis (CFA):** To successfully run a CFA model, the observed and latent variables must 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. This indicates that the latent variables included in the model are divergent or distinct management constructs. Table 4 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 4: Reliability Analysis of Participation in Management Constructs**

| Latent Constructs | Conbrach's Alpha $\alpha$[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 & Brown, 2013). This indicates that the latent variables included in the model are divergent or distinct management constructs. As shown in Table 5, the correlations range from 0.56 to 0.88, which are below 0.9, as such, proving discriminant validity (Gallagher & 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 indicates 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 (Muchara et al., 2014). 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, and therefore efforts.

**Table 5: Co-variances and Correlations between Latent Management Constructs**

| Latent Constructs | Co-variances | 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)

**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 6. 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 6: 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<br>Degrees of Freedom = 66<br>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 the irrigation schedule. The second PC, named financial contribution, is dominated by irrigator's financial contribution to irrigation activities and maintaining infrastructure 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.

**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 7 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 (Muchara et al., 2014).

Hence are more likely to participate more in the management of the scheme. Co-operatives play a unifying role in terms of participation in the schemes. 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. 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. Muchara et al. (2014), noted that training is critical at smallholder level where access to extension services is not always consistent and that farmers in the MRIS, who have received training are more likely to participate in the scheme farmers indicated that young people are less involved in scheme management and not interested in agriculture.

**Table 7: 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 | -035 (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.
**Source:** Survey Data (2018).

**Financial Contributions:** The results in Table 7 show that farmers who feel that the water they receive from irrigation is adequate for the cropping need, tend to participate more in financial contribution. This is expected, 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 management construct. 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. 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 (Chipfupa & Wale, 2018). 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 & 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, members who participate in scheme management are likely in the older age groups. 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).

## 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 use of the resource is highly likely to be unsustainable. 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 identified four dimensions of management constructs in which water-users participate, i.e., decision-making, financial contribution, information distribution and stakeholder engagement. The study concludes that varying factors drive farmers' participation in each management construct and that water-users vary in their participation in different management activities. As such, farmers should be made aware of the benefits of holistic and balanced participation to ensure the successful decentralization of scheme management. Credit access, gender, co-operative membership, agricultural training, water adequacy, governance index, age, and psychological capital positively affect participation in the different scheme management constructs.

Farmers who are satisfied with their land tenure, have a higher governance index, have undergone agricultural training, and are part of co-operatives, are more likely to participate in decision-making activities. As such, policy interventions should be focussed on establishing ways of ensuring that farmers have secure land tenure, as well as access to credit through micro-finance institutions and localized loan schemes. Furthermore, farmers should be encouraged to form and be part of co-operatives, as this also positively affects their propensity to make financial contributions in the schemes. Irrigators that feel that water is adequate for their crop production, participate in scheme stakeholder engagement and financial contribution. Therefore, access to water should be improved in SIS through better water scheduling arrangements and proper rule enforcement in terms of water extraction, which is a secondary effect of improved institutional settings. Agricultural training should be prioritized to increase participation in decision-making and stakeholder engagement across the SIS.

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