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IRRIGATION GOVERNANCE AND VEGETABLE CROP YIELDS: THE CASE OF SMALL-SCALE SCHEMES IN NORTHERN GHANA

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Abstract
In Ghana, although small-scale irrigation schemes have been constructed over the years to improve agricultural performance and rural livelihoods, it is reported that these schemes perform poorly, possibly due to weak management by Water User Associations (WUAs). In this paper, a set of indicators of irrigation governance is developed and used to assess the relationship between irrigation governance and irrigated crop yields in selected small-scale irrigation schemes in northern Ghana. Based on a set of 46 indicators, six dimensions of irrigation governance are distinguished. Regression analysis show that yield per irrigated area is positively associated with the extent to which farmers perceive their participation in the joint management of irrigation schemes, and negatively associated with the extent to which farmers perceive that conflicts on land- and water use are managed well by WUAs. Rules and regulations regarding conflict resolutions in the study area need to be reviewed to discourage free riding and thus break the negative relationship between conflict resolution and irrigated crop yields.

Keywords: *Irrigation Governance, Water User Associations, Smallholder Farmers, Yields, Sustainability.*

Introduction
The aim of building small-scale irrigation schemes in Ghana is to enable less-privileged communities to achieve better economic livelihoods through higher yields and cropping intensities. However, a number of studies indicate that the schemes are underperforming in this respect (Namara et al., 2011; Venot and Hirvonen, 2013). Compared to investment costs, yields from irrigated agriculture are low, with vegetables reported as being relatively more viable (Namara et al., 2011). One reason is that not all the reservoirs are in use and that the reservoirs that are actually being used do not realise their full potential. In the Upper East Region for instance, a high number of small reservoirs appear not to be in use. In their study of 126 small-scale reservoirs, GMAT (2010) found that 58% of the reservoirs were not used for irrigation, while 18% used irrigation in catchment/reservoir areas, thereby reducing the irrigation potential of the schemes. They attribute the high share of non-used schemes to governance challenges in the construction of the schemes, particularly the fact that Water User Associations (WUAs) had no say in infrastructure construction. Their study also highlights major problems in the maintenance of schemes, and finds that communal activities related to the maintenance of irrigation reservoirs depend on the quality of the soils and the spillways. Lamptey et al. (2011) explained that the institutional mandate for irrigation development in Ghana is unclear due to the presence of many institutions in the irrigation sector with overlapping roles. This lack of transparency leads to low use of

irrigation facilities and therefore to poor performance.

Other studies blame the quality of governance at the scheme level, particularly in the technical and organisational aspects of irrigation management (Venot and Hirvonen, 2013; Dittoh et al., 2013; Poussin et al., 2015). Some irrigation facilities have defects in design and construction and require further investment to correct them, but this is often not done. Other irrigation facilities lack clear oversight responsibilities in terms of monitoring and supervision, which are critical for the sustenance of resources. In a comparative study of small-scale irrigation schemes in Africa and Asia, Mutambara et al. (2016) blamed part of the poor performance of African schemes on weak Irrigation Management Committees or WUAs. In general, proper governance of communal irrigation schemes depends on the specific institutional arrangements that are in place (Agrawal, 2003; Howarth et al., 2005; Venot and Hirvonen, 2013; Poussin et al., 2015). In group-managed irrigation schemes, governance entails the use of rules and regulations to ensure sustainable use of communal resources. Rules and regulations are important, especially in multifunctional resources, where resources fulfil different demands among users. The rules and regulations refer to different dimensions of governance, such as accountability, participation, transparency, and cooperation (GWP 2009; Tortajada, 2010; Lautze et al., 2011). While some rules may be geared towards fairness and equity in a group, others may be aimed at sustainable use of resources. Some dimensions of governance can thus have more impact on performance of irrigation schemes than others, which occurrences need exploration.

In this paper the performance of WUAs in northern Ghana is evaluated by distinguishing different irrigation governance dimensions based on perceptions of farmers, and using these to assess the relationship between irrigation governance and irrigated crop yields. Survey data from households within 37 small-scale irrigation schemes are used for this purpose. The paper contributes to the debate on the role of governance in sustaining jointly managed irrigation schemes by empirically testing the extent to which different dimensions of irrigation governance relate to the performance of irrigation schemes through crop yields. There are studies on general governance of irrigation which evaluate governance based on the physical status of irrigation infrastructures and the availability of concrete institutions for irrigation management. GMAT (2010), for instance, discussed the technical aspects of irrigation governance in terms of infrastructural availability and whether available schemes in Ghana are functioning or not. For small-scale irrigation schemes that are functioning, the critical governance issues are related to scheme maintenance and allocation of land and water to users. This study therefore focuses on the activities of land and water users and their relationship with the WUA, and how the latter governs the irrigation processes that affect crop performance along various dimensions.

Study Area and Research Context

The research was done in the Northern, Upper East, and Upper West Regions of the Savannah zone of Ghana. These regions are considered the poorest areas in the country. Ghana has a poverty incidence rate of about 23.4% (GSS, 2018) from a population of about 30 million people. The poverty incidence is wider in the Savannah zone with a record of 46.3% (ibid). The area is comparatively dry with an annual rainfall of about 1,000 mm. Dry-season farming in communities that have access to water bodies complements rain-fed harvest. The terrain of a community is a major determinant to the type of irrigation systems that exist in communities. Irrigation through small-scale reservoirs is predominant in the study area. Rice and vegetables are the major irrigated crops.

Irrigation schemes in Ghana have been managed by the Ghana Irrigation Development Authority (GIDA) over the years. GIDA was established in 1977 by the government to replace the Irrigation Development Department of the Ministry of Food and Agriculture. However, GIDA was unable to fulfil its mandate satisfactorily and the government laid off most of its staff as part of the governments' structural adjustment programmes. Participatory Irrigation Management (PIM) was introduced in the early 1990s (Namara et al., 2011). The PIM approach allows beneficiary farmers and other water users to jointly manage irrigation facilities by paying costs for irrigation services and providing labour for small maintenance activities in public irrigation schemes. In addition to the 22 public irrigation schemes in Ghana, there are several small-scale irrigation schemes in the form of reservoirs and dugouts throughout the country. These schemes are normally funded by donor organisations and built by GIDA or leased to private consultants (Namara et al., 2011). Unlike the public schemes, these small-scale schemes use open-channel irrigation methods (that is, without a measuring gauge), which often waste lots of water. They are normally designed and constructed to have one main canal (to convey water from the reservoir) with several laterals (to convey water from the canal to farms). These schemes have various uses in addition to irrigation, including watering livestock, domestic use, and fish production. Normally, after their construction, WUAs are formed as local-level water management structures of the schemes while GIDA provides supervision and extension services. The idea of the WUA approach was adopted to relieve the government and to encourage a sense of ownership among users for the sustainable management of small-scale irrigation schemes. According to Ostrom (1990), collective management is a pre-condition for effective maintenance of communal resources like public irrigation schemes.

Water use rights and policies in Ghana are generally regulated and coordinated by the Water Resources Commission. The Water Resources Commission Act 1996 (Act 522) is however silent on the existence and mandate of WUAs. As in many countries in Africa, Ghana still needs to incorporate laws and regulations for WUAs into national law. Current practice is based on a WUA's own rules and regulations, which are linked to GIDA and donor guidelines. However, institutions at the local level such as chiefs, do interfere with WUA activities, as happens in most African countries (Aarnoudse et al., 2018). This is partly due to gaps created by weak irrigation agencies and unclear institutional mandates (ibid). In Ghana, WUAs are mainly responsible for minor maintenance activities and daily management, while traditional authorities have the leading role in settling irrigation-related disputes and conflicts (Acheampong and Venot, 2010).

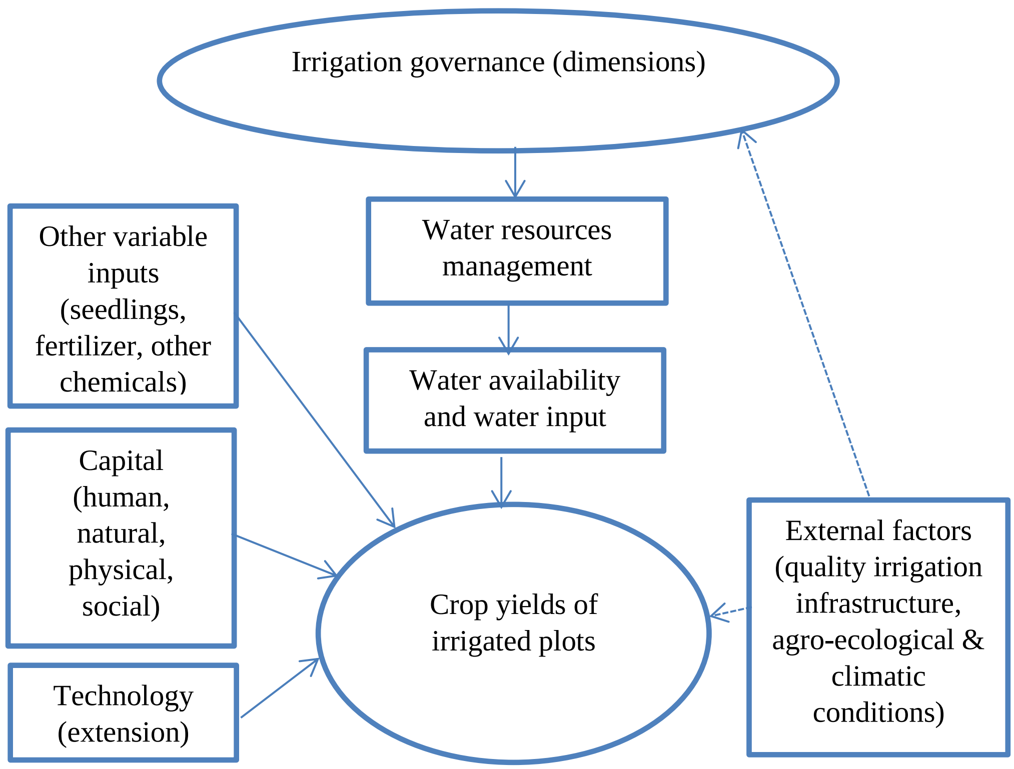
Theoretical Background

Relation Between Governance and Irrigated Crop Yield

The main goal of investing in irrigation infrastructure in arid regions of Africa is to improve agricultural productivity and thereby reduce hunger and poverty (Oates et al., 2015). However, as indicated by Lam and Ostrom (2010), infrastructure investments will not result in the sustainable performance of irrigation systems unless farmers organise themselves, make their own rules, and augment the rules through collective action. Inocencio et al. (2007) pointed out that when farmers contribute to the development of their schemes and assume significant management responsibility for them, costs will be low and performance will be high.

For self-governed irrigation schemes, sustainability is a crucial concern to its users. Evaluating the economic performance of irrigated agriculture in terms of quantity, quality, and price of irrigated products is imperative for assessing the impact irrigation has on the livelihoods of users (Poussin et al., 2015). Achieving higher and more sustainable performance depends on many factors, including the existing overall governance structure of the irrigation schemes (Agrawal, 2003; Ostrom, 1990; Poussin et al., 2015; Venot and Hirvonen, 2013). The real issues that require the attention of irrigation management are the questions concerning how the irrigation facilities should be maintained and how water extraction should be arranged for a fair and sustainable use. Rules and regulations must be introduced and enforced to prevent misappropriation and damage to irrigation facilities. Note that irrigation governance differs from irrigation management, although they are sometimes intertwined. Governance is mainly concerned with decision making on the allocation and use of resources, while management concerns implementation with regard to how resources are practically allocated (Aarnoudse et al., 2018). In the case of self-governance as in WUAs, resource users carry out both governance and management activities with minimal supervision from mandated authorities. They take up all responsibilities needed in the governance process, make their own decisions, and perform all the required tasks in maintaining the facilities, basing their actions on local knowledge and their own rules and regulations (Palerm-Viqueira, 2009). Therefore, irrigation governance in this study is the use of rules and regulations when making decisions to monitor water extraction and to enforce order in the maintenance of irrigation facilities. Figure 1 presents the analytical framework.

Figure 1: Analytical Framework



***Source**: Author's Construct (2021)*
Note: Relationships indicated by dashed arrows are not examined in this study

Together with other variable inputs used in agricultural production and assets available to a household, the use of irrigation water determines the performance of irrigated plots (yields) under given agro-ecological conditions (such as rainfall, soil quality). These conditions not only affect the performance of plots, but also the rules and regulations of user groups on water extraction and maintenance, as well as the perceptions individual users have of irrigation governance. The relationships indicated in Figure 1 form the basis of the specification of the regression model that is estimated. Note that rainfall does not directly affect irrigated crops (rainfall is unimodal in northern Ghana), but only indirectly by increasing the amount of water in a reservoir. Rainfall can therefore only influence irrigation governance in this way. It is assumed that the availability of water to individual farmers depends on how well the water resource is managed, and this is positively influenced by a better performance of irrigation governance (Fig 1). The objective is therefore to establish to what extent yields indirectly depend on irrigation governance through its effect on loosening the constraints that farmers face in their access to water. In constrained instances, such as in the case of poor conditions of irrigation and drainage networks (Poussin et al., 2015), communal governing principles determine the amount of water individual farmers can use on their land. Good governance can thus increase water availability, and an adequate water supply may lead to higher yields for households. Note that water productivity (i.e., agricultural output per unit of water) is not the focus of this study. In Ghana it is difficult to measure water use volumetrically. Most small-scale schemes are not equipped with the devices necessary for measuring water use. Studies on the water productivity of irrigation reservoirs, such as Faulkner et al. (2008) and Mdemu et al. (2009), are based either on case studies of specific reservoirs (typically about two) in which these devices are present, or where researchers install and monitor some for the study period only.

Following the analytical framework, the yield (Y) of a farmer household may be expressed as a function (*f*) of water extraction (*W*), land size (*L*), variable inputs such as labour and fertiliser (*V*), and capital (*C*):

$$Y = f(W, L, V, C) \quad (1)$$

The availability of water and land is limited by maximum quantities $\overline{W}$ and $\overline{L}$:

$$W \leq \overline{W}(G) \text{ and } L \leq \overline{L} \quad (2)$$

$\overline{W}(G)$ indicates that the availability of water depends on governance G. Assuming that the constraints on water and land are binding, we obtain after substitution:

$$Y = f\left(\overline{W}(G), \overline{L}, V, C\right) \; f^{*}\left(G, \overline{L}, V, C\right) \quad (3)$$

The availability of water to a household depends on how users and their leaders adhere to their own rules and regulations, and thus on how effective the existing governance structures deal with the competition for water use, including the future demand for water. This complex of relations is only implicitly captured by the 'black box' function $\overline{W}(G)$. Because water supply is assumed to be limited, this implies that governance indirectly influences the performance (i.e., yield per acre) of a household's irrigated plots. Also, amount of land is considered limited for a household. In the study area, users have no control over the size or location of their plots. Furthermore, each user can be assigned to an upstream or downstream plot, which is important due to the differences in accessing water. Hence, plot location is controlled in the empirical estimations.

Governance Dimensions

Various institutional arrangements account for the sustenance of jointly managed irrigation schemes, such as simple and easy-to-understand rules, easy enforcement of rules, and graduated sanctions, among others (Agrawal, 2003). These arrangements are important for users' compliance with established principles when using communal resources. The processes and effects of these institutional arrangements are often mapped into broad dimensions of governance, including transparency, accountability, rule of law, and participation (GWP, 2009; Tortajada, 2010; Lautze et al., 2011). The extent to which a specific set of arrangements works well results in a dimension of governance that is rated as either good or bad. In the case of irrigation governance, negative qualifications will hinder the performance of schemes and their sustainability. In Agrawal's framework, accountability of the institutions that manage common pools (in terms of monitoring and being able to account for successes and failures) is one of the governance dimensions mentioned. Each dimension relates to a list of indicators that characterise a specific set of institutional arrangements (Agrawal, 2003). Governance dimensions other than accountability can also influence the performance of irrigation resources.

The available literature suggests that the choice of dimensions may be context-specific, depending on the nature of the resource and data availability. Allan and Rieu-Clarke (2010) concluded from a review of good governance categorisations that participation, accountability, and transparency are central principles of good governance. Other studies, particularly Mansungu, (2004), GWP, (2009), Tortajada (2010), and Lautze et al., (2011), suggest additional dimensions that are considered as critical in the sustainable governance of irrigation systems, including conflict management, equity and fairness, cooperation, and sustainable use. Combining cooperation with transparency which go hand-in-hand, six dimensions are used for this study and include participation, transparency and cooperation, accountability, equity and fairness, conflict management, and sustainable management. Different dimensions of governance may have different effects on water access and therefore on crop performance. The challenge is how to empirically test these relationships. As explained by Kaufmann et al. (2011, 2006), some aspects of governance are difficult to measure quantitatively. They suggested that in such cases, data on participants' perceptions about governance aspects could help. In user-managed irrigation resources where data on governance is hardly recorded, the perceptions of land and water users are likely to provide appropriate measures of governance.

Data Source and Empirical Estimation

A questionnaire was used to collect primary data from 370 vegetable farmers in 37 randomly sampled functioning small-scale irrigation schemes (dams with canals), from November 2014 to April 2015. Three crops were considered in the study: tomatoes, onions, and pepper. The relationship between irrigation governance and yield is likely to vary across crops. For convenience and ease of sampling, water users who cultivated one or more of the three crops were included in the sampling frame for the household interview. A random sampling using lottery method was employed to select the required number of respondents from each WUA. Vegetable farmers within each WUA were invited and they gave their consent to participate. Names of farmers who agreed to take part in the study were written on pieces of papers and folded. The folded names were mixed in a basket and drawn one after the other.

The collected data also include characteristics of the WUA's management structure and its activities (governance in general) and, for each selected user, information on crop/livestock production, farm inputs, land tenure arrangement, quantity of water used, and yields and prices, among others. Also, group discussions with water users were held in all the 37 schemes in separate groups of men and women to understand the governance structure at the WUA level. Experts from the regional directorates of GIDA were consulted on sampling and validation issues.

A user-based approach was used to estimate dimensions of irrigation governance. In this approach, 46 indicators of irrigation governance (Described in Author "A", 2021) were incorporated into a household questionnaire, in the form of positive statements for respondents to indicate their degree of agreement on a five-point Likert scale. Agrawal (2003) noted that some variables of sustainable resource governance are correlated and can be formed into indices as single measures. Additionally, some aspects of governance are difficult to measure quantitatively (Kaufmann et al., 2011, 2009). The user-based approach is supported by the assumption that users of communal resources have the greatest stake in the sustainability of resources (Abernethy, 2010), and therefore, their assessments would likely reflect whether governance strategies are actually motivating for sustainable use or not. Governance dimensions that are highly rated by water users may indicate that irrigation resources with respect to these dimensions are properly managed. Users' perceptions of how irrigation is governed may also influence their decisions about production and performance. Perception data, however, have some challenges. Joshi (2010) explains that perception data are sometimes exposed to the judgement bias of the author or the evaluating body. Kaufmann et al. (2006) and Gelb et al. (2011) also argue that questions about perceptions are sometimes vague and open to different interpretations. According to Mainhardt-Gibbs (2010), a systematic approach to limit or avoid these biases is to apply questionnaires to relevant stakeholders, as done in this study. Jones and Tanner (2015) noted that, for comparison purposes, it is better to use closed questions rather than open and semi-structured interviews. The latter can enable in-depth insights, but it also increases the risk of bias when authors try to quantify results for comparison purposes. For this reason, closed questions were used.

A Likert-scale approach was used to measure the six dimensions. In this approach, respondents are asked to indicate their degree of agreement to a positive statement posed for each of the 46 items on a 5-point scale. The indicators are then grouped into a "survey scale" by calculating the mean values of all indicators belonging to a dimension. This approach is recommended in cases where it is unlikely that a single survey item will fully capture a relevant concept, such as the governance dimensions in this study (Sullivan and Artino Jr, 2013). Quantitative analysis can then be performed using total scores or mean scores calculated for the scale items, provided that the scale passes Cronbach alpha test of internal consistency (Ibid). A Cronbach alpha of 1 is undesirable, as this may mean that the grouped components measure only one aspect of a dimension and not the required variability. Multicollinearity among the governance dimensions is checked using the Variance Inflation Factor (VIF) statistics generated from regression analysis.

Empirical Model

The interest in this study is on the indirect relationship between irrigation governance and irrigated crop yield. A production function is therefore estimated where irrigation water use is replaced by governance dimensions. A Cobb-Douglas specification is used for ease of interpretation and specified as following:

$$lnY = \alpha + \beta lnG + \gamma ln\overline{L} + \delta lnV + \lambda lnC + \mu T + \mathfrak{z} lnX + \varepsilon \qquad (4)$$

where

Y = yield of a household per acre

G = ratings of the six governance dimensions

$\overline{L}$ = land used for irrigation by a household

V = variable inputs used on irrigated plot per unit area

C = capital used by households for irrigation per unit area

T = technology (extension)

X = set of control variables

α, β, γ, δ, λ, μ and $\mathfrak{z}$ = parameters to be estimated

$\boldsymbol{\varepsilon}$ = the error term

Some capital and control variables contain zero observations (see Table 2). Those variables were not transformed by taking their natural logarithms.

Results and Discussions

Table 1 presents definitions of variables used in the analysis and their descriptive statistics. Of the six governance dimensions, conflict management receives the highest mean score (4.22). Interestingly, it also shows the lowest variation among all surveyed users, indicating that there is general agreement on appropriate conflict management in the irrigation schemes. Participation also receives a relatively high mean score (4.11), but it shows more variation. Sustainable use has the lowest mean score (3.42), while the mean scores of equity and fairness (3.64), and accountability (3.70) are also relatively low. Positive associations between the six governance indicators and yields were expected. Note that the data on yields, variable inputs, and physical capital are measured in monetary value to allow aggregation of the underlying components that are measured in different units. This approach assumes that the prices for these components are exogenous.

Table 1: Definition and Descriptive Statistics

Variable	Description	Mean	Std.	Min.	Max.
Yield value	Market value of yield harvested per acre (in GH₵) of irrigated crop	1,141.77	836.305	140	4,081
Governance dimensions					
Participation	Mean score per scheme from five Likert items using a 1-5 scale	4.11	0.454	2.98	5
Accountability	Mean score per scheme from five Likert items using a 1-5 scale	3.70	0.662	2.16	4.6
Conflict management	Mean score per scheme from four Likert items using a 1-5 scale	4.22	0.331	3.45	4.8
Transparency and cooperation	Mean score per scheme from fourteen Likert items using a 1-5 scale	3.83	0.522	2.67	4.54
Equity and fairness	Mean score per scheme from seven Likert items using a 1-5 scale	3.64	0.405	2.67	4.37
Sustainable use	Mean score per scheme from eleven Likert items using a 1-5 scale	3.42	0.401	2.33	3.93
Variable inputs					
Seedlings	Value of seedlings of specific crop (tomatoes, pepper, onions) (in GH₵)	79.497	49.093	10	300
Fertiliser	Expenditure on fertilisers used on crop (in GH₵)	108.500	71.019	17.500	490
Chemicals	Expenditure on other chemicals used on crop (in GH₵)	20.986	14.289	4	120
Capital					
Human capital					
Labour	Labour time spent on crop (in man-days)	55.505	15.090	30	113
Natural capital					
Land	Size of land used for crop (in acres)	0.293	0.172	0.125	1
Head	Plot location: 1 = head-end, 0 = otherwise	0.276	0.447	0	1
Tail	Plot location: 1 = tail-end, 0 = otherwise	0.270	0.445	0	1
Tomatoes	Main crop: 1 = tomatoes, 0 = otherwise	0.459	0.499	0	1
Onions	Main crop: 1 = onions, 0 = otherwise	0.270	0.445	0	1
Physical capital					
Tools	Value of tools (like hoes and scythes) used on irrigated plot (in GH₵)	55.023	19.189	22	154
Technology					
Extension	Number of visits by extension agents	2.616	1.1526	0	6
Other controls					
Age	Age of irrigator (in years)	41.76	12.11	16	85
Sex	Gender of irrigator: 1 for men, 0 for women	0.614	0.488	0	1

***Source**: Author's Computations (2021)*

Table 2 presents the results of the Cronbach alpha test for the six governance dimensions. The values range from 0.70 – 0.85. These results indicate that the components of each governance dimension are intercorrelated and can be considered internally consistent. They are therefore acceptable when assessing the six governance dimensions.

Table 2: Cronbach Alpha Test of Irrigation Governance Dimensions Scales

Irrigation Governance Dimension	Number of Components	Average Interim Covariance	Scale Reliability Coefficient (α)
Participation	5	0.27045	0.72
Accountability	5	0.30676	0.70
Conflict management	4	0.24497	0.82
Transparency/cooperation	14	0.36959	0.85
Fairness and equity	7	0.22681	0.71
Sustainable use	11	0.23550	0.70

Note: $\alpha \geq 0.7$ is acceptable

Source*: Author's Computations (2021)*

The results of the model as specified in (4) are shown in column (1) of Table 3. The main focus of this study is on the relationship of yields with six WUA governance dimensions, as proxies of irrigated water use for which data is unavailable. The results indicate that participation perceptions have a strongly significant positive association with crop yields of irrigated land. Estimated coefficients for the other dimensions are either insignificant or even negative. In other words, participation in the joint management of a scheme seems to be a crucial dimension in successful governance of irrigation schemes. Conflict management, on the other hand, has a significant negative association with crop yield. A potential explanation for this unanticipated finding is that rules and regulations put in place to avert conflicts contribute to free riding and other anti-social behaviour by users exploring the limits of those rules and regulations. More research is needed to examine whether this result can also be found in jointly managed irrigation schemes located elsewhere, and to what extent the potential explanation offered can be substantiated.

The insignificance of the other governance dimensions may be signalling collinearity among those dimensions. Table 4 shows that correlation coefficients are highest (higher than 0.7) for three variables: participation, accountability, and transparency and cooperation. These three variables also have the highest Variance Inflation Factors (VIFs) in Table 6. In columns (2) – (4) of Table 3, the regression results when only significant governance dimensions are included in the equation (column (2)) and when two seemingly correlated dimensions are included in the equation instead of participation (columns (3) and (4)) are therefore presented.

As seen in column (2), the estimated coefficients for participation and conflict management remain significant and have the same signs, but change somewhat in magnitude, when the insignificant dimensions are dropped. When participation is replaced by one of its correlated dimensions, those dimensions are found to have no significant association with yields (columns (3) and (4)). The latter result suggests that it is indeed participation – and not its correlated dimensions (accountability, transparency, and cooperation) – that associates with yields.

Table 3: Regression Results (OLS)

Variables	(1)	(2)	(3)	(4)
Participation	2.310***	1.393***		
	(0.778)	(0.442)		
Accountability	-0.638		0.444	
	(0.619)		(0.286)	
Conflict management	-1.889*	-2.282**	-1.612*	-1.685
	(1.039)	(0.864)	(0.813)	(1.007)
Transparency and	0.076			-0.355
Cooperation	(0.631)			(0.359)
Fairness and equity	0.081			

	(0.491)			
Sustainable use	0.264			
	(0.372)			
Land	-0.612***	-0.589***	-0.584***	-0.606***
	(0.156)	(0.152)	(0.160)	(0.155)
Seed	0.044	0.045	0.051	0.047
	(0.082)	(0.074)	(0.074)	(0.074)
Fertiliser	0.146**	0.147**	0.151**	0.150**
	(0.056)	(0.061)	(0.062)	(0.063)
Chemicals	0.274***	0.281***	0.282***	0.269***
	(0.069)	(0.070)	(0.070)	(0.073)
Labour	0.205	0.189	0.189	0.242
	(0.214)	(0.220)	(0.228)	(0.225)
Head plot	0.041	0.043	0.050	0.056
Dummy	(0.074)	(0.073)	(0.073)	(0.074)
Tail plot	0.072	0.077	0.089	0.091
Dummy	(0.076)	(0.075)	(0.076)	(0.076)
Tomato dummy	0.231*	0.225*	0.215*	0.230*
	(0.133)	(0.120)	(0.127)	(0.127)
Onion dummy	0.394**	0.408***	0.439***	0.472***
	(0.147)	(0.124)	(0.134)	(0.133)
Tools	-0.248	-0.272	-0.251	-0.229
	(0.194)	(0.190)	(0.198)	(0.196)
Extension	0.172*	0.169*	0.157*	0.147
	(0.088)	(0.092)	(0.090)	(0.090)
Age	-0.003	-0.003	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Sex	-0.005	-0.004	-0.000	-0.007
	(0.068)	(0.070)	(0.070)	(0.070)
Constant	5.500**	6.941***	7.249***	7.927***
	(2.691)	(1.941)	(2.121)	(2.665)
Observations	370	370	370	370
R-squared	0.46	0.455	0.442	0.44

Notes: *** p<0.01, ** p<0.05, * p<0.1; Robust cluster errors in brackets

***Source**: Author's Computations (2021)*

Table 4: Correlation Matrix of Governance Dimensions

	Partici-pation	Accounta-bility	Conflict management	Transparency and cooperation	Fairness and equity	Sustain-able use
Participation	1.0000					
Accountability	0.7534	1.0000				
Conflict management	0.5245	0.6063	1.0000			

Transparency and cooperation	0.7120	0.8003	0.5807	1.0000		
Fairness and equity	0.4811	0.4778	0.4261	0.6365	1.0000	
Sustainable use	0.2921	0.2748	0.3477	0.4106	0.5783	1.0000

***Source**: Author's Computations (2021)*

Table 5: VIFs of Governance Dimensions

Variable	VIF	1/VIF
Accountability	3.74	0.2677
Transparency and cooperation	3.72	0.2689
Participation	2.44	0.4099
Fairness and equity	2.10	0.4765
Conflict management	1.74	0.5746
Sustainable use	1.54	0.6487

Note: VIF > 10 signals severe collinearity
***Source**: Author's Computations (2021)*

Table 3 also indicates that most estimates regarding conventional production function inputs are consistent with apriori expectations. The significant negative impact of irrigated-farm size supports results of previous studies on the existence of an inverse relationship between land size and productivity in smallholder agriculture (e.g. Carletto et al., 2013; Otsuka et al., 2016). This means that small plots of irrigated land produce more output per unit area than large plots. Increased farm size comes with an associated increment in production cost. For instance, for large farms, farmers have to hire labour but may only use family labour for small farms (Otsuka et al., 2016). For farmers in northern Ghana, it may be difficult for farmers to cater for extra costs incurred in their farm expansions, hence the inverse relationship. This may be explained by the fact that most smallholder farmers in this area are poor and, in some instances, have no access to agricultural credits.

Use of fertiliser, other agro-chemicals, and extension services have significant positive effects on yields, with other chemicals having the highest elasticity (0.27). That means more use of these inputs leads to high crop yields. The results however suggest potential overuse of labour, seed, and tools, as their estimated coefficients (i.e., elasticities) do not differ significantly from zero. This may be because most irrigation farmers in northern Ghana use family labour and their own stored seeds, and farm tools from other crop farms. They may thus see these inputs as being freely available and at no cost, hence the overuse. In terms of crop choice, productivity is significantly higher on tomato and (especially) onion plots, as compared to plots planted with pepper. As crop yields are measured in value terms, this finding may (partly) reflect favourable market prices for these two crops during the year of observation. The location of a plot does not significantly affect crop yields of irrigators in the sample. The estimated coefficients for both head-end and tail-end plots do not significantly differ from zero, suggesting that access to irrigation water is not significantly affected by plot location. As indicated earlier, perceived governance of WUAs is good, implying an adequate management of irrigation resources. Therefore, a farmers' plot location does not influence his or her access to water. The two demographic factors included as explanatory variables – age and sex of the irrigator – do not have significant effects on crop yields of the farmers that we interviewed. Male and female irrigators, as well as young and old ones, are thus found to have similar productivities when other inputs into production are controlled.

Conclusion

The results indicate that governance generally has a positive association with irrigated yields. Of the two dimensions that influence crop yields, perceptions on participation are positively associated, while conflict management shows a negative relation with irrigated crop yields. These findings suggest that participation of users in the governance of small-scale irrigation schemes is of crucial importance for enhancing the output generated by these schemes. It includes participation in decision making and, in the use, management and maintenance of the facility without distinguishing between men and women. There is therefore the need to encourage participation in schemes where participation perceptions are found to be low before implementing development interventions. Assessment of participation perceptions can normally be carried out through a baseline survey before interventions are undertaken.

The negative relation found between conflict management and yields may simply reflect that more conflicts occur in WUAs where users are relatively satisfied with the way these conflicts are handled. The finding may reflect that there is a higher tendency towards conflict-enhancing behaviour and free-riding when the users of an irrigation scheme believe they will face jointly agreed upon sanctions only when their behaviour passes certain thresholds. To break the negative link between, rules and regulations regarding conflict resolutions will need to be reviewed and those that seem to encourage conflict-enhancing behaviour and free riding (if any) eliminated. More generally, WUAs can be made to handle conflicts wholly based on their own set of rules instead of relying on traditional authorities as in most cases. When an issue is beyond their capacity however, they may call on traditional authorities or any law enforcement body. Complete decentralisation of resource governance (to either user groups or traditional authorities, whichever suits the description) may be more sustainable than a blend of two or more authorities in irrigation governance.

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