

Determinants of farmer awareness of water governance across gender dimensions in smallholder irrigation schemes in KwaZulu-Natal Province, South Africa

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Water is a vital resource for irrigated agricultural production. Its availability and accessibility are critical for alleviating poverty and achieving food security in rural households. However, smallholder irrigated agriculture in South Africa faces limited water supply emanating from scheme governance problems, with weak institutional arrangements that fail to equitably and effectively govern water resources. South African water policy has been transforming over the years. However, statutory laws remain unknown in smallholder irrigation schemes. This study sought to assess farmer awareness of water governance and identify the determinants of farmer awareness of water governance dimensions across gender dimensions in Mooi River, Tugela Ferry, and Ndumo irrigation schemes. The study employed principal component analysis to generate water governance indices, that is, formal institutions, the existence and effectiveness of scheme constitutions, scheme committees and enforcement of informal rules in the scheme. The ordinary least square regression technique was then used to identify factors determining farmer awareness of formal and informal water institutions in the three irrigation schemes. The findings suggest that formal water institutions are unknown and factors such as household characteristics, scheme location, stakeholder participation and involvement in scheme decision-making processes significantly influence awareness of governance. Therefore, there is a need to raise farmer awareness of formal water institutions and to strengthen the informal institutions which are functional, recognised and in line with irrigation management transfer.

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INTRODUCTION

Water is a vital resource for agricultural production, both irrigated and non-irrigated. Its availability and accessibility are critical for alleviating poverty and achieving food security in rural households. However, smallholder irrigated agriculture in South Africa faces limited water supply emanating from scheme governance problems and weak institutional arrangements that fail to equitably and effectively govern water resources (Denby, 2013). In many African countries, water has been traditionally acquired from open water sources such as natural springs, hand-dug wells or surface water; hence institutions regarding management were unknown (Schnegg and Bollig, 2016). This is because in the past, water rights were not important and were inferior to land rights. According to Tshuma and Monde (2012) and Muchara (2014), poor institutional arrangements and management in smallholder irrigation schemes (SISs) in South Africa make most of them dysfunctional. Therefore, water rights, water governance and institutional arrangements to control and regulate the use of water become extremely important. However, the nature of water and its properties in rural areas make the definition of water rights difficult and costly. Water rights are inherently linked to land rights because ownership of an irrigation plot automatically gives the right to irrigation water access.

South African water policy has transformed to address past racial imbalances in accessing water that were created by the apartheid government. In 1998, South Africa enacted the National Water Act (NWA) (Act 36 of 1998; RSA, 1998) with an intention to 'decentralise and integrate water management, create new local and regional institutions with equal representation, register and licence water use and finally to facilitate the emergence of a water rights market' (Denby, 2013 p. 2). In 2006, the water allocation reform (WAR) policy was implemented to reallocate water from the advantaged to economically disadvantaged individuals. However, the implementation of the NWA and WAR has been slow, and their expected outcomes have not been realised. For example, the compulsory licensing which is one of the mechanisms of the WAR programme has not been widely implemented (DWA, 2013). Likewise, although the NWA is recognised globally as progressive water policy, it is unknown in SISs (Denby, 2013). Meinzen-Dick and Nkonya (2005) argued that if the range and complexity of institutions governing the use of water resources are not understood, any efforts to improve water allocations will be ineffective and not yield the desired outcomes.

According to Gallaher and Heikkila (2014), water governance is about collective decisions and choices relating to the use and management of water resources that emerge through institutions. It encompasses the mechanisms of setting rules and institutions with which water resources are managed. Sokile et al. (2005, p. 1) defined formal institutions as 'the written ordinances created by the legislative council before the independence and contemporary legislation in one hand', while, informal water institutions are defined as 'the set of local, community-based practices that are normally determined by local customs, traditions, and culture of water use.'

The study argues that both formal and informal water institutions are essential for the efficient and sustainable distribution of irrigation water among users since formal and informal water institutions are interlinked (Sokile et al., 2005; Deribe, 2008). Unfortunately, statutory laws are unknown at scheme level due to insufficient communication between government officials and irrigators (Meinzen-Dick and Nkoya, 2005). In the Inkomati catchment management area (South Africa), Mehta et al. (2014) found that smallholder farmers lack knowledge of the NWA, formal water policy and other formal channels for accessing water, reflecting poor communication between the national government, local government and water users at the farm level. Consequently, irrigators in SISs define their own rules and regulations regarding water use and perceived customary laws to be stronger and powerful than formal laws.

Therefore, the study sought to assess farmer awareness of water governance and identify the determinants of farmer awareness of water governance dimensions across gender dimensions in Mooi River, Tugela Ferry and Ndumo irrigation schemes, South Africa. The study was undertaken as part of a project (K5/2556/4) initiated, managed and funded by the South Africa Water Research Commission (WRC) entitled, 'Assessment of policies and strategies for the governance of smallholder irrigation farming in KwaZulu-Natal Province, South Africa'.

METHODS

This section provides a brief explanation of the research methods used in this study, i.e., the study area, data collection and sampling techniques, empirical model and the variables (explained and explanatory) used in the analysis.

Study area

The survey was undertaken in Mooi River and Tugela Ferry Irrigation Schemes located in Msinga Local Municipality in Umzinyathi District, and Ndumo Irrigation Scheme located in Jozini Local Municipality in Umkhanyakude District. Mooi River Irrigation Scheme (MRIS) covers approximately 600 ha made up of 15 Blocks (Block 1 – 15) which serve about 850 irrigators. The scheme primarily depends on the Mooi River for water and uses the canal to convey water to the field. Tugela Ferry Irrigation Scheme (TFIS) has the highest number of beneficiaries (1 500 irrigators). It covers approximately 800 ha made up of 9 Blocks (Block 1, 2, 3, 4A, 4B, 5, 6, 7A and 7B). The scheme is fed by Tugela River and uses the canal, diesel, and electric pumps to convey water to the field. Finally, Ndumo Irrigation Scheme (NIS) is a relatively large irrigation scheme (approximately 1 500 ha comprising of Phase 1 and 2) serving relatively fewer beneficiaries (100 irrigators) compared to the other irrigation schemes. The scheme abstracts water from Pongola River and conveys it to the plots through an electric pump. All the study irrigation schemes are farmer-managed with minimal or no governance assistance. The different location of the schemes, variation in and farmer awareness of water governance across the schemes informed the choice of irrigation schemes.

Data collection tools and sampling techniques

Primary data used in this study were collected through focus group discussions, key informant interviews, and a structured household questionnaire. The household questionnaire was pre-tested, modified accordingly and administered by trained Zulu-speaking enumerators. Survey respondents were selected using a stratified and systematic random sampling technique, where the strata were the blocks within the schemes. A sample of 274 irrigators was drawn from the three irrigation schemes by selecting every fifth irrigator. In stratified random sampling,

samples are randomly drawn from non-overlapping strata of the population (Singh and Chaudhary, 1986), whereas in systematic sampling, samples are drawn by selecting the first unit with the help of random numbers, while the rest get selected automatically (Singh and Chaudhary, 1986). Using the combination of the two sampling techniques made it easier to draw more precise samples that are easy to execute and to ensure adequate representation to irrigators within the schemes (Singh and Chaudhary, 1986).

Empirical model

The study employed principal component analysis (PCA) and ordinary least squares (OLS). PCA was used to generate indices indicating formal and informal water institutions in SISs. OLS regressions were applied to identify factors influencing farmer awareness of formal and informal water institutions.

Principal component analysis

Likert scale type questions were asked to assess the major indicators of formal and informal water institutions, with farmers indicating whether they strongly disagreed, disagreed, were neutral, agreed or strongly agreed. Index values increase from 1 to 5 if the respondent strongly agrees and decreases from 5 to 1 if the respondent strongly disagrees. Principal component analysis (PCA) was then used to generate indices for formal and informal water institutions.

Ordinary least squares regression model

The generated indices from the PCA were regressed against explanatory variables known to influence farmer awareness using ordinary least squares (OLS). The number of regression models to be estimated equals the number of the retained PCs, which captured different dimensions of water institutions. According to Gujarati and Porter (2009), the OLS regression model can be specified as:

$$Y_i = \beta_0 + \beta_1 X_i + \mu_i \quad (1)$$

where Y_i is the water institution index for the i^{th} irrigator; X_i is a vector of explanatory variables; β_0 and β_1 are the vector of parameters to be estimated and μ_i is the error term.

Description of variables

Dependent variables

The Kaiser-Meyer-Olkin (KMO), the measure of sampling adequacy, for formal and informal institutions, was at least 0.5, implying that PCA can be performed (Table 1) (Kaiser and Rice, 1974). Likewise, Bartlett's test of sphericity, which checks if the observed correlation matrix diverges significantly from the identity matrix (H_0 : the variables are orthogonal), were statistically significant ($p < 0.001$) implying that the variables were not perfectly correlated. Therefore, PCA can be performed efficiently. To retain the PCs, the study applied the Kaiser criterion which suggests that PCs with eigenvalues greater than 1 must be retained (Everitt and Hothorn, 2011). Three PCs representing informal, and one PC representing formal water institutions, respectively, were retained. Tables 1 and 2 present the generated PCs as indicators of formal and informal water institutions, respectively.

With reference to Table 1, the first three PCs retained explained 72.13% of the total variation in the data, cumulatively. The first PC had a higher explanatory power, explaining about 36.35% of variation in farmer awareness of formal water institutions. The second and third PC accounted for 18.72% and 17.07%, respectively. PC1 is economically meaningful, as all its

Table 1. Principal component analysis of the major indicators of formal water institutions at scheme level

Description of variables	Principal component		
	PC1	PC1	PC1
Awareness of NWA	0.902	-0.169	-0.095
Awareness of NWRS	0.890	-0.163	-0.101
Knowledge of government aims	0.596	-0.057	0.484
Availability of water licences	0.118	0.758	-0.370
Availability of water rights	0.156	0.610	0.682
Knowledge of any WUA	0.427	0.343	-0.411
Eigenvalue	2.181	1.123	1.024
% of variance explained	36.34	18.72	17.07
Cumulative % variance explained	36.34	55.06	72.13
KMO		0.603	
Bartlett test of sphericity	$\sim\chi^2 = 372.542 (p < 0.001)$		
<i>n</i>	274		

Note: Component loadings greater than |0.40| are highlighted in bold print

coefficients are positive and have larger component loadings. Each variable represents formal institutions governing water in irrigation schemes. Therefore, the positive component loadings indicate that PC1 represents farmer awareness of formal water institutions (FORMAL_INSTI), while PC2 indicates farmer possession of legal water requirements. The analysis will be performed on the first PC which is more economically meaningful.

The first retained PC in Table 2 explained 35.02% of the total variation in the major indicators of formal water institutions. PC1 is economically meaningful, as all its coefficients are positive and have larger component loadings. Each variable is closely related to farmer awareness of informal water institutions governing the scheme operations. Hence, it was named informal institutions (INFORMAL_INST).

Irrigation schemes have rules developed for managing water resources, and those rules are stipulated in the constitution. For these rules to work effectively they need to be enforced. The second retained PC explained 21.81% of the total variation in the major indicators of informal water institutions. This PC is economically meaningful and closely related to farmer perceptions of rule enforcement in the scheme. Hence, the PC was named rule enforcement (RULE_ENF).

Explanatory variables

Studies that have been done on farmer awareness indicated that household characteristics, membership in farmer organisations, source of information, access to extension services and stakeholder participation are some of the influential factors to farmer awareness of national policies (Muatha, 2014; Okpeke et al., 2015; Duhan and Singh, 2017; Duhan and Dhingra, 2018). Therefore, this study predicted that farmer awareness of water institutions is influenced by household demographics, scheme location, stakeholder involvement in the scheme, participation in scheme leadership and in decision-making processes, membership in farmer organizations and accessible sources of information. However, the effects of factors influencing farmers awareness of water institutions vary across formal and informal water institutions. Table 3 provides a description of the variables included in the analysis.

Table 2. Principal component analysis of the major indicators of informal water institutions at scheme level

Description of variables	Principal components	
	PC1 INFORMAL_INST	PC2 RULE_ENF
Presence of appropriate rules in irrigation water management	0.385	-0.667
Satisfaction with the current executive committee	0.625	0.069
Difficulties in rule enforcement	0.227	0.797
Fair penalties to non-compliance	0.751	0.071
Satisfaction with conflict management in the scheme	0.772	-0.026
Eigenvalue	1.751	1.091
Variance explained (%)	35.019	21.815
Cumulative % of variance explained	35.019	56.834
KMO		0.594
Bartlett test of sphericity	$\sim\chi^2 = 111.588 (p < 0.001)$	
<i>n</i>	274	

Note: Component loadings greater than |0.40| are highlighted in bold print

Age: Age is one of the factors influencing the level of awareness. According to Duhan and Singh (2017), younger farmers read more from different information sources and are not as reluctant as older farmers to adopt changes in agricultural/water policies; hence are more aware compared to older farmers. They attributed this discrepancy to a different level of education obtained by the two groups. Therefore, in this study, older irrigators are anticipated to be least aware of formal water institutions and more likely to be aware of informal water institutions.

Gender: In SISs and the African culture women tend to be treated as inferior although they constitute the largest proportion of smallholder farmers. Women are usually denied access to attend meetings, workshops or training (Mudege et al., 2017). Sometimes they are held back by household activities they need to perform. According to Muatha (2014), male irrigators have a higher likelihood to be exposed to water institutions. Therefore, holding other factors constant, male irrigators are anticipated to be more aware of water institutions than female irrigators.

Level of education: According to Duhan and Dhingra (2018), literacy level and educational qualification influence levels of understanding and awareness of agricultural innovations. Less-educated irrigators are assumed to be less aware of water institutions. However, this is not always the case. SISs are dominated by older farmers with no formal education (EDUC_LEVEL) but tend to be more aware of the scheme governance. A positive association between education and farmer awareness of formal institutions is expected, ceteris paribus.

Scheme location: The location of an irrigation scheme (municipality) can influence farmer awareness of water institutions through the extent of external stakeholder involvement in water resource management. Since the study irrigation schemes are in different local municipalities located under different tribal authorities, either a positive or negative influence on farmer awareness of water institutions can be expected.

The role played in scheme leadership: Irrigators who participate in scheme decision-making processes are more likely to be informed about formal institutions and community affairs. According to Mowo et al. (2013), local leaders are relatively better educated and are the ones who formulate local

Table 3. The description of variables included in the analysis and their anticipated effects

Variable	Description	Anticipated effect
Explanatory variables		
AGE	The age of an irrigator (years)	-/+
GENDER	The gender of an irrigator (1 = male; 0 = otherwise)	+
EDUC_LEVEL	The level of education an irrigator has received (1 = formal education; 0 = otherwise)	+
SCHEME_LOC	Scheme location, the local municipality where the irrigation scheme is located (1 = Msinga Local Municipality; 0 = Jozini Local Municipality)	+/-
ROLE_SCHMLED	Role played in scheme leadership (1 = ordinary member; 2 = block committee; 3 = secondary committee)	+
WATM_TRAIN	Whether an irrigator have received formal water management training (1 = yes; 0 = otherwise)	+
WUA_MEMB	Whether an irrigator is a member of Water Users Association (WUA) (1 = yes; 0 otherwise)	+
GOVT_INV	Involvement of government departments in the scheme management (index)	+
TRIBAUTH_INV	Involvement of traditional authorities in the scheme management (index)	+
INV_SCHMDEC	Irrigator participation in decision-making processes in the scheme (index)	+
INFO_SOURCE	Source of information (index)	+
Dependent variable		
FORMAL_INST	Farmer awareness of formal water institutions (index)	
INFORMAL_INST	Farmer awareness of the informal water institutions in the scheme (index)	
RULE_ENF	Farmer perception about rule enforcement in the scheme (index)	

institutions through their leadership roles. This is because the block committee and secondary committee members are scheme leaders. Everything that has to do with farmers in SISs goes through the scheme committee, and if there is training or a workshop to be provided to farmers, scheme committee members are always expected to attend.

Training: Water management training is critical for improving water-use efficiency and sustainable use of irrigation water in SISs (Namara et al., 2010). Irrigators who have received water management training are more likely to be aware of formal water institutions, *ceteris paribus*. Water management training provided by the irrigation committee is likely to disseminate information on the intentions of informal water institutions. Therefore, water management training (WATM_TRAIN) is anticipated to be positively related to farmer awareness of formal and informal water institutions, *ceteris paribus*.

Farmer organizations: Farmer organizations serve as a convenient platform for farmers to disseminate agriculture- and water-related information. Water user associations (WUA) are a formal farmer organization established as a strategy for

establishing governance of the scheme and for disseminating information about formal water institutions (Manzungu, 2000; Sokile et al., 2005). It is therefore anticipated that membership in a WUA (WUA_MEMB) is expected to positively increase farmer awareness of both formal and informal water institution, *ceteris paribus*.

Stakeholder participation: Water resources in SA are managed through water legislation (NWA) focusing on ensuring equitable and sustainable allocation of water resources through authorization (licensing and registration) to avoid and control the risks of unsustainable water management (Namara et al., 2010). The involvement of government departments (GOVT_INV) in irrigation schemes will inform irrigators about the formal NWA, its aims and strategies. Involvement of tribal authorities (TRIBAUTH_INV) is anticipated to increase farmer awareness of informal water institutions as they also play an important role in rule enforcement. Traditional authorities, particularly chiefs, have the power to influence rural farmers (Sokile et al., 2005; Deribe, 2008). Farmer involvement in decision-making processes in the scheme (INV_SCHMDEC) relating to water management activities is anticipated to raise farmer awareness of water institutions and thereby enhance decision-making capacity, *ceteris paribus*. In addition, Muatha (2014) asserted that farmer engagement in scheme decision-making processes also plays an important role in maintaining harmony among irrigators.

Source of information: Access to information plays a significant role in agricultural development (Mudege et al., 2017). The most important and easily accessible information sources in the study irrigation schemes include extension officers, media, irrigation committee, and fellow farmers. Among these information sources, extension officers and the media play an important role in providing information on national policies (Muatha, 2014). Holding other factors constant, the source of information (INFO_SOURCE) is expected to positively increase farmer awareness of both formal and informal water institutions.

RESULTS AND DISCUSSION

This section presents the study findings. It starts off by providing a brief description of household characteristics of the study and farmer awareness of formal water institution in MRIS, and TFIS, and finally gives an overview of the regression results.

Descriptive statistics

Household characteristics

The results obtained from the household survey conducted for the study irrigation schemes indicated that MRIS and TFIS are dominated by female, elderly farmers with an average age of 57 and 55 years, respectively, who had not acquired formal education (Table 4). The dominance of women in MRIS and TFIS can be attributed to the fact that irrigation farming is regarded as a female activity in Msinga, while males concentrate on cattle rearing and non-farm activities (Muchara, 2014; Sinyolo et al., 2014). On the contrary, Ndumo Irrigation Scheme is dominated by young irrigators with an average age of 46 years and who are better educated with a considerable proportion of irrigators with high school and tertiary levels of education (Table 4). Unlike in other SISs, Ndumo irrigators are predominantly male.

Farmer awareness of water institutions across irrigation schemes

The results presented in Table 5 indicate that most irrigators were not aware of formal water institutions (NWA, NWRS, and WUAs). Hence, the WUAs were non-existent. On average,

very few irrigators indicated having received water management training in these schemes. Across the irrigation schemes, irrigators always participated in scheme decision-making if they were informed about the opportunity to do so by the irrigation scheme's institutions. Moreover, irrigators across the schemes (MRIS= 4.44; TFIS= 3.62; NIS= 3.44) were satisfied with the involvement of traditional authorities in the scheme. Farmer awareness of formal water institutions showed statistically significant variation, meaning that the awareness differed across irrigation schemes. NIS irrigators are most aware and have received more water management training than those in the other two irrigation schemes. This could be attributed to the variation in the level of education acquired, the average age of irrigators and the availability of information sources across the schemes.

Regression results

With reference to Tables 6 and 7, the *F*-tests on all the estimated regression models were statistically significant ($p = 0.001$), implying that all the explanatory variables included in the models jointly had a meaningful influence on farmer awareness of formal and informal water institutions in MRIS, TFIS, and NIS. The variance inflation factors (VIFs) used to test for multicollinearity among variables were all less than 10, indicating that multicollinearity was not a serious problem in the data set (Gujarati and Porter, 2009). Moreover, heteroscedasticity was accounted for by using robust standard errors in the OLS regression.

Table 4. Household characteristics across the study irrigation schemes

Variable	Description	Irrigation scheme			χ^2
		MRIS	TFIS	NIS	
Age group (%)	20 – 35 years	10.1	7.5	32.4	***
	36 – 56 years	37.0	42.5	38.2	
	57 – 69 years	34.5	35.0	23.5	
	70 – 88 years	18.5	15.0	5.9	
Gender (%)	Male	15.8	12.5	67.6	***
	Female	84.2	87.5	32.4	
Education (%)	No formal	64.7	59.2	23.5	***
	Formal	35.3	40.8	76.5	

Note: *** = $p < 0.01$; ** = $p < 0.05$; * = $p < 0.10$; NS = not statistically significant

Table 5. Farmer awareness of water institutions across irrigation schemes

Water institution	Awareness	Irrigation scheme			χ^2
		MRIS	TFIS	NIS	
Awareness of NWA (%)	Agree	14.2	1.7	29.4	***
	Strongly agree	2.5	0.0	17.6	
Awareness of NWRS (%)	Agree	10.0	0.8	14.7	***
	Strongly agree	1.7	0.0	14.7	
Knowledge of WUAs (%)	Yes	6.7	0.8	6.7	*
Member of WUA (%)	Yes	0.0	0.0	3.1	**
Water management training (%)	Yes	29.2	18.3	44.1	***

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

Table 6. Factors influencing farmer awareness of formal water institutions in Mooi River, Tugela Ferry and Ndumo irrigation schemes, 2018

Explanatory variables	FORMAL_INSTI		VIF
	Coefficient	Robust Std. Error	
AGE	-0.001 ^{NS}	0.004	1.34
MALE	0.526 ^{***}	0.191	1.31
FORMAL_EDUC	0.335 ^{***}	0.136	1.36
SCHEME_LOC	-0.536 ^{***}	0.291	1.34
WATM_TRAN	0.399 ^{***}	0.142	1.09
ROLE_SCHMLED	0.079 ^{NS}	0.180	1.14
GOVT_INV	-0.012 ^{NS}	0.030	1.13
TRIBAUTH_INV	0.037 ^{NS}	0.035	1.06
INV_SCHMDEC	0.097 ^{**}	0.042	1.18
INFO_SOURCE	-0.052 ^{NS}	0.056	1.19
_cons	0.089 ^{NS}	0.570	
Model summary	<i>F</i> -stat = 6.90; $p < 0.001$ $R^2 = 0.2358$; $n = 274$		Mean VIF = 1.21

Note: *** = $p < 0.01$; ** = $p < 0.05$; * = $p < 0.10$; NS = not statistically significant

Table 7. Regression results of factors influencing farmer awareness of informal water institutions in Mooi River, Tugela Ferry and Ndumo irrigation schemes, 2018

Explanatory variables	INFORMAL_INST		RULE_ENF		VIF
	Coeff.	Rob. std err.	Coeff.	Rob. std err.	
AGE	0.001 ^{NS}	0.004	0.007 ^{NS}	0.004	1.30
MALE	-0.171 ^{NS}	0.148	0.081 ^{NS}	0.155	1.31
FORMAL_EDUC	-0.102 ^{NS}	0.113	0.221 [*]	0.126	1.36
SCHEME_LOC	-0.161 [*]	0.188	0.415 ^{**}	0.195	1.37
WATM_TRAN	0.117 ^{NS}	0.113	0.109 ^{NS}	0.128	1.09
ROLE_SCHMLED	-0.203 [*]	0.111	0.106 ^{NS}	0.137	1.13
GOVT_INV	0.158 ^{***}	0.032	0.007 ^{NS}	0.027	1.12
TRIBAUTH_INV	0.307 ^{***}	0.047	-0.053 ^{NS}	0.036	1.07
INV_SCHMDEC	0.449 ^{***}	0.072	0.185 ^{***}	0.045	1.18
INFO_SOURCE	-0.029 ^{NS}	0.063	-0.406 ^{***}	0.047	1.20
_cons	-2.249 ^{***}	0.647	1.158 ^{**}	0.505	
Model summary	<i>F</i> -stat = 8.55; <i>p</i> = 0.001 <i>R</i> ² = 0.2940; <i>n</i> = 274		<i>F</i> -stat = 11.39; <i>p</i> = 0.001 <i>R</i> ² = 0.2613; <i>n</i> = 274		Mean VIF = 1.21

****p* < 0.01; ***p* < 0.05; **p* < 0.10; NS = not statistically significant

Factors influencing farmer awareness of formal water institutions in smallholder irrigations schemes

The regression model for the first PC had an *R*² of 0.2358, implying that 23.58% of the variation in farmer awareness of formal water institutions is explained by the explanatory variables included in the model. The regression results indicated that, among the explanatory variables included in the model, male, formal education acquired, water management training, scheme location and farmer engagement in scheme decision-making processes had a positive and significant influence on farmer awareness of formal water institutions, except scheme location which had a negative association with farmer awareness of formal water institutions.

The estimated coefficient of ‘male’ was found to be positive and statistically significant (*p* < 0.01) as anticipated. This suggests that male irrigators were more aware of formal water institutions relative to female irrigators, by 0.526 units, *ceteris paribus*. Cheteni (2016) found a positive association between gender and farmer awareness of biofuel crops. He argued that male farmers obtain information faster than female farmers, and thus tend to have a higher level of awareness on agricultural activities or innovations.

A statistically significant (*p* < 0.01) and positive association between formal education and farmers’ awareness of formal water institutions was found as anticipated. Irrigators who have received formal education were more aware of formal water institutions, by 0.335 units, than those with no formal education, *ceteris paribus*. According to Duhan and Singh (2017), the level of education directly influences the level of awareness and the correlation between education and awareness level is high. They found a positive relationship between the level of education and farmer awareness of crop insurance.

The estimated coefficient of scheme location (Msinga) was found to have a negative and statistically significant (*p* < 0.01) relationship with farmer awareness of formal water institutions. Irrigators in Msinga are less aware of formal water institutions than irrigators in Jozini by 0.536 units, *ceteris paribus*. This significant discrepancy between farmer awareness across these locations could be associated with differences in the accessibility of information and different sources of information.

A statistically significant (*p* < 0.01) and positive relation was found between farmer awareness of formal water institutions

and water management training. Irrigators who had received water management training were more aware of formal water institutions, by 0.399 units, compared to those who have not received the training.

The estimated coefficient of farmer involvement in scheme decision-making processes was found to be a positive and statistically significant relationship (*p* < 0.05), as anticipated. An increase in farmer involvement in the scheme decision-making processes increases farmer awareness of formal water institutions by 0.096 units, *ceteris paribus*. Participation in decision-making processes in the scheme causes irrigators to be aware and updated about new water laws implemented at the central level, given that the scheme committee is also aware of formal water institutions.

Factors influencing farmer awareness of informal water institutions in smallholder irrigations schemes

The regression results presented in Table 7 show that farmer perceptions of the informal institutions governing the scheme were influenced by the role played by an irrigator in scheme leadership (ROLE_SCHMLED), government involvement in SISs (GOVT_INV), tribal authority involvement in SISs (TRIBAUTH_INV) and farmer involvement in scheme decision-making processes (INV_SCHMDEC). The *R*² was 0.2940 implying that 29.40% of the farmer awareness of the scheme governance is explained by the explanatory variables included in the model.

Formal education (FORMAL_EDUC), scheme location (SCHEME_LOC), farmer involvement in the scheme decision-making processes (INV_SCHMDEC) and the source of information (INFO_SOURCE) had a statistically significant influence in rule enforcement in the scheme. The *R*² for the model is 0.2613, implying that 26.13% of the variation in rule enforcement in the scheme is explained by the explanatory variables included in the model.

Farmer awareness of informal institutions governing the scheme

A negative and statistically significant relationship between the role played by an irrigator in the scheme leadership implies that being in the scheme leadership reduces farmer

awareness of informal institutions governing the scheme. This relationship contradicts prior expectations of the study. This can be attributed to the dominance of irrigators who are not part of the scheme committee, since this involves only very few irrigators in the scheme. The positive and statistically significant ($p < 0.001$) association between government and tribal authority involvement in SISs and farmer involvement in scheme decision-making processes and farmer perceptions of informal institutions in the scheme is consistent with the study expectations. Scheme governance involves various stakeholders such as government departments, traditional leaders, irrigators and the scheme committee, who work together for effective water management. In farmer discussions in MRIS, it became apparent that advisors from the local Department of Agriculture and Rural Development (DARD) are aware of the scheme governance as they work with irrigators, providing advisory services, implements and farm inputs. The involvement of tribal authorities in SISs increases farmer awareness of informal institutions governing the scheme. This is because all the study irrigation schemes are located in traditionally oriented areas where the authority of traditional leaders is most respected and obeyed. It was evident from focus group discussions that tribal authorities are aware of the operations in the scheme and know the scheme rules. They are also involved in the disciplining of non-compliance. Attending scheme meetings and participating in decision-making processes in the scheme improves farmer awareness of informal institutions governing the scheme. They are aware and updated about amendments in the scheme rules and scheme leadership.

Enforcement of rules in the scheme

Formal education revealed a positive and statistically significant relationship with rule enforcement in the scheme, implying that irrigators who have received formal education are more informed about the significance of rule enforcement. Hence, they were more aware that rules are enforced in the scheme. A positive association was found between the location of an irrigation scheme, farmer involvement in the scheme decision-making processes and farmer awareness of rule enforcement in the scheme. Irrigators in the Msinga Irrigation Scheme and farmers who participate in scheme decision-making processes are more likely to be aware of the rule enforcement in the scheme. This is because there are high incidents of unlawful behaviour and water conflicts in Msinga irrigation schemes compared to Jozini irrigation schemes. It is often difficult to report unlawful behaviour and impose penalties on irrigators due to fear of death; however, there were some cases where irrigators were disciplined and matters are taken to traditional leaders. In this way, irrigators become aware that rules are enforced in the scheme. During the decision-making process issues of non-compliance, the possible punishments to be imposed and the effective ways of enforcing rules in the scheme are often discussed. The source of information does not inform irrigators about rule enforcement in the scheme.

CONCLUSION AND RECOMMENDATIONS

The study concludes that formal water institutions are unknown at the farm level, reflecting insufficient communication between government officials and irrigators. Instead, irrigators in SISs rely on informal institutional arrangements for water management. Formal water management institutions such as WUAs are unknown and/or non-existent. Results revealed that male irrigators were more aware of formal institutions than their female counterparts. This is because male farmers obtain information faster than female irrigators. In addition, customary laws and social norms in the study areas promote

patriarchal power and limit women from participating in public organizations, local water governance, and decision-making processes, as traditionally they are expected to do homestead activities. Age of irrigator did not influence farmer awareness of both formal and informal water institutions in Mooi River, Tugela Ferry and Ndumo Irrigation Scheme.

The study recommends that for the NWA to achieve its goals, it is important that tribal authorities and irrigators should be made aware of the national laws, what they entail and their aims. In SISs irrigators tend to comply with rules locally set by traditional leaders which causes informal water institutions to be preferred to formal institutions. In addition, customary laws should be given recognition and incorporated when formulating national laws.

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