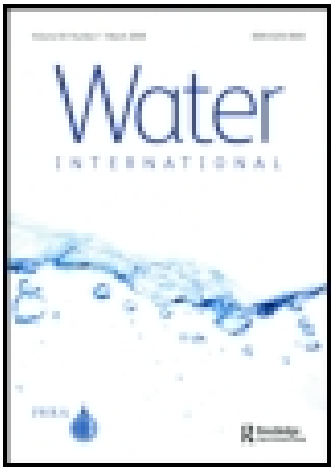

Water International

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rwin20

Assessing the performance of water user associations in the Gash Irrigation Project, Sudan

Lee A. Ngirazie[a], Ageel I. Bushara[b] & Jerry W. Knox[a]

[a] Cranfield Water Science Institute, Cranfield University, Bedford, UK

[b] Hydraulics Research Centre, Wad Medani, Sudan

Published online: 07 Aug 2015.

Water International, 2015
http://dx.doi.org/10.1080/02508060.2015.1072677

Routledge
Taylor & Francis Group

Assessing the performance of water user associations in the Gash Irrigation Project, Sudan

Lee A. Ngirazie[a], Ageel I. Bushara[b] and Jerry W. Knox[a]*

[a]*Cranfield Water Science Institute, Cranfield University, Bedford, UK;* [b]*Hydraulics Research Centre, Wad Medani, Sudan*

(*Received 24 September 2014; accepted 9 July 2015*)

In many countries, water user associations (WUAs) have assumed responsibility for managing irrigation systems, but their performance is known to vary markedly. This study assessed WUAs in the Gash spate irrigation project in Sudan, a decade after their initiation. Fieldwork involved a farmer survey, focus group discussions, benchmarking, and interviews with key informants. Overall, performance was found to be average, but with wide variation between individual WUAs. Performance indicators relating to jurisdiction over hydraulic boundaries and water delivery were poor. A lack of institutional arrangements and land ownership issues also strongly influenced performance. The management system for coordinating WUAs was found to be unnecessarily complex.

Keywords: agriculture; benchmarking; spate irrigation; performance; water management; Sudan

Introduction

Sudan is the third-largest country in Africa, with about 80% of its population dependent on agriculture as the mainstay for the economy and their livelihoods (Avelino, 2012). The Gash Irrigation Project (GIP) operates under the organizational entity of the Gash Agricultural Scheme (GAS) and is located in Kassala State (15°27′N, 36°24′E) in eastern Sudan. The overall goal of the GIP was to rejuvenate the livelihoods of inhabitants in the Gash Delta. To support this, 91 water user associations (WUAs) were formed and linked to the GIP. Spate irrigation has been practised in the GAS since 1924. It is the largest spate irrigation scheme in Sudan and a major source of food production for eastern Sudan. Currently, there are approximately 45,000 farmers with a total irrigated area of 100,000 ha, of which 30,000 ha are irrigated annually (Zenebe, 2012). The GAS is divided into six blocks (Kassala, Makali, Degain, Tendelai, Metateib and Hadaliya); WUAs exist in all blocks except Hadaliya. Each WUA has two *misga*, which refers to a secondary canal that supplies spate flow directly to an irrigated command area, ranging from 450 to 900 ha. Every farmer is allocated six *feddan* (equivalent to 2.52 ha) each year through a lottery. Three *feddan* (1.26 ha) are planted to a food crop while the other three are left fallow in an effort to promote crop rotation. The WUAs manage water in the main and secondary canals. However, each farmer is then responsible for irrigating his allocated three *feddan*.

Globally, many successful WUAs exist, and whilst they face challenges, including increasing water scarcity, by working together to formulate and enforce their own rules

*Corresponding author. Email: j.knox@cranfield.ac.uk

and regulations, they have been able to share that scarcity in a more equitable and sustainable way. Internationally, the success of WUAs has been attributed to adequate monitoring of the resource and users, graduated sanctions for users who violate the rules, access to low-cost local conflict-resolution services to resolve differences between users, rules restricting water resource use which are related to local conditions, participation of members in rule modification within the WUA, and a culture of openness and cooperation with external organizations to promote good working relationships and collaboration. The opposite is true where these attributes are absent or lacking, resulting in the formation of a WUA which is not then sustainable over time (Leathes, Knox, Kay, Trawick, & Rodriguez-Diaz, 2008).

Many countries, including Sudan, have transferred the management of their irrigation systems, including spate irrigation schemes, to WUAs in the belief that performance depends largely on WUA intervention (Uysal & Atis, 2010). This has led to greater women's participation and better compliance with rules and maintenance contributions (Zwarteveen & Meinzen-Dick, 2001) since the importance of gender in influencing the success of WUAs in spate irrigation is well known. In Sudan the roles and functions of WUAs in terms of water governance and efficiency can be related to five principles originally defined by Wang, Huang, Zhang, Huang, and Rozelle (2010) (Table 1). The WUAs are responsible for the provision of adequate and reliable water supplies; yet this can only be achieved where the on-farm delivery infrastructure is in good condition and maintained by WUA members. The Sudanese WUAs lack elements of this principle. For example, whilst the WUAs are able to provide adequate and reliable water, the on-farm delivery infrastructure is neither in good condition nor properly managed by its members. Legal status and active participation have also not been enforced, despite the WUAs being farmer owned and led. The hydraulic boundaries of the delivery system should ideally lie within the authority of the WUAs, but this is not the case with the Sudanese WUAs. Most WUAs assess and collect water charges from their members on an equitable basis. Water pricing is thus an important tool in helping improve water efficiency and the financial sustainability of WUAs (Dinar & Mody, 2004). However, in the GIP, the WUAs are responsible for water delivery, yet it is not measured volumetrically.

Table 1. Five principles of water user association (WUA) management and performance, based on Wang et al. (2010).

Principle	Description
Adequate and reliable water supply	A WUA is organized only where an adequate water supply is available and where on-farm delivery infrastructure is in good condition and can be properly maintained by WUA members.
Legal status and participation	A WUA should be the farmers' own organization, be a legal entity and have a leadership elected by its members.
WUA organized within hydraulic boundaries	The jurisdiction of a WUA should be the hydraulic boundaries of the delivery system.
Water deliveries can be measured volumetrically	A WUA should be able to receive its water under contract from its water suppliers, and water should be able to be measured volumetrically.
Equitable collection of WUA water charges	A WUA should equitably assess and collect water charges from its members and make payment for the cost of water.

In 2003, WUAs were introduced into the GAS by the International Fund for Agricultural Development (IFAD). We define a WUA as a legally incorporated association of farmers under contract with an irrigation agency for the establishment of rights and responsibilities for both parties. Under this contract, the ownership of water and infrastructure is held by the state, with the WUAs responsible for operation and maintenance (O&M) functions. However, the irrigation agency also provides advice to the WUAs despite the fact that they manage the irrigation infrastructure free of charge (Uysal & Atis, 2010). However, in the GAS the WUAs are not legally incorporated associations and have less responsibility for O&M work since they are only responsible for the maintenance of the main and secondary canals. The GAS is responsible for operational work such as river dredging.

Gender equity in management and staffing has also been identified as a key issue. It has not been mainstreamed into the Gash WUA management structure because female participation is not allowed; the local culture forbids disclosure of a mother's name. However, women's participation is essential for strengthening the effectiveness of WUAs through improvement of members' adherence to rules and regulations (Zwarteveen & Meinzen-Dick, 2001). It has also been reported that female participation in WUAs is linked to fewer conflicts and violations of rules (Deribe, 2008). The active participation of women is thus crucial for better operation and maintenance, enforcement of rules and regulations, and improved irrigation management (Fadul Bashir, Bashir, Bushara, & Haile, 2012).

Since their formation, the performance of the WUAs in the GAS has not been assessed. In 2008, a stakeholder consultation was held to identify GAS research priorities, with participants including the Ministry of Finance, Ministry of Agriculture, Ministry of Irrigation and Water Resources, the Gash Authority and the Gash Farmers' Union. The consensus from that meeting was that the impact of WUAs on water management and their contribution to poverty alleviation had been marginal (Gash Sustainable Livelihood and Rehabilitation Project, 2008). Challenges such as the managerial, institutional and policy issues within WUAs were identified as root causes of disrupted livelihoods in the Gash Delta (Taha & Omer, 2007). It is against this background that the rationale for this research was identified, with the objective of identifying the factors that have reduced performance of WUAs in the Gash region so that measures to improve the livelihoods of farmers in the scheme could be initiated.

Methodology

The approach involved three stages. First, an assessment of the scientific literature on the formation, operation and performance of WUAs and their role in African irrigation management was completed. A detailed cross-sectional evaluation of selected WUAs in the GAS was then conducted to assess O&M practices. The WUAs were selected using cluster analysis based on factors such as size, location, age and system typology. Finally, a framework for assessing the future performance of the WUAs, including their technical, financial and operational sustainability, was developed. A brief description of each stage is given below.

A combination methodology including qualitative and quantitative data acquisition was used to allow triangulation of responses from a variety of stakeholders, including project beneficiaries and staff from GAS and the Hydraulics Research Centre working at various operational levels such as irrigation experts, regional irrigation officials and extension officers. Data collection focused on four aspects of WUA performance: water

management; O&M; financial management; and institutional arrangements. A detailed review of the scientific literature on WUA performance including methods of assessment was first carried out to establish a theoretical framework. Data collection tools were prepared, including a questionnaire and checklists for focus group discussions and key informant interviews. Fieldwork was undertaken in the Gash region in June 2013. Project documents containing information on the operation of the WUAs were reviewed to understand the activities of the WUAs in the GAS with respect to their intended functions. Field data collection involved conducting interviews with different stakeholder communities including farmers, key informants including irrigation experts, regional irrigation officials, extension officers, WUA executive members and staff from GAS and the Hydraulics Research Centre. A SWOT (strengths, weaknesses, opportunities and threats) analysis with WUA executive members was also undertaken to assess the role of WUAs in water management. The 91 WUAs were then aggregated into three groups using cluster analysis based on factors such as size, location, age and system typology. The three groups were considered from a classification perspective as emerging, evolving and mature (Leathes et al., 2008). The farmers and WUA executive members to be interviewed were chosen from these clusters using random and purposive sampling.

A farmer household survey involving 74 randomly selected farmers was also undertaken. Sample size was constrained by staff and time resources for conducting the fieldwork. This survey defined a set of attributes to help provide the necessary information to address each of the principles defined by Wang et al. (2010). Focus group discussions and key informant interviews were also carried out using discussion checklist questions to triangulate the results against those from the farmer interviews. Finally, a SWOT analysis and series of online interviews were conducted. The data collection approach is summarized in Figure 1. A summary of the attribute data collected as part of the farmer survey to assess each principle is provided below.

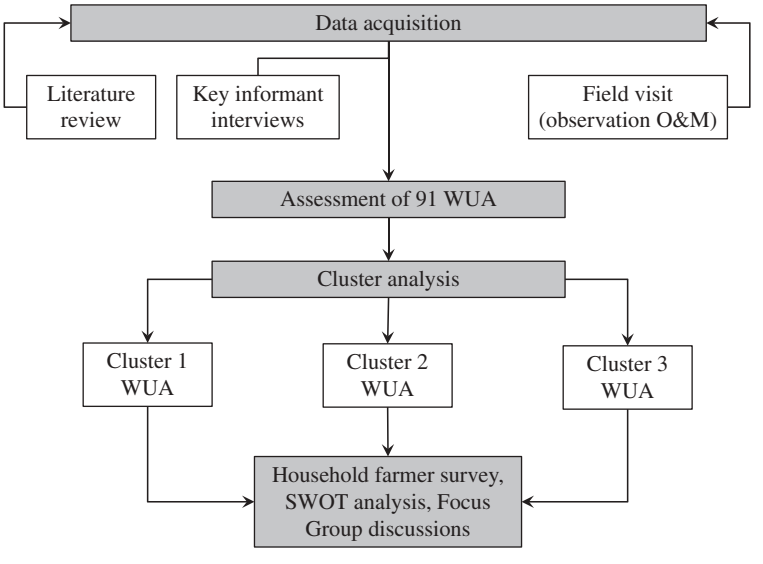

Figure 1. Research design and methodological framework.
Note. O&M = operation and maintenance. SWOT = strengths, weaknesses, opportunities and threats. WUAs = water user associations.

Principle 1: Adequate and reliable water supply. Four attributes were assessed. (1) Farmers were questioned regarding the proportion of their cultivated land that was irrigated and whether they felt they received adequate water. (2) Farmers were asked whether there was equitable water allocation in their WUA. (3) Farmers shared their views on the frequency of their participation in the maintenance of the infrastructure and whether there was any abandoned infrastructure near their farm. (4) The farmers were asked to evaluate the key performance indicators of their WUA in terms of leadership, financial management, resource mobilization, infrastructure maintenance, equity in water distribution, and conflict resolution. Farmers were also asked about their participation in maintenance activities and how labour was allocated.

Principle 2: Legal status and participation. Three attributes were assessed. (1) Farmers provided evidence on irrigation infrastructure ownership. (2) Farmers provided information on the rules and regulations for spate irrigation water usage and whether and how these rules were enforced. (3) The farmers were asked to describe the election and functioning of the WUA committee.

Principle 3: WUA organized within hydraulic boundaries. A single attribute was defined and used to collect farmer evidence regarding irrigation infrastructure ownership and irrigation water allocation (frequency) practices.

Principle 4: Water deliveries can be measured volumetrically. Two attributes were assessed: (1) whether farmers received their water from suppliers under contract; and (2) whether the amounts delivered were measured volumetrically or based on some other alternative approach (e.g. fixed timings).

Principle 5: WUA equitably collects water charges from members. This attribute focused on water fees and whether farmers paid for the delivery of water and their perception of how the fees were then used for O&M activities.

Data from these household surveys on institutional and operational management, water management and distribution, infrastructure maintenance and rehabilitation issues, gender, and agrarian structure were collected and processed using SPSS (version 20.0) statistical software. Qualitative data from individual and group discussions and from field observations were given content and thematic analysis and reported as narrative summaries to contextualize the quantitative data. The data from the interviews, focus group discussions and SWOT analysis were then complemented by an analysis of key performance indicators (relating to leadership, financial management, resource mobilization, infrastructure maintenance, equity in water distribution, and conflict resolution) and the criteria based on the five principles defined by Wang et al. (2010).

Results and discussion

The results from the farmer household survey are described below and summarized in Table 2.

Principle 1: Adequate and reliable water supply. The water distribution system in the Gash was considered fair according to the farmers interviewed because all fields entitled to the first rotation in one year will then be on the second rotation the following year and vice versa. The interviews suggested that 37% farmers had

Table 2. Summary results for each performance principle.

Principle	Attribute	Average score (%)
1. Adequate and reliable water supply	Adequate water supply	57
	Reliable water supply	53
	Infrastructure in good condition	71
	Infrastructure properly maintained by WUA members	43
2. Legal status and participation	Farmers own organization	80
	A legal entity	34
	Leadership elected by its members	95
3. WUA organized within hydraulic boundaries	Authority of WUA should be hydraulic boundaries of system	75
4. Water deliveries can be measured volumetrically	A WUA should be able to receive its water under contract from its water suppliers	66
	Water should be able to be measured volumetrically	0
5. Equitable collection of WUA water charges	A WUA should equitably assess and collect water charges from its members and make payment	95

their whole farm irrigated with spate water, while the majority (63%) had part of their farms irrigated. Spate water provides the only source of water for crop production for most growers (78%), rather than being supplemental to rainfall (8% growers). The main reason for this was a shortage of water, highlighted by nearly a third (27%) of respondents. Most farmers accept that there is sufficient water (69%), while about half confirmed water equity (51%) in the Gash region. Those farmers who reported water inequity stated that unfair distribution of water was the main cause. One of the main problems seems to emanate from poor water management by neighbouring farmers. Nearly three-quarters (69%) of farmers believed that inequality of water distribution stemmed from the fact that farmers who are near the main intake receive more water. Considering that spate water is distributed through guided canals into the command area, it is important that water management be improved through the installation of calibrated sluice gates at each *misga* entry to ensure that water distribution between farmers is more equitable.

Infrastructure maintenance and rehabilitation issues are handled in the GAS through the Gash Apex WUA, an umbrella farmer organization representing the interests of all 91 WUAs. The majority of farmers (58%) do not participate in infrastructure maintenance because of this arrangement. This is a major issue since previous research has stressed the importance of the role of WUAs in irrigation system maintenance (Yercan, Atis, & Salali, 2009). The current levels of O&M funding being collected are also insufficient, as the fees paid (USD 12 per ha per year) are considered too low (Fadul Bashir et al., 2012). If all farmers paid their full fee based on their total irrigated area, then USD 360,000 would be available to support O&M activities. However, many farmers default on their payment into the GAS, often through a lack of trust and transparency over how fees are spent.

Sedimentation was also highlighted as a major problem by most farmers (72%) as this limits water flow and reduces discharge into the fields. Management of this problem was identified as a major challenge since farmers have little capacity to alleviate the problem. The use of heavy machinery was viewed as the only solution,

although sedimentation impacts could reduced by regular flushing. However, 45% of farmers suggested that sedimentation is actually beneficial for crop production as it includes silt (alluvial soils), which improves soil fertility and structure, thereby increasing soil water availability for crop growth.

Principle 2: Legal status and participation. The ability of WUAs to define appropriate rules and regulations and then enforce them while maintaining levels of low conflict is considered to be at the core of organizational performance (Kolavalli & Brewer, 1999). This can only be attained if a WUA has effective leadership that can provide the driving force in terms of institutional and operational management. This farmer survey revealed that almost all Gash WUAs (99%) have executive committees elected through general assembly and voting. This confirms that they have leadership governance which has been established in a legitimate way. Although leadership appointments have been transparent, the main dispute relates to the originality of the WUA concept which was initiated by IFAD in 2003. Because of this, ownership has not been part of the whole process, thereby posing a challenge for the long-term sustainability of the WUAs. Two factors relevant to performance include age and whether the impetus for organizing the WUAs came from within or as an external driver. Generally, the older established WUAs tend to be more stable than newer ones, although this does not imply that they are active. In the Gash region, the WUAs can be classified as fairly new and therefore may need time to reach maturity so that they can stabilize the operation of their activities. It is generally easier for farmers to have a sense of ownership if the WUA starts spontaneously among farmers rather than outsiders introducing the concept (World Bank, 1997).

Over three-quarters of farmers (77%) were members of a WUA; those who were not indicated that they did not see any direct benefits of membership. WUAs are strong if membership is defined, as this strengthens the relationship among members through common interests (Cernea & Meinzen-Dick, 1992; Uphoff, 1986), although it has been contested that this may not be a sufficient basis for common interests (Goldensohn, 1994). The ownership of irrigation infrastructure, including land, by the government probably contributes to the attitude of farmers regarding their participation in WUA activities. About half (54%) confirmed that their WUAs have rules and regulations on spate water usage. All farmers interviewed indicated that the rules and regulations do not have sufficiently punitive measures for defaulters. This supports findings from Kolavalli and Brewer (1999), who reported that enforcement of rules and regulations requires a credible threat of punishment if WUAs are to perform satisfactorily.

Principle 3: WUA organized within hydraulic boundaries. Most respondents (75%) confirmed that the authority of the WUA should lie within the hydraulic boundaries of the irrigation system, which is the situation observed in the GAS.

Principle 4: Water deliveries can be measured volumetrically. The survey data confirmed that most farmers (65%) in the Gash region WUAs received their water under contract from local water suppliers. However, all confirmed that the water received was not measured volumetrically. Water diverted from the Gash River is usually sufficient to meet demand; the problem is more likely to be linked to scheme management, as many farmers over-irrigate and then create water shortages elsewhere in the system. It is therefore essential that water deliveries be measured

Table 3. Key performance indicators and water user association management rating.

Key performance indicator	Assessment (%)	Rating
Leadership	34	Average
Financial management	36	Average
Resource mobilization	10	Poor
Infrastructure maintenance	36	Average
Equity in water distribution	60	Good
Resolving conflict	85	Very Good

volumetrically, as this would enhance water management thereby ensuring more water for more people.

Principle 5: WUA equitably collects water charges from members. Fees for collection have previously been reported to be of high importance in achieving efficient use of water and financial sustainability in WUAs (Dinar & Mody, 2004). Most farmers (93%) who were members in the GAS paid their water fees based on area rather than volume. However, this high response may be attributed to the existing arrangement of allocating water only to those who pay. Farmers do not have land title deeds, since they do not have permanent land rights; they move from one site to another based on the lottery for land allocation (IFAD, 2003). Some conflicts between farmers were reported over water utilization due to the breaking of bunds. Therefore, there is a need to adopt more robust measures for water utilization, such as using calibrated water levels to stop water wastage or water theft.

The six key performance indicators for the Spate Irrigation Committee included leadership, financial management, resource mobilization, infrastructure maintenance, equity in water distribution, and conflict resolution (Table 3). Based on the preceding analyses, the results for leadership, financial management and infrastructure maintenance (34%, 36% and 36%, respectively) are rated as fair. Resource mobilization (10%) is poor, while equity in water distribution and conflict resolution are good (60%) and very good (85%), respectively. These results closely reflect the situation in the GAS since resource mobilization is poor and WUAs do not seek external funding though they collect only limited funds from water fees. The community in GAS has a tribal base with an efficient system of management. Conflict resolution is therefore very good, as one tribe (Hadendowa) dominates the Gash region with 75% land allocation (IFAD, 2003). The head of the tribe is highly respected and has power to resolve conflict. The same is true of equity in water distribution. The low key performance indicators for leadership, financial management and infrastructure maintenance could be attributed to a lack of motivation, as most farmers cannot quantify the direct benefits of WUA membership.

Agrarian structure

The dominant crop, grown by 97% of farmers in the region, is sorghum, which is grown as both a main and a second-season crop. Other crops, which are grown mostly in the second season, include watermelon and vegetables. The introduction of other

high-value crops in the Gash region could enhance WUA performance. Most farmers (89%) reported that they sell their crops to local markets. Market penetration is said to boost the economic returns from irrigated agriculture, hence motivating farmers in WUA activities (World Bank, 1997). There is thus scope to organize farmers into groups to market their crops; this would also empower them to diversify and develop their marketing channels.

Key informant interviews and focus group discussions

Key informant interviews were used to validate the farmers' responses. Not surprisingly, the evidence differed between the two samples, particularly as there is disagreement and blame regarding the reasons for poor performance in the WUAs. The key informant interviews suggested that overall performance of WUAs in the Gash region is average, and that capacity building could enhance performance. Feedback from interviews with irrigation experts revealed that the management of the spate irrigation system is under control of the Ministry of Agriculture and Irrigation, the main and secondary canals are controlled by the GAS, and the Gash River is controlled by the Gash River Training Unit; *misga* are managed by each individual WUA. The Gash WUA organogram was also questioned by farmers in terms of bureaucracy as they are not in contact with the Apex WUA for administrative issues. A study in Nepal indicated that a three-level organogram of WUA contributes to the successful performance of WUAs (Subedi & Gautam, 1992). Therefore, a review of the organogram and reducing the ladder to three levels could support improvements in service delivery for the Gash WUAs.

The focus group discussions with farmers confirmed that the concept of WUAs introduced by IFAD in 2003 has had major implications for land ownership. The farmers reported that WUAs are managed by WUA executive committee members using a bottom-up approach. However, their capacity needs to be enhanced so that they know how to manage WUAs to improve performance. Furthermore, the rules and regulations need to be enforced and should include more punitive measures for those who do not respect them.

An interesting but separate issue impacting WUA performance is linked to the presence of mesquite (*Prosopis juliflora*). This hostile shrub was identified as being an important factor in decreasing the area of cultivable land available to farmers in the *misga*. Therefore, its removal and the planting of other competing species should be investigated. Key informants highlighted that farmers also have problems dealing with mesquite with respect to O&M of irrigation infrastructure.

SWOT analysis

The SWOT analysis highlighted certain strengths which should be exploited in the Gash region WUAs (Table 4). For example, most WUAs are dominated by the Hadendowa tribe, which could influence attitudes towards implementing more appropriate and fair water distribution policies, thereby reducing water allocation conflicts. Some weaknesses could be addressed by taking advantage of specific opportunities. For example, the number of defaulters on water use could be reduced if women were included in WUAs since their participation is known to strengthen WUA effectiveness. By combining information from the farmer household surveys with the key informant stakeholder data, an overall assessment of WUA performance, by principle and by irrigation block, was completed (Table 5). The performance of WUAs in the Gash

Table 4. SWOT analysis of the role of water user associations (WUAs) in water management.

Strengths	Weaknesses
Water distribution process is considered fair	No punishment for defaulters
Each farmer knows his land allocation and it is sufficient for his needs	Lack of transparent annual evaluation of WUA performance and leadership
Strong leadership of WUAs	Weak implementation of rules and regulations by other WUAs
Farmers mostly from one tribe, which promotes unity	No effective water fee collection system
Tradition of sharing benefits after crop harvest with those who didn't receive irrigation water and hence had reduced harvest	No transparency with the fees collected
Traditional laws for conflict resolution	No activities on financial mobilization
Opportunities	**Threats**
There is sufficient water to meet current and future agricultural needs	Ageing maintenance machinery
Extending the WUA election period from two to three years	Mesquite reducing cultivable land for crop production
Inclusion of women as WUA members	Spate flow reduction in Gash River resulting in reduced groundwater recharge
Strengthen relationship with government and nongovernment organizations: this could for instance help in obtain funding, materials such as machinery, and training	

Table 5. Derived Gash water user association (WUA) performance assessment indicators for four selected blocks, based on Wang et al. (2010). All figures in per cent.

Principle	Kassala	Makali	Degain	Tendelai	Average	Assessment
Adequate and reliable water supply	66	38	58	58	55	Average
Legal status and participation	58	61	40	42	50	Average
WUA organized within hydraulic boundaries	20	50	50	40	40	Poor
Water deliveries can be measured volumetrically	45	48	15	24	33	Poor
Equitable collection of WUA water charges	100	100	100	80	95	Excellent

region across all blocks is "average", but varying from poor to excellent. For Principle 1, water in the Gash region is adequate and reliable; the main problem is one of management. For Principle 2, although the legal status does not reflect current approaches used elsewhere internationally, there is at least active participation. Although in theory the WUAs in the Gash region operate within hydraulic boundaries, analysis for Principle 3 found that in practice actually most WUAs are not organized within hydraulic boundaries. For Principle 4, water deliveries are not measured volumetrically, contributing to poor overall scheme performance. The "excellent" rating for Principle 5 is attributed to farmers' being allocated land, which reflects payment of water fees; this drives farmers to make timely and regular payments. Finally, the crucial element across all these principles is the need for sound implementation of rules and regulations and for land tenure so that ownership is brought into the minds of farmers thereby motivating them to be part of the WUA.

Conclusions

This article summarizes the findings from a study to assess the performance of water user associations in the Gash Agricultural Scheme in Sudan. Using five principles to assess WUA management, the study confirmed that overall performance of 91 WUAs in the region is "average", although there is wide variation between irrigation bocks. The role of WUAs in water management is not cohesive, as there are gaps in coordination for maintaining on-farm delivery infrastructure by WUA members. Also, O&M practices in Gash WUAs are not coordinated in a systematic manner, with limited rules and regulations being implemented. Whilst the water delivery mechanism for spate irrigation schemes is unique, deliveries are not being measured volumetrically, creating problems for water allocation and accounting. Finally, there is a need for better commitment and coordination between stakeholders, including the community, project staff, management staff and the policy makers in the government sector, if performance is to be improved and long-term scheme sustainability is to be achieved.

Funding

The lead author thanks the Marshal Papworth Trust, Allan and Nesta Ferguson Trust and Cranfield University for their financial support. Thanks also to the Sudanese Government through the Spate Irrigation Project based at Hydraulics Research Centre for supporting the field visit on which this research is based.

References

Avelino, J. C. (2012). *Optimization of farm water management and agronomic practices under spate irrigation in Gash Agricultural Scheme, Sudan* (MSc Thesis WSE-HELWD-12.12: UNESCO-IHE). Institute for Water Education.

Cernea, M. M., & Meinzen-Dick, R. (1992). Design for water users associations: Organizational characteristics. In developing and improving irrigation and drainage systems. World Bank Technical Paper No. 178. Washington, DC: The World Bank.

Deribe, R. (2008). *InstitutionaL analysis of water management on communal irrigation systems: The case of Atsbi Wemberta District in Tigray Region and Ada'a District in Oromiya Region, Ethiopia* (MSc Thesis). School of Graduate Studies, Addis Ababa University, Ethiopia.

Dinar, A., & Mody, J. (2004). Irrigation water management policies: Allocation and pricing principles and implementation experience. *Natural Resources Forum*, *28*, 112–122. doi:10.1111/narf.2004.28.issue-2

Fadul Bashir, E. M., Bashir, E. E., Bushara, A. I., & Haile, A. M. (2012). Sharing the experiences among water users associations in spate irrigated schemes (Regional workshop report). Kassala: Hydraulics Research Centre.

Gash Sustainable Livelihood and Rehabilitation Project. (2008). *Mid-term review report. The Eastern Sudan rehabilitation and development fund*. Khartoum: Gash Sustainable Livelihoods Regeneration Project.

Goldensohn, M. (1994). *Participation and empowerment: An assessment of water user associations in Asia and Egypt*. Washington, DC: United States Agency for International Development, Irrigation Support Project for Asia and the Near East.

International Fund for Agricultural Development. (2003) *Republic of the Sudan Gash Sustainable Livelihoods Regeneration Project target group and project description*. Volume 1 Appraisal Report 1462-SD. IFAD Rome, Italy: The IFAD Near East and North Africa Division Project Management Department.

Kolavalli, S., & Brewer, J. D. (1999). Facilitating user particiaption in irrigation management. International Water Management Institute. *Irrigation and Drainage Systems*, *13*, 249–273. doi:10.1023/A:1006211725291

Leathes, W., Knox, J. W., Kay, M. G., Trawick, P., & Rodriguez-Diaz, J. A. (2008). Developing UK farmers' institutional capacity to defend their water rights and effectively manage limited water resources. *Irrigation and Drainage*, *57*(3), 322–331. doi:10.1002/ird.v57:3

Subedi, R., & Gautam, U. (1992). Formation of water users' organization in Nepal: A case of Mahakali irrigation project. In *Proceedings of the National Workshop on Participatory Management in Agency-managed Irrigation Systems in Nepal*, Lazimpat, Kathmandu, Nepal, 29–30 April 1992. Edited by S. R. Pant, A. Valera and U. Pradhan. No. H011543. Nepal: IWMI.

Taha, A., & Omer, M. A. (2007). Rapid appraisal of policies and institutional frameworks for agricultural water management (Sudan Country report. IMAWESA Policy Report 9). Sudan: IMAWESA.

Uphoff, N. (1986). *Improving international irrigation management with farmer participation: Getting the process right*. Boulder, CO: Westview Press.

Uysal, O. K., & Atis, E. (2010). Assessing the performance of participatory irrigation management over time: A case study from Turkey. *Agricultural Water Management*, *97*, 1017–1025. doi:10.1016/j.agwat.2010.02.007

Wang, J., Huang, J., Zhang, L., Huang, Q., & Rozelle, S. (2010). Water governance and water use efficiency: The five principles of WUA management and performance in China. *Journal of American Water Resources Association*, *46*, 4. doi:10.1111/j.1752-1688.2010.00439.x

World Bank (1997). User organizations for sustainable water services, volumes *23-354* (World Bank Paper No. 354). Washington, DC: The World Bank.

Yercan, M., Atis, E., & Salali, H. E. (2009). Assessing irrigation performance in the Gediz river basin of Turkey: Water user associations versus cooperatives. *Irrigation Science*, *27*, 263–270. doi:10.1007/s00271-008-0142-z

Zenebe, T. (2012). Sediment control and management in the diversion and main canal of Gash Agricutural Scheme, Sudan (MSc Thesis WSE-HELWD-12.20). UNESCO-IHE. Institute for Water Education.

Zwarteveen, M., & Meinzen-Dick, R. (2001). Gender and property rights in the commons: Examplesof water rights in South Asia. *Agriculture and Human Values*, *18*, 11–25. doi:10.1023/A:1007677317899