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# Assessing governance of irrigation systems: A view from below

Margaret Atosina Akuriba[a,*], Rein Haagsma[b], Nico Heerink[b], Saa Dittoh[a]

[a] University for Development Studies, Tamale, Ghana
[b] Development Economics Group, Wageningen University and Research, The Netherlands

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ABSTRACT

Attempts at irrigation development in Ghana, as in many other parts of sub-Saharan Africa, have been characterized by governance challenges at various levels. This paper aims to provide an empirical assessment of irrigation governance in 37 small-scale irrigation schemes in northern Ghana, derived from the perceptions of their users. We first distinguish six dimensions of governance based on the available literature to include participation, accountability, conflict management, transparency and cooperation, equity and fairness, and sustainable use. Next, we measure these irrigation governance dimensions using ratings provided by local water users. We then examine the relationship between these governance measures and some objective factors that possibly drive the assessments of users. The results indicate an overall good governance in the sampled schemes. Relatively, sustainable use had the lowest score and conflict management had the highest score. We further find that in schemes located in areas with relatively high annual precipitations, users report better irrigation governance. Within schemes, both users with plots at the head end and users with plots at the tail end are more critical about irrigation governance than other users. Remarkably, the number of users of a scheme has no significant effect on their overall assessment of its governance, although users in larger schemes are more positive on opportunities to participate in governance bodies and to keep these bodies accountable. To improve their sustainability, small-scale irrigation schemes (dams) may be better maintained for domestic and livestock watering. Promoting water-conserving irrigation techniques such as drip irrigation and ground water techniques is essential.

## 1. Introduction

Agriculture is an important sector and a major element in development policies in sub-Saharan Africa. To help mitigate effects of erratic and unevenly distributed rainfall patterns, current advocacies are in favour of irrigation development. The New Partnership for Africa Development (NEPAD)'s Comprehensive African Agriculture Development Programme stresses the need to rapidly increase the area equipped with irrigation, especially small-scale water control, in order to provide farmers with opportunities to raise output on a sustainable basis and contribute to the reliability of food supplies (NEPAD, 2003).

The evolution of formal irrigation in Ghana thrived in the 1960s with the construction of public irrigation schemes. Attempts at irrigation development in Ghana, as in many other parts of sub-Saharan Africa, have however been characterized by problems concerning construction, maintenance, management and coordination at various levels over the years (Balmisse, Faure, & Ilu, 2003; Dittoh et al., 2013a). Envisaging these challenges, such as faulty or complicated designs and poor maintenance activities, which often result in siltation of reservoirs and canals among others, many development programs encouraged African countries to switch to participatory approaches for irrigation management in the 1980s. Participatory Irrigation Management (PIM) was introduced in the early 1990s in Ghana (Namara et al., 2011). The PIM approach allows beneficiary farmers and other water users of small scale schemes to jointly manage irrigation facilities by paying costs for irrigation services and providing labour for maintenance activities in small-scale irrigation schemes. The participatory approach generally transfers authority to Water User Associations (WUAs) and the private sector for the management of irrigation schemes. Moreover, the prominence of management and coordination challenges in large-scale irrigation schemes has created a preference for small-scale irrigation (Birner, McCarthy, Robertson, Waale, & Schiffer, 2010; van Edig et al., 2003).

Irrigation in Ghana is broadly classified into two systems: conventional or public systems and emerging systems (Namara et al., 2011). Public systems are designed and developed by the government or by non-governmental organizations for public use. Most of them are surface irrigation systems. Emerging systems are privately owned. They

* Corresponding author.
*E-mail addresses:* akumerg@gmail.com (M.A. Akuriba), rein.haagsma@wur.nl (R. Haagsma), nico.heerink@wur.nl (N. Heerink).

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employ various irrigation technologies such as drip or pumping machines (for underground water) to grow crops, mostly for export. Though small reservoirs in Ghana have several uses, including fishing, block moulding, and livestock watering, WUAs are mostly composed of farmers with irrigated plots (Acheampong & Venot, 2010; Gyasi, Schiffer, & Mccarthy, 2005). The size of the developed area for irrigation is the main criterion used in classifying schemes. Those up to 200 ha are regarded as small-scale, between 200 ha and 1000 ha as medium-scale, and 1000 ha and above as large-scale (Kyei-Baffour and Ofori, 2007; Namara et al., 2011).

Construction of small-scale irrigation schemes usually aims at economic empowerment of less-privileged communities in terms of livelihoods. Most of these schemes are located in the northern part of Ghana, where rainfalls are mono-modal, erratic, and unevenly distributed. The Ghana Irrigation Development Authority (GIDA) designs and constructs the facilities with funding from donor agencies. Learning from the unsuccessful experience in public management of irrigation schemes in the past, in most cases WUAs are formed to manage the small-scale schemes after construction (Namara et al., 2011).

Small-scale irrigation is however not without challenges. Birner et al. (2010) tried to assess whether small-scale reservoirs can avoid the governance challenges experienced in large-scale irrigation in Ghana. They reported that many small reservoirs in the Upper East Region were not in use, which they blamed on governance failures, particularly that WUAs had no say in infrastructure construction. Their study also highlights major problems in the maintenance of schemes, and finds that collective activities related to the maintenance of reservoirs are positively related to the quality of the soils and spillways. Farmers may earn more when soils are good, and well-built spillways may dispose excess water appropriately without causing havoc to farms. Other studies show that the institutional mandates on irrigation development in Ghana are unclear, while in many schemes poor operation and maintenance of facilities have led to low rates of utilisation (Dittoh et al., 2013a; Lamptey et al., 2011). As pointed out by Ostrom (1990), without strong and effective institutions, common pool resources such as irrigation facilities will generally be overexploited.

Good governance is essential for irrigation systems to work effectively (Dittoh et al., 2013b; Howarth et al., 2005; Norton, 2004). The success of governance may differ from one resource to another depending on the characteristics of the governing WUA (Agrawal, 2003; Zhang et al., 2013) and the physical features of the resource, such as its geographical location and dominant crop grown (Wang et al., 2013). The nature of the resource informs the governance strategies to be employed by WUAs for long-term sustainable use (Ibid). Similar strategies applied to resources with different physical characteristics may yield different degrees of governance success.

Following Herrera, Davies, and Baena (2014), we define irrigation governance as the rules and regulations that determine the use and management of irrigation resources by local users. The question that arises is: which dimensions of irrigation governance can be identified to assess the performance of WUAs? It is difficult to find and agree on appropriate indicators since good governance carries political connotations (Hyden & Court, 2002; Kaufmann et al., 2011). The World Governance Indicators developed by Kaufmann et al. (2004, 2009, 2011) include both objective and perceptions data to measure and compare governance across countries. It was noted that data for objective governance dimensions are often not available; when they are available, they may capture what the regulatory environment requires, which often differs substantially from the realities on the ground. Moreover, subjective perceptions of governance are assumed to matter as well. The 2013 Resource Governance Index also includes both objective and subjective indicators to measure governance of the extractive sector (Revenue Watch, 2013). At the micro level, composite indicators that comprise both objective and subjective measures have been used to evaluate, for instance, Lake Basin water governance (Cookey, Darnsawasdi, & Ratanachai, 2016) and the performance of urban water supply utilities that can inform governance directions (Gallego-Ayala, Dimene, Munhequete, & Amos, 2014).

Even though the low performance of public irrigation schemes in Ghana is commonly attributed to bad irrigation governance (Dittoh et al., 2013b; Poussin et al., 2015; Venot and Hirvonen, 2013), measures of irrigation governance have not yet been developed to our knowledge, neither for Ghana nor for other regions in the world. Such measures can be used to compare the levels of governance of different irrigation systems, and relate them to the performance of those irrigation systems. This paper aims to provide an empirical assessment of irrigation governance in northern Ghana derived from the perceptions of users, and to explore the factors that may potentially be related to the perceived quality of irrigation governance. For this, we first identified different dimensions of irrigation governance based on the available literature. Next these dimensions were measured through ratings provided by local water users. Finally, the relationship between the resulting values of the irrigation governance indicators (IGIs) and some objective factors that possibly drive the users' ratings was examined in order to obtain insight into what factors may explain variation in IGIs across irrigation systems.

By allowing water users to assess irrigation governance, we employ a view from below. As asserted by Agrawal, "local users are often the ones with the greatest stakes in sustainability of resources and institutions" (Agrawal, 2002). Sustainability of irrigation resources is not only about the physical property of the systems, but also about the incentives of local users to sustain the systems (Abernethy, 2010). Users' satisfaction with management strategies can be an important incentive for sustainable use of irrigation facilities. Hence, stakeholder opinion is vital in assessing governance. Inadequate records of irrigation management data in Ghana and the fact that certain aspects of governance are difficult to measure objectively (Kaufmann et al., 2011, 2009, 2004) also motivated the use of subjective measures in this study.

Following Agrawal (2003) resource governance framework, we developed questions related to factors considered relevant for sustainable governance of irrigation systems. Users' perceptions were rated using a five-point Likert scale. The responses were mapped into six dimensions of governance. Tobit-Cluster-Robust regressions were performed to examine the relationship between each of these dimensions and factors that potentially explain their variation across and within irrigation systems.

In Section 2 we present a conceptual background encompassing the assessment of governance through perceptions, critical factors influencing governance perceptions, our hypotheses, and the different dimensions of governance that we distinguish. The research methodology is presented in Section 3, followed by results and conclusions in Section 4 and Section 5, respectively.

## 2. Conceptual background and hypotheses

### *2.1. Assessing governance through perceptions*

Public irrigation schemes are so-called common pool resources, which are resources characterized by rivalry in consumption and non-exclusiveness (Ostrom and Gardner, 1993; Ostrom, 2000). Their open-access nature can lead to overuse of the resource by some individuals and thereby create negative externalities for others in the short or long run (Birner, Schiffer, Asante, Gyasi, & McCarthy, 2005; Ostrom, 2000). Without proper governance, therefore, public irrigation schemes are likely to suffer from the "tragedy of the commons" (GWP, 2009; Hardin, 1968; Ostrom, 2000; Tortajada, 2010).

Following Herrera et al. (2014), irrigation governance in this paper concerns the rules and regulations that determine the use of irrigation resource by local users. There are several dimensions of governance that one can use to assess whether a resource is properly governed or not, including participation, transparency, accountability, equity, control of corruption, and sustainable management (GWP, 2009; Lautze et al., 2011; Mansungu, 2004; Rogers & Hall, 2003; Tortajada, 2010). These dimensions are often difficult to measure objectively and, therefore, generally require additional subjective assessments by stakeholders.

Common pool resources such as irrigation facilities are indeed best assessed on governance effectiveness when perceptions of stakeholders are taken into consideration for the reasons explained by Kaufmann et al. (2011, 2006). They argue that for certain dimensions of governance, such as corruption, it is almost impossible to get objective data. Campbell (2007) adds that resource managers take decisions based on their perceptions of the most pressing need, which also makes perceptions data valid. Whether perception-based management decisions are appropriate also depends on the physical outcomes of these decisions and the perceived effect this has on stakeholders. Perceptions data particularly allow greater detail when discussing governance dimensions (Joshi, 2010).

However, perceptions data come with some challenges. Joshi (2010) explains that perceptions data is sometimes exposed to judgement bias of the author or the evaluating body. Kaufmann et al. (2006) and Gelb, Ramachandran, Shah, and Turner (2007) argue that questions about perceptions are sometimes vague and open to different interpretations. A systematic approach to limit or avoid these biases, according to Mainhardt-Gibbs (2010), is to apply questionnaires to relevant stakeholders. Jones and Tanner (2015) add that, for comparative purposes, it is then better to use closed-ended questions instead of open and semi-structured interviews. The latter may allow for in-depth understandings, but also increases the risk for bias when authors try to quantify the results for comparative purposes.

This study is mainly concerned with the perceptions of members of water user groups as measures of irrigation governance. In Ghana, Water User Associations (WUAs) are the main bodies in charge of operation and maintenance of public irrigation facilities at the community levels. The irrigation facilities are mostly dams with canals using gravity-flow systems. The Global Water Partnership (Rogers & Hall, 2003) and UNDP (2004) emphasize the importance of active involvement of society or end users in water governance. Moreover, Ostrom (1990) pointed out that when users of a common resource organize themselves into associations, they may manage the resource effectively and sustainably. The effectiveness of governing strategies of WUAs may therefore be best assessed when opinions of the main stakeholders (WUA members) are considered.

### *2.2. Factors influencing governance perceptions*

Governance perceptions may be influenced by several factors exogenous to users. The exploratory analysis in this paper focuses on factors that have direct bearing on farmers' access to water for irrigation and for which data were collected in the survey, i.e. size of irrigation schemes, geographical location of schemes, main crop grown at a scheme, and location of individual plots. We discuss each of them in turn.

Wade (1994) and Agrawal (2001) see the size of a resource as one of the factors affecting sustainable governance of common pool resources, because small-scale resources are easier to manage than large-scale resources. Ratner et al. (2013) notes that small-scale resources allow for more effective monitoring. The management of water resources is particularly affected by the size of the scheme, because large-scale schemes are usually managed by state agencies while small-scale schemes are managed by private user groups (Kyei-Baffour and Ofori, 2007). The size of a resource relative to the number of users also determines whether the resource is scarce or abundant to users. There are two divergent views in relation to natural resource availability (especially water and forest) and implications on resource governance (Mildner et al., 2011). One school of thought explains that scarcity of resources leads to violent conflicts, which impacts negatively on resource governance. The other school argues that resource abundance leads to conflicts over resource use due to the so-called resource curse. Though some of the discussions are at the macro level, the issues raised are evident at community common pool resources (CPRs) and may influence CPRs governance assessment. The size of an irrigation scheme may be a blessing when large schemes meet users' expectations. However, it becomes a curse when leaders (at both local and national level) dwell on its nature to cheat users in terms of resource allocation and imposition of unacceptable laws that potentially lead to conflicts. The size of an irrigation scheme can thus have any directional effect on users' assessment of irrigation governance effectiveness.

Geographical location of the resources also affects governance. In the case of irrigation, both physical and natural features of the locality are critical determinants in siting and managing irrigation facilities. Drier localities generally need irrigation facilities more for sustainable agricultural production than relatively wet areas, making irrigation especially relevant for regions with low annual rainfall (Pimentel et al., 2004). The rapid urbanization of rural settings coupled with climate change also threatens irrigation development (Faures & Mukherji, 2009; UNESCO, 2007). When livelihoods are tied to the existence of irrigation facilities, users may sometimes impose stringent rules to avoid overuse and negative externalities. A user's assessment of the governance of such resources is informed by this need for sustainable use amidst climatic variability.

The kind of crop grown at an irrigation facility can also affect its governance. Water demands vary from crop to crop, from as little as twice a week as in the case of *alefu*, an indigenous vegetable in northern Ghana, to as high as seven times a week in the case of okra and tomatoes (Namara et al., 2011). To ensure equal access to water use, WUAs sometimes have to agree on one particular crop to grow in a season, taking into account water availability, prices, and diseases, among other factors. The choice for a specific crop restricts users' strategies in maximizing farming as a business and may thus affect their perceptions on governance.

The location of one's plot in an irrigation scheme equally plays an important role on how one assesses the governance of a facility. Managing irrigation water can be challenging when there are diverging interests between head-enders and tail-enders (Cardenas, 2011; Ostrom and Gardner, 1993). Aida (2012) explains that head-enders and tail-enders differ in terms of their access to irrigation water: if head-enders use too much water, tail-ender are deprived of their share. This type of heterogeneity among farmers can violate equity among farmers and result in irrigation management failure. The presence of heterogeneity among irrigators makes it difficult to implement equitable management strategies (Bardhan & Dayton-Johnson, 2002). User perceptions of irrigation governance will therefore depend on the extent to which a user's own interests as a head- or tail-ender are taken into account in the management of the resource and on management failures resulting from the inability of dealing with diverging interests among users.

Fig. 1 is a schematic illustration of factors that influence users' assessments of irrigation governance. The ovals indicate the governance setting. The nature of the irrigation resource determines the sort of rules and regulations to set for its use. The effective application of these rules and regulations constitute the main governing structure for a user group. The individual user eventually assesses the system for its effectiveness on his/her irrigation activities. All these relations along the ovals are affected by exogenous factors including the location of the irrigation scheme, scheme size, main crop grown in the scheme and plot location of users, as shown by the block arrows.

In line with the above discussion of four critical factors that may influence governance perceptions, this study investigated the following four hypotheses:

1. Scheme Location hypothesis. Given that irrigation is practised at different locations in Ghana, we expect that the governance of irrigation schemes differs by region because of the following. Irrigation reservoirs can store water from upstream rivers and underground recharge. However, water supply from most rivers is insufficient due to

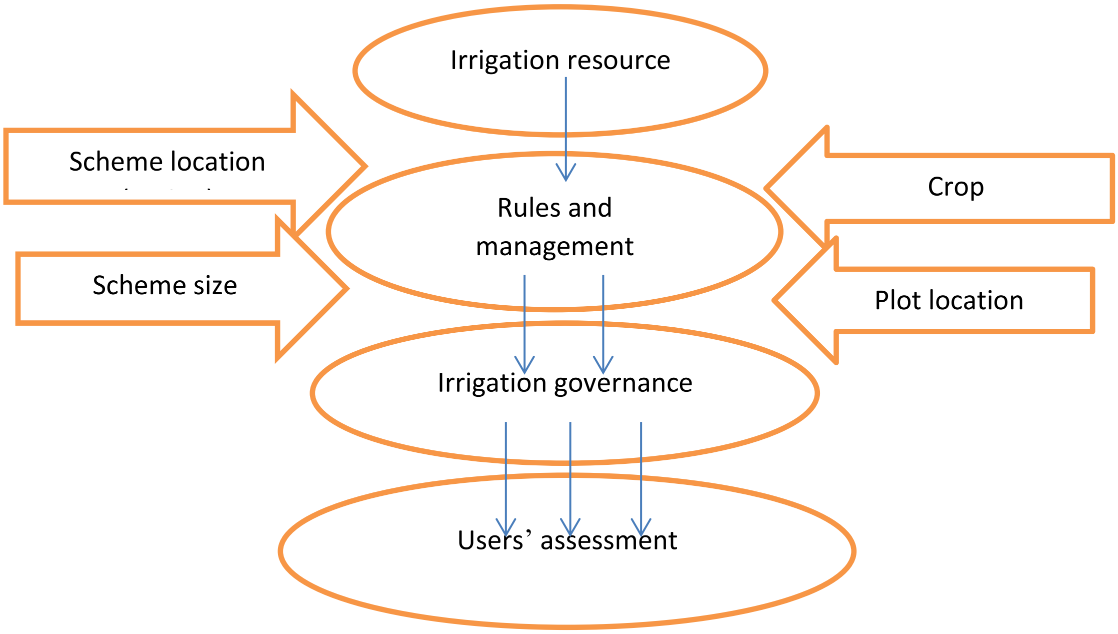


**Fig. 1.** Irrigation governance framework. Source: Authors' Construct.

their short tributaries, so that most schemes also rely on local precipitations. Especially the annual precipitation within the immediate confines of the reservoir influences the amount of water stored and/or recharged. Low annual precipitation may thus lead to low water availability for irrigation. Water scarcity is likely to increase tensions among users, thereby creating challenges for good governance that may be hard to face. Therefore, we hypothesize that "users in dry locations will report lower governance ratings".

2. Crop hypothesis. Because crops differ in water demand, the dominant crop grown at a scheme may affect the governance of irrigation facilities. Some crops demand frequent irrigations for short or long periods, while other crops require lower frequencies of irrigation. Uncertainties in estimated volumes of water in reservoirs and in water demands of users make it especially difficult to govern the irrigation of more water-demanding crops. Our hypothesis, therefore, is that "users of schemes growing more water-demanding crops will report worse irrigation governance".

3. Size hypothesis. Management strategies differ from scale to scale. Schemes with larger reservoirs have more users, and therefore put higher demands on strategies that can ensure equity among users and long-term sustainable use. At the same time, schemes managed by many users raise problems of collective action, such as free riding, which affect sustainable governance of those schemes. Following e.g. Wang et al. (2010) and Zhang et al. (2013), we represent size by number of users in a scheme, and hypothesize that "users in larger schemes will report worse irrigation governance".

4. Plot hypothesis. The location of an irrigator's plot usually influences the timeliness of water allocated to the plot. Head-enders (those who are closest to the reservoir) are normally first to be allocated, before middle- and tail-enders, respectively. In the event of water shortage or reservoir defects, it is likely that tail-enders will suffer the most impact. Hence, plot location will affect expectations as well as evaluations of irrigation water governance, with tail-enders being the most critical. Thus we hypothesize that "tail-enders will report lower governance ratings".

### *2.3. Defining dimensions of irrigation governance*

Governance can be measured along several dimensions, where each of these dimensions should consider an aspect of governance that is desirable to measure. For common resources like irrigation schemes managed by users, the selected dimensions should in any case include aspects of sustainable use and equal access. Below we explain six dimensions of governance that we selected for our study, largely based on the available literature on preconditions for successful governance of irrigation resources (GWP, 2009; Lautze et al., 2011; Mansungu, 2004; Rogers & Hall, 2003; Tortajada, 2010). We collected information on indices of six governance dimensions that were developed from a preliminary desktop study and a reconnaissance survey of some schemes and institutions including the regional directorates of GIDA and Water Resources Commission. The six dimensions are summarized and grouped in Table 2.

#### *2.3.1. Participation*

Understanding and willingness by users to participate in the management of a common resource is important in irrigation development (Howarth et al., 2005; Mansungu, 2004; Ostrom, 2000; Rogers & Hall, 2003). It is not only important in ensuring strong and effective WUAs (Howarth et al., 2005), but also gives users a voice in management decisions (Kaufmann et al., 2011). Participation at the design stage of the irrigation resource is recommended, but this is mostly ignored in the case of Ghana. Women are sometimes marginalized in the use of resources due to socio-cultural and physical reasons, but their inclusion is recommended for the sustainable management of water resources (Phirun and Chhuong, 2014; UNDP, 2004). The different roles of men and women recognized at community level may complement each other in completing maintenance tasks. Maintenance activities involve the stacking of embankments and canals with gravel and stones, desilting of canals and waterways, weeding around facilities, and other activities. They improve water flows downstream and encourage on-farm water management for higher yields.

We measure participation by assessing the extent to which users have access to good irrigation facilities and can influence their access through participation in WUAs. Thus, we asked, among other things, whether decisions on management and maintenance are taken jointly involving all users; whether users have rights to use all facilities; whether this holds for both men and women; and whether WUAs are determined to gain recognition by higher authorities like the District Assembly (and thus to be considered for best farmer awards among other incentives) (see Table 2).

### 2.3.2. Accountability

WUAs are required to be accountable to their members, with clear procedures and rights of appeal (Howarth et al., 2005; Marimbe and Manzungu, 2003). This is accomplished through either the formation of unit committees or the election of leaders from WUAs. Whichever form it takes, the leadership should be accountable to its members (Howarth et al., 2005; Marimbe and Manzungu, 2003). Leadership is also required to show commitment to its responsibilities by allowing free flow of information concerning all activities (Norton, 2004). When there is trust in the way a scheme is being managed and led, users will be encouraged to adopt best practices needed for sustainable productivity increases.

We assessed accountability by asking users about their access to general information from their leaders and specifically on expenditure and financial standings of WUAs. We further asked whether they thought that their WUA leaders were committed to tasks for which they were appointed and whether WUA members had confidence in the way their executives carried out their duties, especially on management of finances.

### 2.3.3. Conflict management

Conflicts in irrigation schemes often occur over the direct extraction of water from canals between users, and about regulations concerning use of the facility (Kramm and Wirkus, 2010). Conflicts may also arise from land and water allocation, tensions in leadership, price negotiation, and expenditures. As noted by Howarth et al. (2005), disputes over the use of financial resources are common reasons for WUAs to become dormant. Being able to manage conflicts among water users is important in successfully governing irrigation facilities. There is a need for rules concerning conflicts, and a step-by-step process in sanctioning rule breakers in the use of common pool resources. However, arenas for conflict resolution should be low-cost for sustainable common pool resources (Ostrom, 1990).

Our index for conflict management is assessed from several indicating factors of proper conflict resolutions including WUAs' ability to: resolve conflicts to the satisfaction of parties involved; handle tensions in leadership; resolve price- and market-related conflicts; and use graduated sanctions as recommended in Agrawal (2003).

### 2.3.4. Transparency and cooperation

Transparency is a key component of good resource governance (Revenue Watch, 2013). Sustainable use of irrigation resources at the community level particularly requires cooperation between water users (van Edig et al., 2003). Transparency is needed at all levels of information, procedures, finances, and distribution of water to an agreed schedule (Howarth et al., 2005). WUA executives have to be transparent in order to gain trust and cooperation from WUA members.

We assessed transparency and cooperation from about 15 indicating factors ranging from democracy to effective monitoring and control of water discharge (Table 2). In terms of democracy, we enquired whether group members had the freedom of expression regarding management decisions, and for corruption we assessed the existence of fraudulent acts in groups, such as stealing of group money by leaders or execution of transactions unapproved by groups.

### 2.3.5. Equity and fairness

Equity and fairness are important in governing irrigation resources (Hussain & Hanjra, 2003; Namara et al., 2010). All rightful users have rights to be allocated land and water. However, tensions sometimes arise due to disparities in allocating land and water to users. Men and women are treated differently in some traditional settings and this affects their rights to economic resources like land and water. Also, head-enders and tail-enders are in some instances made to pay the same water charge even when they do not benefit from water allocation equally. These are some of the challenges influencing irrigation-governing decisions.

We assessed this dimension by making enquiries about whether users of the irrigation resource in question are well-defined. "Well-defined users" as indicated in Agrawal (2003) is one characteristic of users that is required for successful resource governance. The first step to ensuring equity and fairness is to allocate irrigation resources to rightful users without biases. Other indicators included availability of irrigable land, equitable access to irrigation water and land, adequacy of water charge, and available buyers and good prices for irrigated products (Table 2).

### 2.3.6. Sustainable use

Sustainable use of water resources is critical in irrigation governance (Mansungu, 2004; Marimbe & Manzungu, 2003; Rogers & Hall, 2003; UNESCO, 2015). As proposed by FAO (2014), responsible and effective governance mechanisms are required for a sustainable food and agriculture sector. In the governance of irrigation facilities under water scarcity, care needs to be taken so that strong competition for water does not worsen the limiting resource for agriculture (FAO, 2011; Pereira et al., 2002; Wichelns and Oster, 2006). For an irrigation facility to be sustainable it should show signs of producing enough water for the present and the future through effective maintenance and monitoring mechanisms. It is stated in the Ghana Irrigation Development Policy that irrigation development planning should pay attention to "the need for sustainability in terms of operation, maintenance, competing needs and the conservation and responsible use of natural resources" (Lamptey et al., 2011). The output levels, availability of markets, and good prices are also indicating factors of the sustainability of an irrigation facility. When prices are good, irrigators will make good profits to keep them in production and this motivates them to use the facility judiciously. We assessed sustainable use from various indicators including: availability and sufficiency of water in the facilities over the past years; water availability in the future; soil and water quality; irrigated outputs and prices; management and maintenance of irrigation facilities; and trust in the WUA and District Assembly in the general management and support of irrigation facilities (Table 2).

## 3. Methodology

### 3.1. Data collection

A questionnaire was designed to collect primary data from 370 irrigators in 37 small-scale irrigation schemes. Small-scale schemes of this study consist of a main canal that conveys water from the dam and a number of laterals that convey water from the main canal across plots. Data was collected by teaching assistants from the University for Development Studies in Tamale with supervision from the principal researcher from November 2014 to April 2015. Respondents were randomly sampled from membership lists of WUAs using a simple random approach where each member was assigned a number and wrapped in a piece of paper to ensure that every member had an equal chance of being selected.

For each scheme, the WUA Chairman (or Assembly man in the case of Gbache and Balawa communities) was informed about the research. The chairmen then announced to all group members who cultivated a particular crop (whichever one was predominant in the scheme) to attend a meeting on a scheduled date. In some instances the chairmen passed the information through lateral leaders, in other instances through community leaders (in cases where the dam served more than two communities). In each community there are designated people who beat drums to draw people's attention to announcements. It is the usual method used if information is required to reach all members of a community. However, social activities such as funerals, which are performed in the dry season, may have prevented a few users from attending. Selected farmers who were not present were replaced (this only happened in two schemes). We assume that the few absentees do not have characteristics fundamentally different from the majority who

**Table 1**
Summary of irrigation governance dimensions and their variables.[1]

| Participation | Accountability | Conflict management | Transparency and cooperation | Equity and fairness | Sustainable use |
|---|---|---|---|---|---|
| Participation of eligible users in the use and management of facility (right of use) | Access to information by users | Satisfaction of conflicting parties in land- and water-related conflicts | Existence of an organizational structure | Well-defined users | Suitability of soil for irrigation |
| Participation in decision making involving all users (joint decisions) | Dissemination of expenditure and financial standing of WUA | Handling of tensions in leadership | Transparency in the election of leaders (existence of democracy in group) | Adequacy of irrigable land (compared to number of users) | Management of facility (effective?) |
| Recognition of users by higher authority (e.g. participation in best farmer awards) | Leaders' commitment to duties | Price- and market-related conflict resolutions | Application of rules and regulations (Rule of Law) | Equitable access to water | Availability of water over the years |
| Participation by gender (women involvement in irrigation management) | Confidence of users in leaders | Use of graduated sanctions | Adequacy of group meetings | Adequacy and fairness of water charge | Sufficiency of water for irrigation in the current year |
| Participation of all users in maintenance | Management of finances | | Openness of group members at meetings | Available market for irrigated produce | Availability of water in coming year |
| | | | Cooperation of individual users in collective action (members' commitments) | Equitable access to land | Water quality |
| | | | Openness of leaders in respect to transactions concerning the group | Equity in handling user concerns | Output from irrigation |
| | | | Reliability of leaders | | Trust in WUA for the general management of facility |
| | | | Information flow among members of WUA | | Support from assembly and district officials |
| | | | Transparency in water discharge (e.g. timeliness) | | Ready market/good prices for irrigated products |
| | | | Spate of corruption | | Good maintenance of facility |
| | | | Awareness of group members on financial matters | | |
| | | | WUAs' activeness (dormant group or active) | | |
| | | | Monitoring and control of water discharge (is it transparent and are users cooperating?) | | |

[1] Chosen variables were motivated by governance frameworks (Agrawal, 2003; Ostrom, 2009) and the management structure of WUAs.

**Table 2**
Characteristics of water users.

| Characteristic | Distribution | Frequency | Percentage |
|---|---|---|---|
| Age (years) | Mean | 41.5 | – |
| | Min | 16 | – |
| | Max | 85 | – |
| Sex | Male | 252 | 63 |
| | Female | 148 | 37 |
| Household size | Mean | 8.45 | – |
| | Min | 2 | – |
| | Max | 18 | – |
| Mobility* | Mean | 2.95 | – |
| | Min | 0 | – |
| | Max | 28 | – |
| Experience in irrigation (years) | Mean | 16.15 | – |
| | Min | 1 | – |
| | Max | 63 | – |
| Irrigated land per user (acres) | Mean | 0.93 | |
| | Min | 0.13 | |
| | Max | 8 | |
| Region** | UER | 290 | 72.5 |
| | UW | 70 | 17.5 |
| | NR | 40 | 10 |
| Plot location*** | Head | 109 | 27.25 |
| | Middle | 179 | 44.75 |
| | Tail | 112 | 28 |
| Crop | Tomatoes | 190 | 47.5 |
| | Pepper | 110 | 27.5 |
| | Onions | 100 | 25 |
| Number of users in scheme | Mean | 75.92 | – |
| | Min | 17 | – |
| | Max | 200 | – |
| Average annual precipitation in 2012 (mm) | Mean | 980.27 | – |
| | Min | 917 | – |
| | Max | 1091 | – |

* Number of times a water user migrated during the irrigation season.
** Upper East Region (UER), Upper West Region (UWR), and Northern Region (NR).
***Head-enders are irrigators whose plots are located upstream within 1/3 of the irrigable area; tail-enders are located downstream within 1/3 of the irrigable area; middle-enders are located at the 1/3 of the irrigable area between the head and tail of the system. The division was based on lateral numbers.

attended. Because of the heavy presence of Non-Governmental Organisations (NGOs) in northern Ghana, water users are active when meetings are called.

At each scheme, the objectives of the research were explained to WUA members. Those who did not want to take part had an option to leave, but in every scheme, everyone that attended also wanted to take part in the research. Simple Random Sampling technique (lottery method) was used to select ten respondents for the household interviews at each scheme. Those remaining were free to take part in group discussions. Table 1 presents the characteristics of respondents and irrigation schemes.

Data collected included information on crop/livestock production, farm inputs, land tenure arrangements, use of water, WUAs management structure and their activities (governance in general), and yields and prices. From the regional directorates of GIDA, expert opinions were sorted on sampling and validation of the issues that needed to be assessed by users. Potential biases in self-reported survey answers are assumed to be part of the random disturbance term in our analyses.

Three crops were considered in the study: tomatoes, onions, and pepper (see Table 1). Even though a variety of crops are under irrigation in northern Ghana, each scheme has a dominant crop. Households have little control in their choice of crop, and very much rely on group choice or recommendations, because of uncertainty relating to recurring problems such as diseases (for instance presence of nematodes), crop destruction by livestock requiring joint action, and limited market availability. The selected crops are the dominant, if not the only, irrigated crops at most schemes in the study area.

Tomatoes and onions are the most grown cash vegetables. These crops have varying needs of water allocation with an average of about 36 irrigations in onion production per period (thrice a week for three months) to a high of about 84 irrigations in tomato production per period (once a day for three months). Pepper demands on average only two irrigations per week for at least four months (36 irrigations per period, but for a longer period). This means that the water demands of onions and pepper are similar in that they both require about 36 irrigations per period, and only differ in the length of the period; tomatoes demand the most water.

### 3.2. Estimation and analytical approach

#### 3.2.1. Governance estimation

The 46 governance features listed in Table 2 were included in the household questionnaire in the form of positive statements. Respondents were asked to rate these statements using a 5-point Likert scale:

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

A limitation of the Likert scale is the fact that it is a close-ended approach to questioning. Open ended questions give room for respondents to explain the answers. We however used this approach to narrow down ambiguities that may arise as interviewers and interviewees may confuse and/or interchange the varied and numerous indicators that we use in the assessment. Statements were mapped into the six indicated dimensions of governance. We employed the composite indicator approach where the different indicators of governance were assessed and merged into dimensions of governance. To calculate a composite indicator for each dimension, we employed an equal weighting system, which is the most common technique at both macro and micro levels (Cookey et al., 2016; Mazziotta and Pareto, 2013; OECD, 2008). Also, each dimension of irrigation governance is considered equally important in assessing overall irrigation governance. The composite indicator approach allows several indicators to be assessed and merged appropriately into sub-components or a unit component for a simple overview of complex systems (Nardo et al., 2005; Barclay, Dixon-Woods, & Lyratzopoulos, 2019). A major limitation of the selected approach is the possibility that it disguises serious failings in some dimensions due to differences in ratings of the individual indicators (Ibid). This limitation needs to be taken into account when interpreting the main findings of our research.

#### 3.2.2. Hypotheses testing

To test the validity of our hypotheses, we examined the relationship between governance scores per dimension and factors that could be associated with governance perceptions using regression analysis. In studies where a single survey item is unlikely to fully capture a concept being assessed, like irrigation governance dimensions in our case, the Likert-scale approach where several Likert items are created and grouped into a "survey scale" as presented in Table 2 is the recommended practice (Gliem & Gliem, 2003; Sullivan & Artino, 2013). Parametric analysis can then be carried out using total scores or mean scores calculated for the scale items provided the scale passes the Cronbach alpha test of internal consistency (Sullivan & Artino, 2013). The Cronbach alpha test for our governance assessment scales are presented in Table 3.

The Cronbach alpha has an upper value of 1 and no lower limit. As a rule of thumb, a Cronbach alpha greater than or equal to 0.7 is acceptable (George & Mallery, 2003), and implies that the components of the scale are inter-correlated and the grouped items sufficiently measure the underlying variable. A Cronbach alpha close to or equal to 1 is problematic, for this may mean that the variables in the scale only measure one aspect of the concept under study and not the required variability. Table 3 indicates that the set of items included in each governance dimension are closely related as a group. Therefore, for the dependent variable measuring a specific governance dimension, we take the average response of an irrigator to the list of indicators of that dimension. For the dependent variable measuring overall governance, we take the unweighted average of the six dimension-related average responses of an irrigator. A score closer to 1 signifies bad governance, while that closer to 5 will signify good governance. The range is classified as:

$1 \leq \text{IGR}_i < 2$ = very bad governance
$2 \leq \text{IGR}_i < 3$ = bad governance
$3 \leq \text{IGR}_i \leq 4$ = good governance
$4 < \text{IGR}_i \leq 5$ = very good governance

**Table 3**
Cronbach alpha test of irrigation governance dimensions scales.

| Irrigation Governance Dimension | Number of Variables | 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 and 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 reliable.

Given that the dependent variable is limited and censored, we used a Tobit regression approach. An OLS regression produced similar results but we present the Tobit results for consistency of estimation. The model is formulated as

$$IGR_{ik} = f(R_i, U_i, C_i, P_i, O_i) + \varepsilon_{ik} \quad for \quad i = 1, \cdots, 370 \quad k = 1, \cdots, 6$$

$$IGR_i = f(R_i, S_i, C_i, P_i, O_i) + \varepsilon_i$$

Where;
$IGR_i$ = overall governance rating by user $i$
$IGR_{ik}$ = rating of dimension $k$ by user $i$
$R_i$ = annual precipitation of the location of user $i$
$U_i$ = number of users in the irrigation scheme of user $i$
$C_i$ = main crop (pepper, onions, tomatoes) in scheme to which user $i$ belongs
$P_i$ = plot location (head-, middle-, tail-end) of user $i$
$O_i$ = control factors (sex, age, mobility and experience) of user $i$
$\varepsilon_i$ = error term

We used the Conditional Moments Test to test the key assumption of normality of the residuals of a Tobit model (H0: Tobit residuals are normally distributed). We applied the parametric bootstrapping method proposed by Drukker (2002), using 500 replications to obtain our critical values (for details of testing procedure, see Drukker (2002). The test results indicate that, the null hypothesis of normality of Tobit residuals cannot be rejected at 1% level for the models. We further employed the Variance Inflation Factor (VIF) approach to check for potential multicollinearity. VIF quantifies the severity of multicollinearity in Ordinary Least Squares regressions (Farrar & Glauber, 1967; Kock & Lynn, 2012). As a rule of thumb, a VIF greater than 10 may be a signal of the presence of multicollinearity in the predictor variables. None of the VIF estimates of our predictors exceeded 3.

The six equations were estimated independently, even though their error terms may be correlated. As the equations have identical explanatory variables, seemingly unrelated regressions methods will not give more efficient estimates as compared to independently estimated

**Table 4**
Variable definitions and measurements.

| Variable | Definition and measurement |
|---|---|
| Gov (P,A,C,TC,FE,S) | Individual governance ratings, where P = participation, A = accountability, C = conflict management, TC = transparency and cooperation, FE = fairness and equity, S = sustainable use |
| Sex | Male = 1, Female = 0 |
| Age | Age of irrigator (in years) |
| HHsize | Household size |
| Mob | Mobility (number of times irrigator migrated last season) |
| Exp | Experience (number of years irrigator has been irrigating) |
| IrriArea | Irrigable area of scheme (in acres) |
| Users | Number of users of the scheme |
| Rain | Annual precipitations (mm) |
| CropdumP | Dummy for main crop in scheme (pepper = 1) |
| CropdumO | Dummy for main crop in scheme (onions = 1) |
| PlotdumH | Dummy for plot location (head-end = 1) |
| PlotdumT | Dummy for plot location (tail-end = 1) |

equations (Greene, 1993: p. 488).

From Cameron and Miller (2015), a control is needed in regression models where observations can be grouped into clusters, with model errors uncorrelated across clusters but likely correlated within-cluster. An example of "clustered errors" is individual-level cross-section data with clustering on geographical region (scheme in our case). The model errors for individuals in the same scheme may be correlated, while model errors for individuals in different schemes are uncorrelated. Failure to control for within-cluster error correlation can lead to small standard errors, narrow confidence intervals, large t-statistics and low p-values (Cameron & Miller, 2015). In this case, we estimated cluster-robust standard errors. Table 4 summarizes the definitions of the variables in our estimated models and their measurement.

## 4. Results

### 4.1. Irrigation governance ratings (IGRs)

Table 5 presents a summary of the ratings by users of the six governance dimensions and overall governance. The mean ratings of the governance dimensions are all larger than 3.0, indicating good to very good governance. Sustainable use scores lowest (3.42) compared to other dimensions, whereas conflict management has the highest score (4.22), indicating relatively good governance in managing irrigation-related conflicts. The overall governance score is 3.82, suggesting good governance on average in the sampled WUAs.

The standard deviation is relatively high in accountability assessments, indicating much variation in the opinions of irrigators. Accountability is a contentious issue in any social group. What one may see as being accountable may not be acceptable to others due to differences in judgement. There is however close agreement in the overall assessment of irrigation governance, as signified by a low standard deviation.

**Table 5**
Descriptive statistics of irrigation governance dimensions.

| Dimension | No of variables | Mean | Min | Max | Standard deviation |
|---|---|---|---|---|---|
| Participation | 5 | 4.11 | 1.75 | 5.00 | 0.594746 |
| Accountability | 5 | 3.70 | 1.20 | 5.00 | 0.778974 |
| Conflict management | 4 | 4.22 | 1.00 | 5.00 | 0.547243 |
| Transparency and cooperation | 14 | 3.83 | 1.07 | 5.00 | 0.648869 |
| Equity and fairness | 7 | 3.64 | 1.86 | 5.00 | 0.577031 |
| Sustainable use | 11 | 3.42 | 1.82 | 4.73 | 0.580615 |
| Overall governance | 46 | 3.82 | 1.76 | 4.79 | 0.479382 |

### 4.2. Irrigation governance by hypotheses

In this section we present empirical results of the hypotheses on factors associated with individual's assessments of IGRs. The Tobit Cluster-Robust results are presented in Table 6.

#### 4.2.1. Location of irrigation facility

In Table 6, schemes located in areas having relatively high annual precipitations report better irrigation governance. This is significant in accountability assessments and in the overall governance score. This suggests that WUA leaders are more open in information dissemination to members, and in return, are more trusted when annual precipitations are high. The results thus confirm a positive relation between the location of a scheme and the general assessment of irrigation governance.

#### 4.2.2. Crop grown

Onion and pepper as main crops have a statistically significant relationship with some of the irrigation governance dimensions. Table 6 indicates that farmers growing onions have a higher opinion and farmers growing pepper a lower opinion of governance, as compared to farmers growing tomatoes. The perceptions of pepper farmers are significant in the overall governance assessment.

Various reasons could explain these results, including the water demand of a crops, the length of season a crop is irrigated (period), and the economic value of a crop. Compared with tomatoes, onions demand less water, even though both crops have relatively similar periods of irrigation (Namara et al., 2011). The results then imply that irrigators growing less water-demanding crops (onions) are more positive. Furthermore, onions are mostly grown in the north-eastern corridor (Bawku) of Ghana, the driest place in the country. Participation and accountable leadership is needed in maintaining dams for continuous production of onions, the main cash crop of indigenes. This may also explain why onion irrigators are more positive, even though insignificant in the overall governance assessment.

Also peppers demand less water than tomatoes, but peppers take a longer period. Our results suggest that irrigators growing long-period crops (pepper) tend to be more negative in governance assessments than those growing short-period crops (tomatoes), also with respect to the overall governance assessment. Therefore, the main crop grown in a scheme indeed associates with irrigation governance assessment, but the period rather than the frequency of irrigation is likely to be the determining factor. High temperatures in the months leading to the rainy season dry up water bodies, so that crops that span up to this period probably suffer water insufficiency. Water shortage makes it difficult for leaders to coordinate activities in irrigation, a reason for the lack of transparency and cooperation and of accountability, as rated by pepper irrigators.

Due to agro-climatic and other factors, the main crop grown in a scheme varies between regions. Hence, the crop dummies are also likely to reflect regional variation between irrigation schemes in many other aspects besides irrigation frequency and growing period of the crop. In particular, higher layers of governance may differ between regions (and crops) and affect local governance perceptions of farmers in the small-scale irrigation schemes that we surveyed.

#### 4.2.3. Size of scheme (number of users)

In Table 6, the number of users in a scheme generally has a positive association with irrigation governance perception, except in conflict management. This is only statistically significant in participation and accountability in irrigation governance, implying that users in large WUAs are more positive in their assessments. One striking thing about user management of irrigation systems is the collective power in maintaining irrigation facilities. In large WUAs, contribution in cash and kind towards maintenance activities is an advantage due to the high numbers. As evident in our results, participation in large WUA schemes is high. On the other hand, it is worth noting that large user

**Table 6**
Tobit regression results of governance dimensions.

| | Participa-tion | Accounta-bility | Conflict manage-ment | Transpa-rency and cooperation | Equity and fairness | Sustaina-ble use | Overall |
|---|---|---|---|---|---|---|---|
| Sex | 0.006 | −0.057 | −0.006 | 0.011 | 0.021 | 0.003 | −0.004 |
| | (0.101) | (−0.815) | (−0.090) | (0.158) | (0.403) | (0.046) | (−0.090) |
| Age | 0.000 | 0.003 | 0.002 | 0.002 | −0.001 | 0.001 | 0.001 |
| | (0.110) | (0.969) | (0.483) | (0.822) | (−0.285) | (0.541) | (0.568) |
| HHsize | 0.004 | −0.014 | −0.012 | −0.020 | −0.009 | −0.010 | −0.010 |
| | (0.336) | (−1.003) | (−1.159) | (−1.569) | (−0.847) | (−0.947) | (−1.162) |
| Mob | −0.012* | −0.013* | −0.009 | −0.005 | −0.015** | −0.001 | −0.009* |
| | (−1.807) | (−1.677) | (−1.489) | (−0.846) | (−2.585) | (−0.188) | (−1.836) |
| Exp | 0.003 | 0.009** | 0.005 | 0.003 | −0.002 | −0.002 | 0.002 |
| | (0.906) | (2.367) | (1.254) | (0.771) | (−0.692) | (−0.698) | (0.771) |
| IrriLand | 0.234** | 0.243* | 0.205* | 0.227* | 0.089 | −0.023 | 0.153 |
| | (2.116) | (1.821) | (1.730) | (1.822) | (0.779) | (−0.192) | (1.600) |
| IrriLand2 | −0.024* | −0.023 | −0.023 | −0.020 | −0.007 | 0.010 | −0.013 |
| | (−1.773) | (−1.340) | (−1.583) | (−1.253) | (−0.513) | (0.656) | (−1.093) |
| Users | 0.004** | 0.004** | −0.001 | 0.003 | 0.001 | 0.002 | 0.002 |
| | (2.441) | (2.060) | (−0.467) | (1.632) | (0.956) | (1.056) | (1.610) |
| Rain | 0.003 | 0.005** | 0.001 | 0.003 | 0.001 | 0.002 | 0.003* |
| | (1.591) | (1.992) | (0.922) | (1.606) | (0.683) | (1.503) | (1.830) |
| CropdumP | −0.311 | −0.664** | −0.213 | −0.514** | −0.273 | 0.066 | −0.312* |
| | (−1.446) | (−2.040) | (−1.200) | (−2.339) | (−1.461) | (0.455) | (−1.897) |
| CropdumO | 0.335** | 0.408** | 0.188 | 0.135 | 0.070 | 0.015 | 0.175 |
| | (2.416) | (2.403) | (1.185) | (0.970) | (0.497) | (0.101) | (1.440) |
| PlotdumH | −0.057 | −0.207** | 0.020 | −0.207*** | −0.096 | −0.178** | −0.123** |
| | (−0.774) | (−2.418) | (0.270) | (−2.920) | (−1.390) | (−2.565) | (−2.322) |
| PlotdumT | −0.046 | −0.037 | −0.034 | −0.067 | −0.110* | −0.182** | −0.077* |
| | (−0.838) | (−0.578) | (−0.592) | (−1.328) | (−1.667) | (−2.589) | (−1.816) |
| Constant | 0.645 | −1.896 | 2.753* | 0.536 | 2.800* | 1.408 | 1.102 |
| | (0.339) | (−0.726) | (1.690) | (0.267) | (1.940) | (0.944) | (0.745) |
| Observations | 370 | 370 | 370 | 370 | 370 | 370 | 370 |
| Pseudo R-squared | 0.126 | 0.1422 | 0.0388 | 0.1052 | 0.0559 | 0.0495 | 0.1501 |

Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1% respectively. The Tobit-Cluster-Robust t-statistics are in parentheses.

groups have insignificant (negative) associations with conflict management. Increasing numbers of users increase divergent ideas and misunderstandings, which may raise tensions in groups making governance uneasy. These results however do not show sufficient evidence to suggest that the number of users in a scheme influences users' assessments of irrigation governance as the number of users is insignificant in the overall governance assessment.

#### 4.2.4. *Plot location*

Plot location is negatively associated to irrigation governance assessment for both head-enders and tail-enders, and this is significant in the overall irrigation governance assessment. Both head- and tail-enders are indifferent towards their assessments of sustainable use compared to mid-enders and this is negative and significant in both cases. Specifically, head-enders are significantly negative in transparency and cooperation, and accountability assessments. Tail-enders on the other hand are more concerned about equity and fairness treatments in irrigation governance. Fairness and equity is questionable where one is allocated a plot at the tail-end. Tail-enders are normally the last to be allocated water and in cases of water shortage they are usually the hardest hit.

From group discussions and participant observations, it was noticed that head-enders suffer dam malfunction effects directly and in most cases will want leaders to act promptly in curbing negative impacts, but this does not always happen. More than 50% of small-scale irrigation schemes visited had problems of seepage and broken canals. The seepage in most instances occurs in plots of head-enders, causing plots to flood, which may explain the trend of head-enders' assessments. Collective action requires transparency from leaders and cooperation from users for effective governance. The sustainability of the WUA model in irrigation governance is questionable when cooperation in particular is non-existent in groups. Lack of transparency and/or cooperation can lead to a divergent use of resources contrary to agreed principles, which poses challenges for long-term use.

#### 4.2.5. *Control variables*

Among the control variables, mobility, experience, and irrigable land per irrigator associate with the assessment of some irrigation governance dimensions. Experience generally has a positive association but is only statistically significant in accountability. If the adage of "learning by doing" holds, then more experienced irrigators are able to decipher odds from normal practices of good governance to give good judgements. In this study, the more experienced irrigators are positive in assessing accountability in irrigation governance.

High mobility has a significant negative influence in participation, accountability, and equity and fairness assessments. In Agrawal's sustainable resource governance framework (Agrawal, 2003), low mobility is recommended in terms of resource mobility. Similarly, users of common pool resources need infrequent migrations and more participation in the operation and maintenance of common pools for effective governance. Migration of farmers from northern Ghana to southern Ghana in search of greener pastures is common during irrigation periods, which imparts collective action in governance negatively, hence the negative assessments. Mobile irrigators miss out on a lot of activities in WUAs including decision-taking consensus. Good ideas that could be contributed by absentees from meetings end up affecting the governance of irrigation resources. Fairness and equity in groups demands high representations of WUA members in decision making.

The amount of irrigable land per irrigator indicates the degree of dependence of an irrigator on the irrigation facility. Irrigators who depend more on the resource are more positive in their assessments. In other words, irrigators who have access to more land are more satisfied about governance. The square of land showed a negative influence but the turning point of land in each dimension is estimated as high and positive, which means that irrigation land per user generally has a positive association with governance assessment. The availability of irrigable land to meet land demands of irrigators can thus be a reason for positive governance assessments.

Sex, age, and household size of irrigators do not influence their assessments of governance dimensions. Dry season farming is regarded as a business venture for most farmers which may explain why both sexes and generations are indifferent in their assessments. Anything that affects business may be easily acknowledged by all irrespective of gender and age. The negative association of household size with governance assessment may be as a result of frustration. Larger households may be the most hit when irrigation resources are misgoverned. For that matter they tend to be stringent in their assessments compared to respondents from smaller households.

## 5. Concluding remarks

This study aimed at providing an empirical assessment of irrigation governance in northern Ghana derived from the perceptions of users; and at exploring factors that may potentially be related to the perceived quality of irrigation governance. For this, we constructed six dimensions of governance which are participation, accountability, conflict management, transparency and cooperation, equity and fairness, and sustainable use from 46 indicators.

Overall, the users assessed irrigation governance in our study area as "good" even though one would have preferred "very good" governance. The lack of progress in some irrigation facilities in northern Ghana being attributed to bad governance in general (Dittoh et al., 2013a; Poussin et al., 2015; Venot & Hirvonen, 2013) may be specific to some dimensions of governance, depending on the physical conditions and characteristics of the governing WUA, which may need attention.

Relatively, conflict management rated highest among the dimensions which suggests that conflict management is better handled than other dimensions in the use of small-scale irrigation schemes in the study area. Conflict management is important where common pool resources are sited at relatively unstable places in terms of peace as in the case of our study area. Unlike large-scale schemes at the national level such as the Vea and Tono irrigation schemes, where usage is opened to a wide range of people from all ethnic groups with little or no role of traditional leaders, small-scale schemes in general are enclosed, involving the use of traditional authority at a low cost to resolve conflicts. Conflict resolutions are often seen as a responsibility of formal institutions but the presence and role of traditional leaders aids in resolving irrigation-related conflicts in small-scale schemes and this may explain the high score. Sokile and van Koppen (2004) found that informal channels are more effective in resolving water-related conflicts than formal channels in Tanzania, and recommended an amalgamation of both for effective management of water resources. As they explained, local institutions play a significant role in water management and should not be discarded as obsolete. Sustainable use on the other hand had the lowest score among the six dimensions, indicating the need for more proactive measures towards sustaining the irrigation systems.

In the exploratory aspect, we rejected two hypotheses (size and crop hypotheses). Factors that significantly associate with irrigation governance perceptions are the availability of water through high precipitations and plot locations of irrigators. Even though the number of users (size) in a scheme positively influences governance assessments in some dimensions, it is not significant in the overall assessment of irrigation governance, and hence rejected. The main crop grown in a scheme also associates with governance assessments but it is not necessarily the crops with lower water demands that have a positive association as hypothesized. Crops with shorter growing periods (such as onions compared to pepper) yield more positive governance assertions, but regional variation in other factors, like higher layers of governance, may confound these results.

Head-enders who were expected to be more positive in their assessments resulted negative. A question that arises from their assessments is whether the sustainability of an irrigation facility is better looked at as an issue of infrastructural functionality or that of WUA's functionality. In other words, could sustainability be more tied to infrastructural existence? Birner et al. (2010) reported infrastructural defects as a reason why most small-scale schemes have been abandoned in the Upper East Region of Ghana. Both head-enders and tail-enders in our study significantly rated sustainability low because most dams have damaged infrastructure needing urgent attention. Water wastage through seepage and broken canals causes dams to run out of water, thereby making irrigators jobless. Routine repairs of major infrastructural damages beyond the capacity of famer groups are important in sustaining irrigation facilities. Harmancioglu, Barbaros, and Cetinkaya (2013) pointed out that water resources need to be developed and managed on a sustainable basis. It is important to invest in constructing reservoirs for rural livelihoods but it is even more important to invest in maintaining such facilities so that the poor can continue to live. The existence of cooperation, transparency, and accountability, among other dimensions, are good conditions for group existence, but once a reservoir collapses, production ceases, and this is not sustainable. All activities and every dimension of irrigation governance should have a bearing on the long-term sustainable use of the resource. Group existence is important for the sustainable management of the commons but the survival of the commons should be the main aim of sustainable production. Prompt repairs of malfunctioning valves and broken canals by GIDA are highly desirable.

Another concern of interest is whether surface water irrigation through canals is a good approach in tackling agricultural production in dry climates. Sustainable use had the lowest score among irrigation governance dimensions in this study. The method of water allocation in Ghana is not volumetric (not measured by quantity) but judged through time allowed for water use per day. A lot of water is wasted by this method coupled with wastage through seepage and evapotranspiration in high temperatures. Dams are good communal resources but may be better maintained for domestic and livestock watering. Promoting the use of water-conserving irrigation techniques such as drip irrigation and ground water techniques is essential.

## CRediT authorship contribution statement

**Margaret Atosina Akuriba:** Funding acquisition, Writing - original draft, review & editting. **Rein Haagsma:** Methodology, Editing, Supervision. **Nico Heerink:** Formal analysis, Editing, Supervision. **Saa Dittoh:** Conceptualization, Validation.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix

*Abridged questionnaire*

A1. Name of Compound:
A2. Name of irrigator:
A3. Sex (1) Male (2) Female:
A4. Age (in years):
A5. Religion (see codes):
A6. Educational background (see codes):
A7. Major occupation (see codes):
A8. Minor occupation (see codes):
A10. How many years have you been involved in irrigation:
A11. How many months of your labour time was devoted to your own irrigated farm last year:
B1. How many members are in your household (including yourself):
C1. Total land size owned for agricultural purposes in acres:
C13. Total cultivated (irrigated) land size in acres:
C19. Major crops cultivated last year (in descending order with respect to area cultivated):
D6. For how many months in a year does the scheme provide irrigation:
D7. During the past 12 months, how many days did you irrigate with water from the scheme:
D8. How much did you pay as total water fee for the irrigation from the scheme last year:
D9. Where is your main field (tomato, onion, pepper) located in the scheme:

[1] near the headworks; [2] in the middle; [3] at the tail end;

D10. By what means do you transport water from source:

[1] Earthen field channels; [2] Lined channels; [3] Flexible rubber pipes; [4] Other, specify:

D17 How many days did you stay outside the community (travel) last irrigation season (or dry season):

Below are a number of statements regarding the governance of your irrigation facility. Please indicate the extent to which you agree or disagree with each statement (1 = Strongly agree 2 = Agree 3 = No opinion 4 = Disagree 5 = Strongly disagree).

| # | Statement | Response (1 - 5 scale) |
|---|---|---|
| *Participation* | | |
| F33 | Irrigators have rights to use the facility (e.g land, water) | |
| F34 | Decisions concerning the management and maintenance of the facility are normally taken jointly involving all users | |
| F35 | The group is determined to be recognized by higher authority (e.g by the District Assembly in best farmer awards) | |
| F36 | Both men and women are treated equally in the use of the facility | |
| H7 | Members participate fully in irrigation activities (meetings, general maintenance, etc) | |
| *Accountability* | | |
| F37 | Group members have easy access to information from leaders | |
| F38 | Group members are informed of the expenditure and financial standing of the group regularly | |
| F39 | Leaders are committed to their responsibilities | |
| F40 | Group member have confidence in the leaders | |
| H9 | Leaders manage the finances of the group well | |
| *Conflict management* | | |
| F41 | Conflicts relating to land and water allocation are normally resolved to the satisfaction of those involved | |
| F42 | Tensions in leadership are always well handled by the group | |
| F43 | Conflicts arising from price negotiations between irrigators and market women are normally well resolved | |
| F44 | There is a step by step process in sanctioning rule breakers in the group (graduated sanctions). e.g warnings are given first before sacking or ceasing of plots if offense is repeated | |
| *Transparency and Cooperation* | | |
| H1 | There is democracy in the group (i.e. everyone has a say in decision making and free to express ones' opinions) | |
| H2 | There exist an organizational structure in the facility (a hierarchy with clearly defined roles) | |
| H3 | Those who break rules are normally sanctioned according to laid down rules and procedures (rule of law) | |
| H4 | Averagely the number of meetings organized concerning irrigation is adequate | |
| H5 | Group members are always open and sincere at meetings | |
| H8 | Members are fully committed to the maintenance of the facility (e.g. maintenance of plot and canals, less flooding, avoidance of nuisance, etc) | |
| H10 | Leaders are transparent in everything they do concerning the facility (they do not hide information) | |
| H11 | Leaders are accountable (liable leaders) | |
| H12 | Information flow among members is good | |
| H14 | Water discharge is always on time | |
| H16 | There are no fraudulent acts in the group (e.g. stealing group money or transactions unapproved by group) | |
| F38 | Group members are informed of the expenditure and financial standing of the group regularly | |
| G8 | The water user group (WUA) is functioning well as expected | |
| G9 | Water discharge for irrigation is well monitored and controlled | |

| | |
|---|---|
| *Equity/Fairness* | |
| G2 | Those having rights to use the facility are clearly defined |
| G4 | There is enough land for all interested persons to go into irrigation |
| G5 | Everybody has equal access to water/irrigation |
| G15 | The charge for water use is adequate and fair for everybody |
| G18 | There is good market for irrigated products (available buyers and good prices) |
| H13 | Land allocation is fair (no bias) |
| H15 | There is equity in the group (fairness in handling issues) |
| *Sustainable use* | |
| G6 | Soil quality is suitable for irrigation (e.g. does the soil give good yields without extensive input use?) |
| G7 | The irrigation facility is properly managed (leaders are working well and doing the right things) |
| G10 | There has not been any water shortage for irrigation for the past five (5) years. |
| G11 | There is sufficient water in the dam for irrigation this year. |
| G12 | There will be enough water in the dam for irrigation next year for everybody |
| G16 | Quality of the water is good for irrigation (It does not make crops wilt/die) |
| G17 | Output from irrigation activities is good as expected |
| G18 | There is good market for irrigated products |
| G19 | In general, WUA can be trusted in the management of the facility |
| G20 | The assembly man and district officials can be trusted in the management/support of the facility |
| H6 | The facility is well maintained (maintenance activities carried out adequately) |

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