

**Collective Action in Canal Irrigation Systems Management:
The Case of Doho Rice Scheme in Uganda**

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ABSTRACT

Devolution of natural resource management (NRM) from governments to user groups has often been justified on the basis that local users have comparative advantage and self-interest over government agents in managing and monitoring such resources. The Uganda government is transferring the management and responsibility of the Doho Irrigation Rice Scheme (DRS) responsibility to the Doho Rice Scheme Farmers' Association. The success of such a transfer is highly dependent on the ability and willingness of the farmers to organize into a successful collective action.

This study examines the extent and determinants of farmer participation in the collective maintenance of DRS and compliance in paying mandated irrigation fees. Existing regulations and incentives for participation in collective action are also examined. Data used came from a household survey of 411 rice producers that were selected using a stratified random sampling technique. Descriptive statistics are used to analyze the existing regulations and incentives for participation in collective action while determinants of compliance are analyzed using an ordered Logit model.

Results indicate that poor awareness of an irrigation fee payment bylaw, poor enforcement of the bylaw, and perceptions among farmers that the cost of involvement in DRS is higher than the benefits diminish compliance with the fee payment. Regression results show significant positive relationship between participation (compliance with the bylaw) and a high share of income from rice, households headed by males, participation in training on soil and water conservation, ownership of other crops besides rice, access to credit, higher dependency ratio, houses with cemented floor and ownership of certain kinds of rice plots. Compliance is negatively associated with land tenure security, the number of rice plots held by a farmer, experience in rice farming, which, respectively, are factors closely related to education, influence (or leadership), and perceptions that cost of participation exceeded the benefits.

These results suggest that households with a greater dependency on rice for income are more likely to comply with the bylaw and that having alternative sources of income, besides rice farming, enhance compliance. The negative relationship between compliance and the perception that costs of participation in collective action exceed benefits suggests

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a need to increase irrigation water supply to rice plots to motivate greater compliance. To increase compliance and the amount of fees collected to make DRS self-sustaining, there is also need to improve farmers' awareness of the bylaws and strengthen enforcement.

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I. Introduction

Uganda's agriculture is largely rain-fed. But rainfall is becoming increasingly unreliable, reducing crop yields and increasing food insecurity (Pender et al., 2001). Therefore, irrigation is considered one option for enhancing agricultural production. Whereas in the past many sub-Saharan Africa governments provided subsidized agricultural inputs and services in controlled-market environments, today there is a policy shift towards devolution of such services, including the management of natural resources from governments to user groups on the premise that local farmers will have comparative advantage over the government in monitoring and managing such resources through collective action (Meinzen-Dick, et al., 2000).

There are many examples of successes and failures of collective action due to either the absence or breakdown of institutions needed for successful collective action (Baland and Platteau, 1996; Bromley, 1992; Ostrom, 1990; Ostrom, 1992; Runge, 1981; Sarris and Tinios, 1994; Sarris and van den Brink, 1993). When governments fail to effectively manage natural resources, it is not given that resource-users will automatically take over and successfully management the resources, especially if such transfer of responsibility is accompanied by more demand on their time and money (Meinzen-Dick, et al., 2000). There is, therefore, a need to examine the willingness of resource-users' to participate in such collective action because it is critical for the effective implementation of the devolution policy and the development of supporting policies to sustain the collective action in user-managed natural resource systems.

The objective of this study is to determine the extent of farmers' participation in the collective action of maintaining the Doho Rice Irrigation Scheme (DRS) canals after the transfer of the responsibility from the government, and to identify factors influencing farmers participation and compliance with a user-fee payment bylaw. The study was conducted at the DRS in Tororo District, Uganda through a survey of 411 households that produced rice in the first or second crop seasons in 2001. The study is organized as follows: section 2 presents the history of rice production and management of the DRS irrigation system. Section 3 discusses the research questions and methodology used while section 4 presents the research findings. Section 5 concludes the report and highlights some policy implications.

II. History of Rice Production and Management of DRS

Rice production in Doho swamp started in 1942 to feed World War II soldiers. After the war, production declined until 1972 when the government committed to revitalize rice production. However, several constrained this effort including flooding of River Manafwa, scarcity of irrigation water during the dry season, pests and diseases, and lack

of high-yielding varieties (Ogwang, not dated). In 1974, the farmers appealed for government intervention and the latter bought the Doho Swamps and constructed a rice irrigation scheme with help from Chinese experts between 1976-1985.

The objectives of DRS were to popularize rice production, provide irrigation water and supply farmers with improved seeds, farm tools, and marketing and milling services. The government demarcated the land and allocated plots to individual farmers. After Phase II of the project was completed in 1989, the Chinese experts transferred the DRS management to the Ugandan government.

The DRS has a total area of 2,500 acres, out of which 2,380 acres are cultivable and are partitioned into six blocks. A chairman, who also has the responsibility of cleaning irrigation canals, maintaining roads and collecting irrigation user-fees from farmers manages each block. Strip leaders in-charge of 20-acre land-strip assist the chairman while an executive committee, elected by the farmers, and technical staff runs the whole scheme.

The irrigation water used by farmers at DRS comes from River Manafwa, which originates from Mt. Elgon. Its main stream is 70 km long and covers a catchment area of 570 km², where much agricultural activities take place and deposit silt into the river and irrigation canal, reducing the amount of water supplied and rice yields as irrigation canals get silted. In the past, the canals were regularly de-silted by the Uganda government. But starting in the late 1980s, the government withdrew its direct provision of agricultural inputs and services and maintains only payment of staff salaries. As a result, the government's contribution to DRS reduced drastically and the silting of irrigation canals worsened.

In January 1994, heightened concern about reduced efficiency of the irrigation system (manifested in reduced water conveyance) prompted the DRS management to call a high level meeting, which included local and district authorities, to identify means of resolving the problem. A decision was made for farmers to pay an irrigation user-fee of Ushs 5,000 per acre per season, and a committee was set up to collect the funds and execute the de-silting. The de-silting exercise started in May 1994 using hired but was halted in November 1994 due to shortage of funds due to misappropriation and non-compliance of some farmers with the user-fee payment. In December 1994, the DRS farmers formed an association, the Doho Rice Scheme Farmers' Association, to which the government is in the process of devolving responsibility of managing the scheme.

³ Farmers in the DRS have an edge over their counterparts outside the scheme in that they can produce two crops of rice in year—thanks to the irrigation system—compared to one crop a year for those outside DRS whose production is entirely dependent on rain.

⁴ The practice of renting the excavator was later abandoned after the scheme's excavator was repaired.

III. Objectives, Data and Methodology

Objectives

This study addresses three main questions. First, what are the existing incentives (benefits) for participation in collective action or payment of irrigation user-fees at DRS and what extent does this motivate collective action? Second, how effective is enforcement of existing bylaw on user-fee payment? Lastly, why do some farmers comply with the bylaw and others do not?

Data

The study used data from 411 households selected using a stratified random sampling technique from among DRS rice-producers in 2001. Participation in collective action is measured by degree of compliance with the bylaw requiring all DRS farmers to pay the irrigation user-fee. Surveyed households were then grouped into three groups based on level of compliance (none, partial and full-compliance).

Fourteen households (<4%) did not comply with the by-law and never paid any user-fees for either the first or second crop season in 2001. 128 households (30%) partially complied, that is paid the user-fees for one of the two crop seasons in 2001 for at least one of the plots. 269 households complied fully, paying user-fees for all their plots in both seasons in 2001.

Methodology

Descriptive statistics were used to address the first two study questions on incentives and enforcement of participation in the DRS collective action. An Ordered Logit Model (OLM) Regression was used to address the third study question, with an ordinal measure of compliance being constructed from three levels of compliance (none, partial and full) and this was used as the dependent variable (Long, 1997). The OLM is specified as:

$$y^* = X'\beta + \varepsilon$$

$$y = 1 \text{ if } y^* < b_1$$

$$y = 2 \text{ if } b_1 \leq y^* < b_2$$

$$y = 3 \text{ if } y^* \geq b_2$$

where:

y^* is the unobserved continuous variable measuring the net benefit of complying, which predicts the observed degree of compliance $y = 1, 2, 3$

X is a vector of explanatory variables

ε is the unobserved error term that is assumed to be normally distributed

b_1 and b_2 are parameters and β is the “true” vector of parameters estimated in the regression analysis.

⁵ Assurance in this context refers to credible guarantee that if one contributes their share towards provision of the public good, others will reciprocate. Because no individual farmer can solve the siltation problem by themselves through payment of their share (irrigation fee) without others contributing, it is only rational to wait until one is sure that others will contribute their share before making a contribution.

VI. Variable Selection and Hypotheses

Perceived direct economic benefits from de-silting and increases in irrigation water supply motivate irrigation fee-payment as a collective action. The amount of irrigation water available is directly proportion to the distance of field plot from irrigation canals, with an inverted U-shaped relationship between water scarcity and participation in collective action (Meinzen-Dick et al., 2000; Bardhan, 1993). As a result, farmers receiving plenty of water tend not to be active participants and the same applies to those expecting too little water.

Land ownership or tenure security promotes conservation of natural resources such as land and water (Pender et al., 2001). Most farmers at DRS own their land but others lease, borrow or sharecrop their land. The latter regard payment of rental and irrigation fees as incentives to retain access to the land. In other words, compliance guarantees access to land. But weak bylaws and poor enforcement may compromise that relationship such that the effect of land ownership on participation becomes ambiguous.

Wealth or asset endowment might reduce the incentive to participate in collective action (White and Runge, 1992). This is especially true when wealth provides alternative investment choices. Also, some wealthy farmers lease-out or sharecrop their land, making them unlikely to participate in the collective action (White and Runge, 1992). But wealth may also enhance participation in collective action through greater access to technology, land or other services. Wealth also facilitates fee-payment where cash-contributions are made, increasing participation. Thus, the wealth status of a household has an ambiguous effect on participation in collective action.⁶

Age of household head, as proxy to experience in rice production, is ambiguous because older farmers are expected to have better understanding of the consequences of non-compliance with irrigation fees payment. But this experience may make them more or less willing to comply, depending on whether the experience has been good or bad. Also, since older and more experienced farmers grew rice when the government bore the cost of de-silting canals, they are likely to be more resistant to the new fee arrangement and fail to comply.⁷

Education directly influences adoption of improved technologies. Combined with *influence and external recognition*, education enhances successful organization towards collective action (Meinzen-Dick et al., 2000). However, because it also increases people's opportunities outside agriculture, education may lower participation in collective action (Nkonya et al., 2001). On the other hand, educated farmers may have other non-agricultural income sources that make it easier for them to pay the irrigation user-fees, enhancing their participation in the collective action, as do households with *alternative major income sources* rather than rice-production.

Agricultural training and extension on soil and water conservation increases farmers' awareness of siltation problems and appreciation of the need to pay the user-fees

⁶ Six variables were used to proxy wealth: number of rice plots owned; total area of land owned; value of oxen owned; value of other livestock owned; owns a cemented-floor house; and owns metal-roofed house. Only number of rice plots owned and owns cemented-floor house were used in the regression analysis.

⁷ Because age and experience in rice growing are highly correlated, only experience is used in the regression model.

to overcome the problem. A *high dependency ratio* translates into a higher subsistence burden and less money to pay user-fees. *Female-headed households* tend to have limited access to services and resources, and are less likely to pay the user-fees, although they may be hard-pressed to participate as custodians of food security. A *high share of a household's food and income from rice* will likely enhance participation in collective action aimed at increasing irrigation water supply and rice output. *Access to credit* and *farmers' savings* will enhance the ability to pay user fees.

IV. Results and Discussions

From Descriptive Statistics

Table 1 shows that nearly all (99%) of all DRS farmers reported irrigation water as their greatest benefit from DRS, followed by extension and technical advice (50%). Rice milling (41%) and rice marketing (22%) were also considered potential benefits, though these are services offered directly by DRS. There was no significant difference between these proportions across the three categories of compliance.

Table 1: Benefits received by rice farmers from DRS and farmers' perception of these benefits relative to costs

Benefit/service	% Households reporting			
	All HHs N = 411	Category 1 N = 14	Category II N = 128	Category III N = 269
Irrigation water	98.5	100.0 ^a	99.2 ^a	98.14 ^a
Rice milling	40.87	21.43 ^a	41.41 ^a	41.64 ^a
Extension and technical advice	50.36	50.0 ^a	54.69 ^a	48.33 ^a
Marketing/collection center	22.38	14.29 ^a	21.88 ^a	23.05 ^a
Perception of benefits in relation to costs				
<i>First season</i>				
B<C	20.4	28.57 ^a	17.97 ^a	21.19 ^a
B=C	11.9	7.14 ^a	14.84 ^a	10.78 ^a
B>C	67.6	64.29 ^a	67.19 ^a	68.03 ^a
<i>Second season</i>				
B<C	26.7	42.86 ^a	30.47 ^a	24.16 ^a
B=C	13.3	7.14 ^a	18.75 ^a	11.15 ^a
B>C	59.9	50.0 ^a	50.78 ^a	64.68 ^a

N=Number of households reporting. Different superscripts mean statistically significant differences across categories

Table 1 also shows that most DRS farmers (68% in first season and 60% in second season) perceived that the benefits they derived from DRS outweighed the costs they incurred, which included payment of user-fees and additional labor supplied to de-silt the irrigation canals when funds were insufficient. The proportion of those perceiving the benefits were lower than the costs was 20% in the first season and 27% in the second season; and those perceiving the benefits to be equal to the cost constituted 12% and

13%, respectively. Between one-fifth to one-quarter of farmers perceived that the benefits derived from DRS were not worth the cost incurred. This perception was a disincentive to paying the user-fee, with one-third of the farmers failing to comply fully with the bylaw.

Most farmers felt benefits from DRS, save for marketing⁸, had deteriorated in the past 10 years, with supply of irrigation water and provision of extension/technical advice being most affected (Table 2). They blamed the former on a frequent breakdown of the DRS excavator and resultant siltation of the canals and reduction of the amount of water supplied (Table 3). Inadequate water supply led to lower rice yields and inability of farmers to comply with the user-fee payment (Tables 4, 5, 6 and 7). Other reasons cited for non-payment included inadequate income and low or lack of rice harvests (Table 7).

Table 2. Perceived change in benefits/services derived from DRS in the past 10 years.

Benefit/service	% HHs reporting improvement	% HHs reporting Deterioration.
Irrigation water (N = 375)	1.9	98.1
Rice milling (N = 122)	41.8	58.2
Extension and technical advice (N = 156)	17.3	82.7
Marketing/collection center (N=37)	56.7	43.2

N=Number of households reporting.

Table 3. Reasons for deterioration in benefits derived from DRS

Benefit/reason for deterioration	% HHs reporting
<i>Irrigation water (N = 350)</i>	
Breakdown of excavator/increased siltation of irrigation canals	73.1
Change in rainfall pattern	17.4
<i>Rice milling (N = 64)</i>	
Depreciation and poor maintenance of the private milling machines.	95.3
<i>Extension and technical advice (N = 110)</i>	
Lack of facilitation/motivation of DRS administration.	28.18
Lack of commitment and coordination of DRS administration.	27.27
Reduced number of extension staff following government withdrawal from DRS and retrenchment in the civil service sector	41.8
<i>Marketing/collection center (N = 11)</i>	
Low prices of rice	54.5
Low quality of rice attributed to old milling machines.	36.4

N=Number of households reporting.

⁸ The reason why farmers perceive marketing services to have improved could be attributed to the government policy of market liberalization.

Table 4. Adequacy of irrigation water received by household in the first and second seasons of 2001.

Adequacy of irrigation water received	% Households reporting (N=411)	
	First season	Second season
Received adequate water throughout the season	85.4	48.2
Received adequate water part of the season and inadequate water the other part	12.9	24.1
Received inadequate water throughout the season	7.5	31.4
Received inadequate water part of the season and no water at all for the other part	1.9	8.3
Received no water at all throughout the season	1.2	5.6

N=Number of households reporting. The figures add up to more than 100% because some respondents had more than one plot of land.

Table 5. Correlation between adequacy of irrigation water received on rice plot and yield.

Adequacy of irrigation water received	Correlation with rice yield	
	First season (N=614)#	Second season (N=589)#
Received adequate water throughout the season	0.098**	0.091**
Received adequate water part of the season and inadequate water the other part	-0.036	0.005
Received inadequate water throughout the season	-0.046	-0.039
Received inadequate water part of the season and no water at all for the other part	-	-0.022

#N=Total number of plots used in the analysis **=Correlation is significant at 5% level of significance

Table 6. Rice yields and payment of irrigation fees

Season	Average Yield (Kgs/Acre)			
	All Plots	Category I	Category II	Category III
First season	1474.6	1394.3 ^{ab}	1387.9 ^a	1516.2 ^b
	(31.25)	(148.9)	(62.4)	(36.5)
	N=614	N=15	N=185	N=414
Second season	1570.8	1562.7 ^{ab}	1445.9 ^a	1634.9 ^b
	(32.78)	(86.1)	(57.3)	(42.6)
	N=589	N=34	N=187	N=368

N=Total number of plots used in the analysis. Numbers in parentheses are standard errors
Different superscripts mean statistically significant differences across categories.

Table 7. Reasons Given by farmers for not paying irrigation fees.

Reason	% Households reporting	
	First season	Second season
Received inadequate or no water at all.	13.3	16.7
Service for which fee was collected was not provided in previous season.	11.1	5.6
Did not have enough money	22.2	15.1
Irrigation fee was not collected from the farmers	15.6	15.1
Belief that had to pay in only one season	13.3	17.5
Had poor or no rice harvest at all	2.2	7.1
Had not yet harvested (pays after harvesting)	2.2	8.7

* In this particular case N exceeds the actual number of farmers/households that didn't pay irrigation fees because some respondents gave more than one reason for not paying irrigation fee.

There is a bylaw against non-payment of irrigation fees and defaulters lose their plots in the following season. 45 percent of the farmers ranked the fee collection procedure as unsatisfactory (Table 8). Flaws in the collection methods could be a reason why some farmers failed to pay their fees. But it was also evident that only about one-quarter of the farmers understood the correct interpretation and penalty of the fee-payment bylaw, a fact that could influence compliance (Table 9). There is a need, therefore, for more education to make sure everybody understands the bylaw.

Table 8. Farmers' perception/ranking of the irrigation fee collection procedure.

Ranking	% Households reporting	
	First season	Second season
Very well	1.6	1.0
Well	53.9	50.9
Fairly well	27.6	31.1
Poor	15.3	14.9
Very poor	1.6	2.1

Nkonya et al. (2001) observed that it is difficult to effectively enforce bylaws and restrictions that are not clear to farmers. Besides, poor and selective enforcement of the bylaw, evident in Table 10, perpetuates non-compliance. Three-quarters of the farmers rated the current DRS administration poor to fair, mainly as a result of poor maintenance of irrigation facilities and corruption (Table 11 and Table 12). These administrative weaknesses result in inadequate fee collection, irrigation canals not being de-silted well, less water supply, poor rice harvests and a vicious cycle between reduced irrigation water and non-payment of fees. Without a guarantee of adequate irrigation water supply, it may be difficult to enforce the fee payment. Hence, there is need to rehabilitate the entire irrigation system and institute proper management procedures before handing it to the farmers.

Table 9. Farmers' knowledge/awareness of penalty for non-payment of the irrigation fees.

Perception	% Households (N=360)
Plot withdrawn from defaulter for two seasons	56.7
Plot withdrawn from defaulter for one season	25.0
Plot withdrawn for unspecified period	13.1
Defaulter is fined Ushs 2000	1.7
Defaulter fined Ushs 1000	0.8
No penalty	0.3
Defaulter is given warning	0.8
Plot withdrawn for three seasons	0.6
Plot withdrawn for ever	0.6
Plot withdrawn till farmer complies	0.6

Table 10. Categories of defaulters that usually go unpunished

Defaulter category	% Households reporting (N = 112)
Relatives of enforcers	28.6
Friends of enforcers	33.0
Enforcers themselves (DRS administration)	26.8
Rich/influential individuals	7.1

Table 11. Farmers' perception/rating of performance of current DRS administration.

Rating	% Households reporting (N = 411)
Very good	0.5
Good	25.5
Fair	17.3
Poor	48.2
Very poor	8.5

Table 12. Reasons for poor to very poor job rating of DRS Administration.

Reason	% Households reporting	
	Poor (N=198)	Very poor (N=35)
Poor inspection and maintenance of irrigation canals to ensure adequate water supply.	42.4	20
Lack of commitment/Giving priority to private issues and neglecting administrative ones	5.6	5.7
Not paying attention to farmers' problems.	9.6	17.1
Poor accountability/high level of corruption/ lack of transparency	29.8	31.4

N=Number of households reporting.

Table 13. Methods of land acquisition

Method	% Households reporting			
	Entire Sample (N=411)	Category 1 (N=14)	Category II (N=128)	Category III (N=269)
Purchase	34.1	35.71 ^a	32.81 ^a	34.57 ^a
Gift/inheritance	40.4	28.57 ^a	43.75 ^a	39.41 ^a
Government/DRS administration	38.4	50.0 ^a	35.16 ^a	39.41 ^a
Rented in	7.1	0.0 ^a	6.25 ^a	7.81 ^a
Borrowed	0.7	-	-	-
Share-cropped in	0.2	-	-	-

(-) Test for differences in proportions not conducted because of very few observations.

Different superscripts mean statistically significant differences across categories

Note: The column % add up to more than 100% because there are households with more than one plot, each plot acquired through different means.

Table 14. Measures of wealth status of a household.

Asset category	Entire sample	Category 1	Category II	Category III
Average number of plots of land owned in DRS	1.6 (0.042) (N=411)	1.93 ^a (0.322) (N=14)	1.60 ^a (0.076) (N=128)	1.58 ^a (0.05) (N=269)
Average total area (acres) of land owned at DRS	1.27 (0.054) (N=411)	1.74 ^a (0.433) (N=14)	1.28 ^{ab} (0.096) (N=128)	1.25 ^b (0.065) (N=269)
Average value (Ushs) of oxen owned	571,750 (53,698) (N=40)	725,000 ^a (575,000) (N=2)	634,546 ^a (106,621) (N=11)	534,815 ^a (59,118) (N=27)
Average value (Ushs) of other livestock assets owned	427,296 (34,875) (N=366)	412,250 ^a (195,040) (N=12)	480,982 ^a (82,612) (N=119)	400,879 ^a (33,337) (N=235)
% HHs with main residential house having a metal roof	63.3 (N=406)	71.4 ^a (N=14)	59.8 ^a (N=127)	64.5 ^a (N=265)
% HHs with main residential house having a cemented floor.	16.0 (N=406)	28.6 ^a (N=14)	14.2 ^a (N=127)	16.2 ^a (N=265)

*Different superscripts mean statistically significant differences across categories

There is no means to blocking water supply to individual defaulters, making it hard to enforce the fee-payment bylaw. Elsewhere, successful collective action was strengthened by effective enforcement that enabled administrators to cut-off water supply or impose a penalty to non-complying farmers. For instance, Meinen-Dick et al. (2000) found that farmers in India absenting themselves from communal activities had to pay a penalty of 30-60 rupees per day per person. If a farmer refused to pay, the users' group stopped water supply to their plots and doubled the penalty, increasing compliance. In DRS, there are no such mechanisms. Most DRS farmers own their land so that threatening to withdraw their plots is not effective, except to those who rent or borrow land (Table 13). Therefore, tenure security acts as a disincentive to enforcement and compliance. There is need for alternative, innovative compliance-enhancing mechanisms.

The wealth status of a household was measured using six variables: number of plots, total land area, value of oxen, value of other livestock, having cemented-floor house and having a metal-roofed house (Table 14). Among all these variables, only total land area significantly differs between non-complying, partially complying and full-complying farmers. Table 15 shows that education of household head, dependency ratio and share of household income from rice vary significantly between the different household categories.

Table 15. Other socio-economic variables influencing participation in collective action.

Variables	Entire sample (N=411)	Category 1 (N=14)	Category II (N=128)	Category III (N=269)
Average age of HHs head	45.99 (0.690)	51.29 ^a (4.241)	45.81 ^a (1.172)	45.80 ^a (0.868)
Experience (years) of growing rice at DRS	18.69 (0.428)	18.79 ^a (1.902)	19.50 ^a (0.794)	18.30 ^a (0.525)
Education (years) of HH head	5.79 (0.190)	7.14 ^{ab} (1.13)	6.41 ^a (0.312)	5.42 ^b (0.240)
% Male headed households	94.2	92.9 ^a	95.3 ^a	93.7 ^a
Dependency ratio	2.18 (0.062)	2.38 ^{ab} (0.230)	1.98 ^a (0.105)	2.27 ^b (0.080)
% HHs received agricultural training on soil and water conservation	3.6	0.0 ^a	4.69 ^a	3.35 ^a
% HHs that received extension visits in 2001 on the subject of irrigation water management.	3.4	0.0 ^a	3.91 ^a	3.35 ^a
Average Number of extension visits received in 2001 on the subject of irrigation water management.	2.71 (438) (N=14)	-	2.80 ^a (0.860) (N=5)	2.67 ^a (0.527) (N=9)
% HHs participating in programs and organizations whose main activity is agricultural training.	4.14	0.0 ^a	3.91 ^a	4.46 ^a
% HHs with salary/wage employment as the most important income source	5.84	14.29 ^a	5.47 ^a	5.58 ^a
% HHs with sale of crops other than rice as the most important income source.	3.16	0.0 ^a	1.56 ^a	4.09 ^a
% HHs with sale of rice as the most important income source	81.8	78.57 ^a	83.59 ^a	81.04 ^a
% HH income contributed by rice	62.13 (0.012)	55.9 ^{ab} (0.083)	59.1 ^a (0.020)	63.9 ^b (0.015)
% HHs food consumption contributed by rice	22.53 (0.008)	18.79 ^a (0.056)	23.71 ^a (0.013)	22.16 ^a (0.010)
% HHs applied for credit from formal sources in 2001	14.1	7.14 ^a	13.28 ^a	14.87 ^a
% HHs applied for credit from informal sources in 2001.	46.0	71.43 ^a	42.19 ^b	46.47 ^b
% HHs saved by keeping money in bank or at home in 2001.	46.0	42.86 ^a	46.88 ^a	45.72 ^a
% HHs saved by buying capital assets or re-invested surplus money immediately in income generating activity.	43.8	50.0 ^a	42.97 ^a	43.87 ^a

Different superscripts mean statistically significant differences across categories.

(-) Test for differences in proportions not conducted because of very few observations.

Numbers in parentheses are standard errors; N=Number of households reporting.

Results from Regression Analysis

Table 16 presents the description of variables used in the regression analysis. Because income share of rice is endogenous, its inclusion in the model explaining participation in collective action would likely produce biased estimates because of its high correlation with the error term. To solve this problem, a two-step approach is used: the first step estimates an Ordinary Least Squares (OLS) regression model of determinants of the household income share of rice (Table 17). The results of this regression indicate that number of plots owned (wealth) and compliance are significantly and positively related to the household share of income from rice. The results also show that education, gender, value of livestock, savings, access to credit, crop income (rather than from rice) and wage income are negatively related to the household share of income from rice.

Predicted values from the OLS regression in Table 17 are then used together with other exogenous variables as regressors in the Ordered Logit Model (OLM) explaining participation in collective action (Table 18). The regression results show significant positive relationships between participation in collective action and the predicted values of household income share of rice, male-headed households, household dependency ratio, training on soil and water conservation, cemented-floor house, crop income (rather than rice) and access to credit. There are significant negative relationships between participation in collective action and number of rice plots, tenure security, experience in rice farming and perception that costs of participation exceed the benefits.

IV. Conclusions and Policy Implications

Regulation and incentives are some of the strategies used by policy makers to address natural resource management problems, particularly those requiring collective action (Abler and Shortle, 1991). Direct economic benefits are the prime motivation for participation in collective action (White and Runge, 1992). Thus, participation in collective maintenance of the DRS could be enhanced by improvement in the delivery of services or benefits that farmers derive from the scheme. These benefits include irrigation water supply, rice milling services, extension and technical advice and using DRS as a marketing/collection center for rice.

Since several private entrepreneurs constructed milling plants at, and around, DRS, farmers now benefit from better access to these private milling services than their counterparts outside DRS. Also, because of a large population of rice farmers who collectively produce and mill rice at DRS, many rice traders converge there to buy rice, making DRS serve as a rice marketing or collection center. DRS farmers can produce two or more crops compared to their non-DRS counterparts because of the irrigation water. Additionally, DRS's technical staff provides extension and technical services on rice growing, irrigation water management and soil and water conservation, improving the knowledge and management of DRS farmers.

Table 16. Description of explanatory variables used in the regression models

VARIABLE	DESCRIPTION
% RICEINC	Proportion of household cash income contributed by rice in 2001.
TRNSWC	Training in soil and water conservation =1 if household received training; 0 otherwise.
WAGINC	Salary/wage income =1 if salary/wage income is most important income source for the household; 0 otherwise.
CROPINC	Crop income =1 if sale of crops other than rice is the most important income source for the household; 0 otherwise.
FMCRTD	Access to formal credit =1 if household applied for credit from at least one formal credit source; 0 otherwise.
DEPRAT	Dependency ratio = Number of children and adult dependants who don't produce enough for their subsistence/Number of working adults in the household.
DISTCNL	Average distance (kms) from the main irrigation canal to the rice plot(s) operated by the household in 2001.
SQDISTCNL	Square of the average distance (kms) from the main irrigation canal to the rice plot(s) operated by the household in 2001.
TENSEC	Tenure security =1 if household owned at least one of the rice plots it operated at DRS in 2001; 0 otherwise.
#PLOTS	Number of separate rice plots owned by the household at DRS
EXPRICE	Experience (number of years) in rice growing at DRS
EDUHH	Education (Number of years of schooling) of household head.
GENDHH	Gender of the household head =1 if Male; 0 otherwise.
VALVSTK	Value (Ushs) of livestock (cattle and oxen) owned by the household at end of 2001.
EXTWAT	Total number of extension visits received by the household in 2001 on the subject of irrigation water management.
CMTHSE	Cemented House =1 if main residential house had a cemented floor; 0 otherwise.
SAVCASH	Savings in form of cash =1 if household's primary form of saving was keeping cash with bank or at home; 0 otherwise.
SAVCAP	Saving in form of capital assets, merchandise or agricultural produce =1 if the household's primary form of saving was purchase of assets, merchandize or agricultural produce for re-sale; 0 otherwise.
INFMCRTD	Access to informal credit =1 if household applied for credit from at least one informal source; 0 otherwise.
RICEFOOD	Importance of rice as a subsistence crop =1 if rice is a major subsistence crop (constitutes 50% or more of household food consumption); 0 otherwise.
AGTRNORG	Agricultural training organization =1 if household had membership in agricultural training focused program/organization; 0 otherwise.
COMPLIANCE	Level of compliance with the bylaw of irrigation fee payment =1 if not at all; =2 if partial; =3 if full compliance
BENCOST	Perception of costs exceeding benefits of participation in collective action =1 if household perceives costs to be greater than benefits; 0 otherwise
#DEFAULTERS	Number of unpunished defaulters known by the household since 1994 when the irrigation fee bylaw was established
RICEQTY	Amount of rice (kgs) produced by the household in 2001
PRICE	Price (Ushs/kg) of rice received by the household in 2001
DISTMKT	Average distance (kms) from the rice plot(s) operated by the household to the market where rice was sold in 2001.
BLOCK 1	Household operated a rice plot on block 1 in 2001 =1; 0 otherwise
BLOCK 2	Household operated a rice plot on block 2 in 2001 =1; 0 otherwise
BLOCK 3	Household operated a rice plot on block 3 in 2001 =1; 0 otherwise
BLOCK 4	Household operated a rice plot on block 4 in 2001 =1; 0 otherwise
BLOCK 5	Household operated a rice plot on block 5 in 2001 =1; 0 otherwise
BLOCK 6	Household operated a rice plot on block 6 in 2001 =1; 0 otherwise

However, to maintain these benefits and provide incentives for farmers to continue to be efficient and competitive rice producers after the DRS management responsibility is entirely transferred to the farmers by the government will require better management and enforcement of the bylaws. Strict enforcement of the membership rules and bylaws can be an effective means of managing the use of natural resources, especially irrigation water. Weak or poorly enforced bylaws will not provide sufficient incentives for collective action in the provision of this critical public good.

For DRS, solving the siltation problem to increase water supply to members' rice plots requires effective fee-collection procedures, cooperation of the members towards meeting the cost of de-silting. This study examined existing regulations and incentives (benefits) for participation in collective action and found serious weaknesses that will diminish the effectiveness of the management responsibility transfer from government to DRS farmers, which was meant to improve the management of the irrigation system. First, there was limited awareness and poor enforcement of the bylaw that requires all farmers to pay irrigation fees of Ushs 5000 per acre per season. Only one-quarter of the farmers understood the bylaw and one-fifth had observed non-defaulters going unpunished.

Second, the benefits of irrigation water supply and extension received by farmers, which could serve as an incentive for participation, have deteriorated over the years. One-quarter of farmers perceived the benefits to be lower than the costs. This, coupled with limited awareness and poor enforcement of the bylaw, partially explains why some farmers did not pay the irrigation user-fee even when it was meant for their own benefit. The study results indicate a significant negative relationship between participation in collective action (compliance) and the perception that benefits are lower than the costs.

The challenge remains that, without enough farmers paying up the fees, the irrigation system cannot be adequately de-silted, which in turn lowers the amount of irrigation water supplied to the rice plots, hampering rice yields and farmers' ability to pay the irrigation fees in the following season. Therefore, failure to de-silt the canals adequately sets forth a cycle of failure. Breaking this circle will require rehabilitation of the entire irrigation systems to water supply to the farmers, who will then have incentives to improve agricultural productivity.

Once the scheme has been rehabilitated, it will be necessary to enact stronger bylaws and improve awareness about them. The study results show significant differences in compliance across the six blocks that make up DRS. Further research on the nature and extent of these block-level differences and how they influence compliance is needed to provide information on how to increase compliance on blocks where it is currently low.

Table 17. Determinants of household income share of rice (%RICEINC)

Variable	Coefficient	Robust Standard Error	$P > t $
COMPLIANCE	0.040	0.020	0.048
EDUHH	-0.021	0.113	0.062
GENDHH	-0.089	0.047	0.060
DEPRAT	0.001	0.009	0.951
#PLOTS	0.028	0.016	0.090
TENSEC	0.021	0.047	0.648
DISTCNL	-0.031	0.037	0.408
VALVSTK	-0.004	0.002	0.034
EXPRICE	0.016	0.012	0.174
CMTHSE	-0.040	0.031	0.206
SAVCASH	-0.068	0.037	0.070
SAVCAP	-0.109	0.038	0.004
FMCRTD	-0.059	0.035	0.092
RICEFOOD	-0.023	0.036	0.524
CROPINC	-0.393	0.064	0.000
AGTRNORG	0.005	0.056	0.924
INFMCRTD	-0.018	0.023	0.425
WAGINC	-0.270	0.051	0.000
TRNSWC	-0.083	0.056	0.141
RICEQTY	0.003	0.014	0.838
PRICE	-0.00002	0.0001	0.875
DISTMKT	-0.010	0.009	0.221
CONSTANT	0.741	0.135	0.000
N=	398		
$\overline{R^2}$	0.25		

The regression results suggest that households that depend on rice for a large part of their cash income are more likely to participate in collective action (payment of irrigation fees) that reduces the risk of irrigation water scarcity and its negative impact on rice harvests and income. Also having the sale of other crop produce (besides rice) as the primary income source increases compliance. This is probably because the income from these alternative sources increases the ability to pay the irrigation fees. However, rice being a major subsistence food crop does not seem to affect compliance, suggesting that producing rice primarily for subsistence needs of the household may not affect participation in collective action.

Therefore, increasing the commercialization of rice may enhance irrigation fee payment and use of better yield-enhancing inputs such as seed and fertilizer. This is consistent with the new government's plan for modernization of agriculture (PMA) (Government of Uganda, 2000). Agricultural training in soil and water conservation and access to credit sources increases compliance, showing the need for support services such as extension education and credit.

Table 18. Determinants of participation in collective action (Level of Compliance)

Variable	Coefficient	Robust Standard Error	$P > z $
%RICEINC [#]	8.712	1.611	0.000
EDUHH	-0.078	0.137	0.568
GENDHH	0.968	0.545	0.076
DEPRAT	0.200	0.099	0.044
#PLOTS	-0.484	0.164	0.003
TENSEC	-1.000	0.513	0.051
DISTCNL	0.218	1.058	0.837
SQDISTCNL	0.282	0.546	0.605
EXTWAT	0.182	0.195	0.351
TRNSWC	1.153	0.651	0.077
EXPRICE	-0.336	0.123	0.006
CMTHSE	0.619	0.363	0.088
SAVCASH	0.116	0.245	0.637
FMCRTD	0.964	0.371	0.009
RICEFOOD	0.111	0.372	0.765
CROPINC	4.693	1.067	0.000
AGTRNORG	0.869	0.681	0.202
BLOCK 1 [*]	0.873	0.467	0.062
BLOCK 2 [*]	1.046	0.457	0.022
BLOCK 3 [*]	1.058	0.474	0.025
BLOCK 4 [*]	0.700	0.435	0.107
BLOCK 5 [*]	0.654	0.325	0.045
BLOCK 6 [*]	0.462	0.391	0.238
BENCOST	-0.556	0.242	0.022
#DEFAULTERS	-0.012	0.240	0.961
N=	398		
Prob> χ^2	0.0000		

Predicted values generated in step one of the regression analysis.

* All six block dummies were used without dummy variable trap because some households had rice plots on more than one block

These results suggest that households that depend on rice for a large part of their cash income are more likely to participate in collective action (payment of irrigation fees) that reduces the risk of irrigation water scarcity and its negative impact on rice harvests and income. Thus, the importance of rice as a cash income source is a significant determinant of the household decision to comply (pay irrigation fees). Also, having the sale of other crop produce (besides rice) as the primary income source increases compliance. This is probably because the income from these alternative crops increases the ability to pay the irrigation fees. However, rice being a major subsistence food crop does not seem to affect compliance. This suggests that producing rice primarily for subsistence needs of the household may not affect participation in collective action.

Agricultural training in soil and water conservation and access to formal credit sources also increase compliance. This underscores the importance of supporting services (extension education and credit) to increase farmers' awareness of the need to contribute towards the cost of supplying irrigation water through education, as well as their ability to contribute, through credit services.

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