Determinants of Efficiency of Community-based Institutions for the Management of Small-scale Irrigation Systems in Northern Ghana

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Abstract
In many countries, institutional weaknesses and performance inefficiencies of public irrigation agencies as well as poor maintenance and ineffective control over irrigation practices have resulted in the collapse of irrigation systems. Evidence of the potential of local institutions to assure sustainable natural resource management has led to widespread promotion of farmer management of irrigation schemes. Although the actual outcomes of the devolution programs have been mixed, theoretical advantages and growing promotion of community-based irrigation management suggest that these institutions may be successful not only in efficient management but also equitable distribution of benefits from the schemes. In Ghana, community-based irrigation management is receiving attention as a means of increasing efficiency and sustainability of irrigation schemes. What remains unclear is the degree to which the local institutions achieve these objectives, and why some communities appear to be more successful than others. The paper examines this issue with data collected in 52 communities managing small-scale dams in northern Ghana. The results show that membership size, benefits from the scheme, training of leaders, rule conformance, sanctions for deviant behavior, resistance of landlords to land redistribution as well as ethnic homogeneity across villages sharing the use of the schemes impact on community performance. Simple flexible rules established by members, extension education and training programs on group dynamics and cooperative management as well as improved legal backing for local institutions could improve upon the performance of the community-based irrigation management institutions.

Keywords: Devolution, efficiency, institutions, northern Ghana, small-scale irrigation management

1. Introduction

Recognition of the potential of local institutions to assure sustainable resource management has motivated widespread promotion of community-based management of natural resources. This has been in response to the inefficiency of state management in the past and a general move towards decentralization and participatory approaches to development. It is thought that by increasing participation of local communities and user groups, a sense of ownership can be created whereby resource management can be improved (Engel, 2003). Growing evidence suggesting that local groups can indeed be successful in efficiently managing local commons and contribute to equitable distribution

* This research has been conducted within the research group "Determinants and effects of alternative institutions for natural resource management in developing countries." Funding was provided by the Robert Bosch Foundation and the International Water Management Institute (IWMI).

of benefits has led to widespread promotion of farmer management of irrigation systems (Meizen-Dick, 1997).

In northern Ghana, community-based irrigation management is receiving attention as a mechanism for increasing efficiency and sustainability of irrigation schemes. Leading this initiative in Ghana, the International Fund for Agricultural Development (IFAD) has funded the construction and rehabilitation of community-managed dams in the Upper East Region, under the Land Conservation and Smallholder Rehabilitation Project (LACOSREP), with ownership rights and responsibilities transferred to beneficiary communities. The success story of LACOSREP has engendered the replication of this model by other NGO and donor funded programs with irrigation components in northern Ghana. Indeed, the Ghana Irrigation Development Authority's (GIDA) new policy direction emphasizes important roles for beneficiary communities, not only in management but also in planning, designing and construction of the schemes. The idea is to instill a greater sense of ownership, and to make it possible for the resource users to gain some technical capacity in the operation and maintenance of the schemes.

Despite the appeal of local management of irrigation systems, the devolution process is not without problems. Often the outcomes are mixed, and the widespread assumption that communities and user groups will manage the systems successfully may not hold for all cases (Knox and Meizen-Dick, 2001; Shah et al, 2002). Evidently, communities in the study area differ in terms of management outcomes (maintenance efficiency, equity, etc). The devolution program implies more efforts from the user groups. So success depends on the ability of the user groups to organize successful collective action for the maintenance of the schemes. Given the widespread interest in community-based irrigation management, there is a need for the evaluation of the success of the communities in managing the irrigation schemes.

The paper aims at identifying the factors that influence the collective maintenance efforts in the community irrigation schemes in northern Ghana. For this purpose, data was collected in 2003 in the Upper East and Upper West regions in northern Ghana, through a survey of 52 community-managed irrigation schemes. Two rounds of survey were conducted. The first involved a technical evaluation of the state of the irrigation schemes to serve as the principal indicator of the user group's success in mobilizing resources for the maintenance of the irrigation facilities, using a checklist of irrigation system quality measures. The second round covered 52 communities with functional irrigation schemes. The sets of questionnaire developed for the survey covered elaborate socioeconomic information about the communities as well as the structure of the WUAs, functions, norms, and rules for distribution of costs and benefits.

The remainder of the paper is structured as follows. Part 2 provides background on irrigation management in northern Ghana. Part 3 presents descriptives on maintenance performance and hypotheses on the factors explaining differences in performance across communities. Empirical results from testing these hypotheses through econometric analysis are presented in part 4. Part 5 concludes.

2. Irrigation management in northern Ghana.

The paper focuses on community irrigation management in northern Ghana, especially the Upper East and Upper West regions. These regions are predominantly rural, and

agriculture is the main source of livelihood. High population density, erratic rainfall regimes and poor soil fertility have led to annual food shortages and a vicious cycle of poverty, as rainfed agriculture continues to fail.

The region is, however, drained by the tributaries of the Volta River as well as a large number of streams, and has a topography that is, for the most part, suitable for irrigation. Several dams were constructed as far back as the late 1950s to provide water for livestock and vegetable gardening in the dry season when much of the local population was idle with no means of livelihood. Close to 300 dams and dugouts were developed across northern Ghana with the majority in the Upper East region, which is in the forefront of community irrigation management in Ghana. Indeed, the two largest irrigation schemes in Ghana, Tono and Vea are located in the region. The scope of this paper is, however, limited to the small-scale schemes under community management, reflecting the current trend in Ghana towards smaller schemes.

In the past, the Ghana Irrigation Development Authority (GIDA) managed all the schemes. Technical officers stationed at the schemes combined the roles of construction foremen, agronomist and *de facto* managers (Ayariga, 1992). There was virtually no farmer participation in planning, construction, operation and maintenance of the irrigation systems (Dittoh, 1998). Lack of state funding and poor maintenance (in many cases complete lack of it) resulted in deterioration and a state of disrepair of many schemes.

Over the past decade, as part of poverty alleviation strategies in the region, several donor organizations, government agencies and NGOs have been involved in the rehabilitation of the old schemes and construction of new ones under farmer management. The major rehabilitation programs are the IFAD-funded Land Conservation and Smallholder Rehabilitation Project (LACOSEP) of the Upper East Region and the Upper West Region Agricultural Development Project (UWADEP). IFAD and other donor organizations involved in irrigation development in northern Ghana continue to spearhead the promotion of beneficiary involvement in planning and management as essential for sustainability of the irrigation systems.

The local unit of organization for the management of the schemes in northern Ghana is the Water Users' Association (WUA), which is responsible for operation and maintenance of the schemes, allocation of land to members, collection of water fees, and dispute resolution. Technical support, in the form of training is provided by GIDA, and the Ministry of Food and Agriculture (MoFA). A major problem facing the WUAs is in the area of land allocation, as some landlords continue to resist the land redistribution policy, which was to ensure that many members of the communities benefit from the schemes.

Past experiences of scheme collapse largely due to neglect have made maintenance of the schemes very central to the sustainability of the schemes and core to the functions of the WUAs. In the following sections we examine the maintenance performance of the WUAs and the factors that may account for the differences across schemes.

3. Maintenance performance and potential explanatory factors

The quality of maintenance the community produces depends on the ability of the WUA to mobilize labor and other resources for maintenance activities. Thus, a principal indicator of communities' irrigation management performance is the state of repair of the

irrigation infrastructure (Bardhan, 2000; Dayton-Johnson, 2000). Throughout this paper, quality of maintenance (i.e., the state) of the irrigation schemes is used as a measure of community management performance. To assess the state of the infrastructure, irrigation system inspection was conducted at each of the schemes surveyed. Specifically, a set of indicators was created through expert judgment, covering: (1) the state of the dam infrastructure (cracks in dam wall, seepage at dam toe, rip-rap on upstream slope, erosion on down stream slope, structure of spillway, inlet/outlet structures, control valves, etc.), (2) state of canals and drains (cleanliness of canals, drains, and laterals; state of slabs, etc), (3) state of the catchment area (vegetative cover; bunds; grass cover on bunds, etc), and (4) other measures undertaken by the WUA to protect the irrigation system. The state of each of the elements was ranked on a scale of 0 to 5 (very poor to excellent). The values of these categorical variables for the surveyed communities are summarized in Table 1 below.

Table 1: Distribution of key indicators of state of maintenance of the irrigation infrastructure (Percentage of communities surveyed)

Condition of ..*	V. Poor	Poor	Fair	Good	V. Good	Excellent
Dam embankment	0	4.5	41.0	28.2	24.4	1.9
Side slopes	1.9	2.5	34.6	36.6	24.4	0
Spillway	0	6.7	25.9	44.3	23.1	0
Physical structure of canal	7.7	4.8	42.3	39.5	5.7	0
Cleanliness of canals	6.7	5.8	46.2	31.7	9.6	0
Secondary canals	1.9	31.7	50.9	9.7	5.8	0
Main drain	0	29.8	58.7	11.5	0	0
Catchment area	0	5.8	28.8	51.9	13.5	0
Bunds	25.9	22.2	24.0	25.0	2.9	0

Sample size = 52.
*These measures are part of a larger set of indicators of the quality of the irrigation system
Source: Gyasi (forthcoming)

From the categorical variables a single index depicting the state of the irrigation infrastructure was constructed and translated into an ordered response framework.[1] Thus, from the quality index, a three-level ordered response ("1" bad, "2" fair and "3" good) was constructed. Based on this indicator, an Ordered Probit model specifying quality of maintenance as a function of resource attributes, community specific variables, group characteristics, institutional factors, as well as external factors was used to econometrically analyze the determinants of community maintenance performance in the local irrigation systems.

Variables such as scheme size, water supply condition, quality of the rehabilitation work, rehabilitation technique, and profitability are taken as scheme

[1] Irrigation system's quality index for scheme j was calculated using the following relationship.

$$Qindex_j = \sum_{j=1}^{n} (Score_j - Minimum\ score) \Big/ (Maximum\ score - Minimum\ score)$$

where Qindex refers to quality index, Score is the score of community j; $n(=23)$ is the number of components (indicators) evaluated; Minimum score is 23 and maximum score is 92.

characteristics. Group and community characteristics include variables such as WUA size, inequality, training of WUA executives, rule conformance, ethnicity of villages sharing use of the scheme, and landlord resistance land redistribution. Institutional variables used in the model are sanction regimes that include fines and forfeiture of rights to plots as well as rules for distributing cost and benefits, while market access and local wage are some of the external factor that can affect collective action on commons management. However, profitability, allocation rule and rule conformance are endogenous to the system. Therefore, the predicted values of these variables are used in this estimation. Table 2 defines the variables included in the regressions and provides a summary of the hypothesized direction of effects.

Table 2: Description of variables included in regression equations

Variable	Definition	Sign
Scheme size	Size of the command area (Ha)	-/+
Water shortage	1= if experienced frequent water shortages, 0 otherwise	-/+
Quality of rehab.	1= if community was satisfied with quality of rehabilitation work, 0 otherwise	+
Labor intensive	1= if scheme rehabilitation by labor intensive techniques, 0 otherwise	+
WUA size	Membership strength of water users (number of gardeners)	-/+
Training	1= if leaders received training in the past two years, 0 otherwise	+
Plot gini	Inequality measured as gini coefficient of plot sizes	-/+
Ethnic villages	1= if villages using the scheme (≥75%) are from the same ethnic group, 0 otherwise	+
Landlords resist.	1= if original landlords resisted land redistribution, 0 otherwise	-
Profitability	Average gross margin per hectare at scheme level	+
Market access	Distance to nearby market (km)	-/+
Fine	1= Penalty for breaking rules is a fine, 0 otherwise	+
Forfeiture	1= Penalty for rule breaking is forfeiture of plots, 0 otherwise	+
Wage rate	Local wage rate per hour	-
Rule violation	Non-conformance, measured by predicted probability of water poaching	-
Water alloc rule	Predicted probability of continuous flow arrangement	+

Source: Extracted from Gyasi (forth-coming)

A credible threat of sanctions is expected to have a positive impact on the quality of maintenance. Threat of sanctions such as fines and forfeiture of plot are expected to increase participation in maintenance, and hence improve the state of the infrastructure. Conversely, quality of maintenance is expected to be low where defaulters are only warned. The organizational ability of the WUA is greatly affected by its size. However, the direction of the effect of group size on the capacity of user group to undertake successful collective action is *a priori* ambiguous (see Agrawal, 2001; Baland and Plateau, 1999). Direct economic benefit constitutes one of the prime motivations for participation in collective action for the maintenance of the irrigation facility (White and Runge, 1992). Quality of maintenance is, therefore, expected to be high in scheme where farmers grow crops that give them high economic returns. A priori, water scarcity has an ambiguous effect on quality of maintenance. If water supply is abundant to the extent that no shortages occur there should be no incentive for farmers to participate in the

maintenance of the irrigation schemes. In extreme scarcity and unreliability of water supply it is hard to achieve improvements though collective action. At moderate levels, an increase in scarcity (water shortage) is expected to have a positive effect on quality of maintenance (Baland and Plateau, 1996; Tang, 1992).

Ethnicity of villages sharing the use of an irrigation scheme is used as a proxy for sociocultural heterogeneity. Social heterogeneity is often hypothesized to have a negative effect on cooperation, because differences in social norms make creating and enforcing decisions more costly (Dayton-Johnson, 2002). It is expected that quality of maintenance will be lower in schemes used communities of different ethnic backgrounds. The quality of maintenance is expected to be low in communities where landlords resisted the land redistribution policy. The noncooperative behavior of the landlords weakens group cohesion and undermines the authority of the WUA to enforce its bylaws.

The direction of effect of economic inequality is *ex ante* not clear (see for instance Agrawal, 2001; Baland and Plateau, 1999; Bardhan and Dayton-Johnson, 1999), as there are counteracting effects. On the one hand, large owners may act as leaders and engage in more maintenance themselves. On the other hand, small landowners may free ride. The effect of market access on success of local management is mixed. On the one hand, better access may increase the profitability of the scheme and the return from managing the resource efficiently, thereby favoring collective action. On the other hand, markets may make exit options (including non-farm market activities) more accessible and increase the opportunity cost of labor. Cooperation for collective maintenance of the irrigation systems is less likely where farmers are less dependent on irrigation. Two techniques were adopted in the rehabilitation of the dams studied: labor intensive (relying mainly on labor from the beneficiary communities and technical expertise of GIDA), and capital intensive (where work was done by contractors using heavy equipment). Where dam rehabilitation/construction was done by labor-intensive methods, the local communities develop a sense of ownership of the facility as the practice confers symbolic transfer of ownership. The learning effect of the labor-intensive technique improves the skills and capabilities of the WUA to undertake quality maintenance. Apart from poor works done by many of the contractors engaged in the program, the capital-intensive strategy can result in a 'charity – recipient' mentality on the part of the beneficiaries. It is therefore hypothesized that the labor-intensive technique leads to higher-quality maintenance. Higher outside wages result in higher opportunity cost of cooperation. This is especially so where there are more rewarding opportunities outside irrigation agriculture. Local wage is expected to have a negative effect on maintenance performance.

4. Results and discussion

Table **3** presents the results of the ordered probit model of determinants of maintenance quality. The results show that most of the effects are consistent with our *a priori* expectation. The results show that the quality of maintenance is high where villages sharing the use of the same scheme are of the same ethnic background. This suggests that organizing across ethnically diverse communities can impose higher costs and consequently exhibit lower levels of cooperation, *ceteris paribus*. Social norms are easier to enforce across villages of ethnic similarities. Similar findings have been reported in Dayton-Johnson (2000a) and Bardhan (2000), which suggests that cultural homogeneity enhances cooperation and promotes efficiency of local management of natural resources.

Table 3: Ordered probit estimates of quality of maintenance of the irrigation schemes

Variable	Coefficient	Standard Error	P|z|	Marginal effect of outcome (Good = 3)		
				Coef.	S.E	P|z|
WUA size	-0.00283	0.00132	0.033	-0.00079	0.00039	0.043
Plot Gini	1.39046	1.81430	0.443	0.39195	0.52145	0.452
Training	2.56449	0.88171	0.004	0.27784*	0.08104	0.001
Forfeit plot	2.16354	0.82149	0.008	0.71683*	0.19523	0.000
Pay fine	2.13047	0.68714	0.002	0.52174*	0.14960	0.000
Water scarcity	1.20402	0.52216	0.021	0.32140*	0.13671	0.019
Labor intensive	0.02927	0.38921	0.966	0.00818*	0.19048	0.966
Ethnicity of villages	1.04568	0.61646	0.090	0.23079*	0.10329	0.025
Distance to market	0.00471	0.08731	0.957	0.00133	0.02461	0.957
Rule conformance°	-2.04842	0.82215	0.013	-0.57742	0.24234	0.017
Wages per hour	-0.00055	0.00417	0.189	-0.00015	0.00012	0.182
Quality of rehab. work	-0.12845	0.50044	0.797	-0.03538*	0.13429	0.792
Landlords resist	-2.30903	0.96008	0.016	-0.25445*	0.07849	0.001
Water allocation rule°	0.10817	0.76852	0.888	0.03049	0.21610	0.888
Profitability°	0.63727	0.45723	0.163	0.17964	0.13604	0.187
_Cut 1	11.68665	6.27336				
_Cut 2	13.16610	6.31698				
No. obs	52					
LR χ^2 (15)	38.86					
Prob > χ^2	0.0007					
Pseudo R^2	0.3403					

(*) dy/dx is for discrete change of dummy variable for 0 to 1
(°) Predicted variables

Group size term has a negative and statistically significant effect on the quality of maintenance. The result indicates that quality of maintenance is low in larger groups. This is consistent with Olson's (1965) group size hypothesis. Though not statistically significant, the coefficients of the variable representing economic inequality (inequality in land holding) indicate a positive effect of inequality on community maintenance performance. The coefficient of the variable for labor intensive technique is positive, but insignificant in inducing cooperation for collective action. The directions of effect of all the coefficients of the institutional variables are positive, and are statistically significant (see also Gyasi et al., 2004). These support our hypotheses that sanctions such as payment of fines or loss of opportunity to farm (forfeiture of plots) for failing to participate in collective maintenance activities and promotes greater maintenance participation and hence higher-quality maintenance. This backs existing results from field and experimental studies which conclude that without effective institutions common-pool resources will not be sustainably managed (see for instance, Larson and Bromley, 1990; Ostrom et al., 1994; Tang, 1992; Bromley et al., 1992).

The results indicate that training improves capacity and significantly improves the quality of maintenance. Quality of maintenance is high for schemes where leaders receive frequent training. Continuous post-rehabilitation training support to the WUA enhances group cohesiveness and cooperative behavior required for successful collective action.

The coefficient of the variable representing water shortage shows a positive and statistically significant effect on the quality of maintenance of the schemes at the community level. This shows that communities that do not experience water shortages may not be serious with their maintenance schedules. Implicitly water shortages induce the user groups into action, especially in communities with past experience of hardships resulting from water scarcity that resulted from the collapse of the schemes.

Resistance of original landowners to land redistribution has a negative and significant impact on the quality of maintenance. The results support our initial assumption that quality maintenance is low in community schemes where landlords resisted the land redistribution policy. Apart from undermining the authority of the WUA, the noncooperative behavior of landlords could have a negative effect on group cohesion and unity required to organize successful collective action. Quality of rehabilitation work done by contractors does have a significant effect on quality of maintenance. But the direction of effect is opposite to the impact that would be consistent with our *a priori* expectation. The result is also inconsistent with the effect of community perception about quality of rehabilitation work on household decision to participate in collective maintenance activities, as established in Gyasi et al. (2004). It, however, appears that the user groups have been able to improve the quality of the schemes that were perceived to be poorly done through collective action.

As expected, local wages negatively affect the quality of maintenance of the irrigation schemes, although the effect is only significant at the 19% level. Although not statistically significant, distance to markets is positively related to maintenance quality implying increased access to markets leads to decreased quality of maintenance. As stated earlier, this is likely to be due to the fact that increased exit options that become available as a result of market access may reduce reliance on the irrigation facility and for that matter reduce commitment towards the sustainability of the schemes. The low level of significance may, however, be due to the potential counteracting effects described earlier. Profitability has a positive impact on quality of maintenance, although only significant at the 16 per cent level We find that quality of maintenance is higher in profitable schemes because of the economic interests at stake. This supports the assumption that the viability of the irrigation scheme is an important factor that conditions participation and success of cooperative management of the schemes. If farmers do not make enough money from irrigation they may not pay fees or contribute effort towards maintenance, and if the WUAs cannot collect enough fees or mobilize enough labor they will not be able to carry out the operation and maintenance tasks efficiently. The variable representing rule conformance has significant impact on the quality of maintenance of the irrigation schemes. That is, frequent violation of rules governing the management of the schemes has a negative effect on the ability of user groups to achieve successful collective action for the maintenance of the community irrigation schemes. Thus, quality of maintenance is poor where rules are frequently violated. Water allocation rules on the other hand did not have a statistically significant effect on quality of maintenance.

5. Conclusions

The analysis presented in this paper suggests that frequent training of group leaders on operation and maintenance techniques is very essential for improved quality of

maintenance to ensure sustainability of the irrigation schemes. Quality of maintenance is high in profitable schemes, as higher returns induce greater participation by group members in collective maintenance activities. Socio-cultural (ethnic) homogeneity also promotes collective action and for that matter efficient management of the schemes. Quality of maintenance is higher where villages sharing use of the same scheme are of the same ethnic identity. The results also conclude that higher outside wages (and exit options in general) reduce quality of maintenance. Rule conformance plays a very important role in efficient local management.

Local regulatory mechanisms elicit cooperation for collective action in the management of the irrigation schemes. Graduated sanctions are significantly associated with high levels of rule conformance and of efficient management. In particular, monitoring and sanctioning limit free-riding and provide incentives for members to fulfill their commitments to the maintenance of the scheme.

It is essential that farmers enforce bylaws and regulations, strengthen monitoring and evaluation mechanisms to ensure efficient and sustainable management. Policy measures that facilitate the development of local institutions could enhance the ability of local organizations to sustainably manage their resources. Enactment of legislation recognizing the WUAs as the legitimate users and managers of the irrigation systems will go a long way to promote legitimacy and efficiency of the local organizations.

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