IRRIGATION PERFORMANCE AND COLLECTIVE ACTION. A CASE STUDY IN THE OFFICE DU NIGER (MALI)

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ABSTRACT

This paper investigates the relation between collective action and performance for a case study in the Office du Niger irrigation scheme in Mali. As a result of irrigation management transfer at tertiary level, farmers are now collectively responsible for water supply to the tertiary block, water allocation within the tertiary block, coordination of the cropping calendar and infrastructure maintenance. The research is based on a field study including about 300 farmers from 36 tertiary blocks and 9 villages. First, the different aspects of both collective action and performance are measured through developing indicators. Regarding collective action, these indicators measure coordination of the cropping calendar, maintenance of tertiary infrastructure, coordination of water demand at tertiary level, and coordination of water allocation within the tertiary block. The performance indicators incorporate the viewpoint of the irrigation scheme's management as well as farmers and are irrigation efficiency, easiness of irrigation, occurrence of conflicts and agricultural productivity. Next, the relation between collective action and irrigation performance is quantified using statistical models. The main finding is that not all aspects of performance are affected by collective action, and when they do, not by all aspects of collective action. The choice of indicators when studying collective action is thus of primary importance. In the Office du Niger, coordination of water supply and demand and coordination of water allocation affect efficiency and easiness of irrigation respectively. Given the increasing importance of these aspects of performance, they must form the primary focus of efforts to enhance collective action.

Key-words: collective irrigation schemes, irrigation performance, collective action, Mali

INTRODUCTION

Nowadays, the premise is that through collective action, local users can increase the performance of common-pool resources (Ostrom 1999, Dietz et al. 2003), such as collective irrigation schemes. A growing number of papers study the emergence of collective action in irrigation (for example Aggarwal 2000, Bardhan 2000, Ray and Williams 2002, Meinzen-dick et al. 2002, Rinaudo 2002, Sarker and Itoh 2003, Kurian and Dietz 2004, Fujie et al. 2005). These papers however generally analyze factors affecting the emergence of collective action rather than its impact on performance. Given the methodological difficulties in measuring collective action (Meinzen-dick et al. 2004, Poteete and Ostrom 2004), it is sometimes even studied by analyzing its outcome (i.e. performance), assuming there is a direct relationship between both. In practice, this is not necessarily so. First, performance might be affected by several

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other factors, such as the type of irrigation infrastructure (Horst 1999). Second, in the scope of governance of common-pool resources, collective action contains usually multiple aspects, and the same goes for performance. It is then possible that different aspects of collective action affect different aspects of performance. In turn, factors affecting the emergence of collective action might as well differ for each of its aspects.

The Office du Niger in Mali irrigates 80 000 ha and is one of the largest irrigation schemes of West Africa. The principal crop is flooded rice cultivated during the rainy season, with transplanting being the common practice for crop establishment. Institutional reforms, accompanied by physical rehabilitation of infrastructure, led to irrigation management transfer to farmers at tertiary level. Farmers are now collectively responsible for water supply to the tertiary block, water allocation within the tertiary block, coordination of the cropping calendar, and infrastructure maintenance. All of these are matters of collective action, and can have consequences on irrigation performance.

Up to date, water is not scarce in the irrigation scheme, so that demand is virtually unrestricted. First, especially during the rainy season, water availability in the Niger River, which supplies the irrigation scheme, is abundant. Second, head works have spare capacity, being built in the scope of a substantially larger irrigated area. Finally, tertiary canals are over-dimensioned with respect to peak irrigation requirements because of reasons related to canal construction. Furthermore, the entire irrigation network is continuously filled with water and supply is on-demand. The abundant water supply easily leads to over consumption. In particular, without coordination of water supply and demand at tertiary block level, the tertiary intake is often left open when water demand has halted, with excess irrigation water choking the drainage system. Despite the abundant water supply, temporary shortage can occur in periods of supply problems at secondary level or peak aggregate water demand. The capacity covers largely the peak water requirement on a weekly basis, but canal intakes are designed such that only about one fifth of field canals can irrigate simultaneously at their design capacity. In absence of coordination, often more field canals are opened so that the water level in the tertiary canal drops, resulting in irrigation problems. Regarding the cropping calendar, with water being permanently available, farmers can decide independently on transplanting dates. Stretching of the growing season at the level of a tertiary block on the one hand diminishes the scope for congestion of the tertiary irrigation canal, but can lead to conflicts between irrigation and drainage. Furthermore, when a basin filled with water neighbors a drained basin, the latter is often refilled through lateral seepage. Tertiary infrastructure maintenance is necessary in order to avoid degradation of the canal bed and banks, which diminishes its capacity and makes overflow through breaches likely. In severe cases, excessive flooding of fields results in yield loss.

A number of rules aimed at introducing coordination of all of these aspects are stipulated in the joint contract negotiated between the Malian state, the Office du Niger and farmer representatives. Furthermore, at tertiary block level, an elected canal chief must organize collective action and supervise compliance with the rules. As they are not backed by a formal sanctioning system, many canal chiefs do not perform their assigned task and rules are often not respected. In practice, collective action does emerge on some tertiary block and for some aspects of water management. When it does, it is in a very informal way and depends heavily on farmers' awareness of the benefits of collective action and the capacity of one or more group members to establish a consensus on certain rules or activities. As a result, observed levels of collective action vary greatly among tertiary blocks.

Based on empirical evidence from the Office du Niger, this paper aims to quantify the impact of collective action on irrigation performance at tertiary level of the irrigation scheme in a comprehensive way. This implies two distinct objectives. First, an attempt is made to measure the different aspects of both collective action and performance through devising indicators. Second, their relation is analyzed using statistical models.

METHODS

1. Description of the study area

The Office du Niger manages five administrative zones that are dominated by a dam on the Niger River from which irrigation water is conveyed through abandoned river channels to a hierarchic irrigation network composed of primary, secondary and tertiary canals. A village accommodates the farmers of the downstream plots of one to three nearby secondary canals. The tertiary canals serve tertiary blocks, of which 3 218 exist in the five administrative zones together. In a tertiary block, field canals deliver water to the rice basins and if required, evacuate it to a hierarchic drainage network. All irrigation and drainage canals are unlined. Each farmer owns several neighboring basins constituting a plot with an average total surface of two hectares. Allocation of plots is such that field canals are often shared by two or three farmers.

Yearly rainfall varies from 300 to 600 mm and is concentrated in the months from July to September. The main rice-growing season sets off at the end of May with the installation of seedbeds. Rice transplanting begins gradually by mid-June and continues until the end of September. The peak irrigation demand falls during the month of September, when over ninety percent of the cultivated surface is irrigated and the rainy season reaches its end. The first fields are harvested already by mid-September and harvesting continues until the end of December.

2. Indicators of irrigation performance

In the scope of this paper, performance is defined as the discrepancy between objectives and results (Dia 1993). The objectives of water management typically depend on the viewpoint of different actors (Plusquellec et al. 1994). Since different aspects of collective action can have different impacts on different aspects of performance, this paper aims at evaluating irrigation performance from the perspective of both the irrigation scheme's management and its farmers. The management's objectives are clearly stated in the joint contract and consist in maximizing rice production while minimizing water input (Office du Niger 2002, 2005). A study on farmers' perception of water management in the Office du Niger revealed that from their point of view, the objectives of water management are being able to irrigate easily at all moments and with a minimum of social conflicts (Bastiaens 2005). To irrigate easily implies an adequate, timely, reliable and readily available water supply to every individual plot. This corresponds well to the findings of similar studies in other irrigation schemes (Manor and Chambouleyron 1993, Naik and Kalro 2000, Abernethy et al. 2001). Based on these objectives, four performance indicators are developed: irrigation efficiency, easiness of irrigation, occurrence of conflicts and agricultural productivity.

2.1 Irrigation efficiency

Many indicators have been developed that measure irrigation efficiency by comparing irrigation requirements to delivery (for example Clemmens and Bos 1990, Molden and Gates 1990, Burt and Styles 1999). In this paper, we use the indicator proposed by Molden and Gates (1990).

$$P_F = \frac{1}{T}\sum_T \left(\frac{1}{R}\sum_R p_F \right) \quad \text{with} \quad p_F = \frac{Q_R}{Q_D} \quad \text{if} \quad Q_R \le Q_D \quad \text{and} \quad p_F = 1 \quad \text{otherwise}$$

The indicator divides the volume of water required (Q_R) by the water delivered (Q_D) of a certain subregion (R) during a certain period (T) and is a measure for the excess of water delivered in comparison with the requirements. The indicator takes a maximum value of one, with decreasing values indicating a lower efficiency. Irrigation efficiency is calculated for each tertiary block, and thus provides a measure for losses in the tertiary canal as well as at plot level. The period (T) covers the months June to October. Since water can be stored in the rice basins, shortage of delivery at one moment can be compensated for by excess delivery on a previous moment. Therefore, water requirement and delivery are calculated over intervals of one month. Calculation methods for Q_R and Q_D are explained in Vandersypen et al. (2006).

2.2 Agricultural productivity

A second indicator is agricultural productivity, expressed as tons of paddy harvested per hectare. This indicator is measured at plot level, which is the basic unit of production. Since farmers know the number of bags of paddy harvested on their field, and with one bag containing on average 75 kilos, the indicator was assessed trough a questionnaire survey on the total cultivated surface and the total number of bags harvested. In the process of harvesting, some of the rice is lost during transportation and threshing. This method thus probably implies an underestimation of agricultural productivity compared to the method applied by the Office du Niger, who samples unharvested rice. However, it is sufficient in the scope of a comparative analysis.

2.3 Easiness of irrigation

Even though water supply is mostly adequate at tertiary block level (Vandersypen et al. 2006), irrigation might still be problematic at plot level when water is unevenly distributed within the tertiary block. With no flow measurement structures available at plot level, conventional irrigation performance indicators based on flow data are not suitable. An obvious alternative is to assess directly the opinion of farmers (Svendsen and Small 1990), but few scholars of irrigation performance have attempted to do this in a systematic and quantitative way. Sam-Amoah and Gowing (2001) and Ghosh et al. (2005) calculated the utility of water delivery services from farmers' perspective using fuzzy set theory to analyze their responses concerning the provided service. Since responses are noted down as linguistic expressions, this method is however time-consuming, which limits the sample size under budget and time constraints. Abernethy et al. (2001) quantified farmer's opinions on water services by asking them to indicate the level of agreement or disagreement with a set of statements. The authors assert that for the method to work best, the set should be kept as small as possible and preferably not contain more than 15 statements. The scope for obtaining detailed information on the various aspects of irrigation performance is thus limited.

In this research, it is aimed to quantify the easiness of irrigation in a simple indicator and to supplement it with more detailed information about its determining factors so that the results can be fully understood. From a preparatory survey with 43 farmers from the study area, it appeared that the easiness of irrigation from farmers' perspective encompasses two distinct aspects. The first is the occurrence of irrigation problems, and the second is the application of strategies to mitigate those problems. For each of these aspects, different features can be distinguished, consisting in the various causes of irrigation problems and the various strategies respectively.

This approach implies a more detailed survey. In order to combine a large sample size with detail, a new method was developed. Farmers were surveyed using a closed-question survey with scaled responses. The performance indicator is derived from the key question 'Has irrigation been easy?' A three-point answer scale ('always', 'mostly', 'never') accompanied the question. The first two categories were further combined in order to obtain a dummy variable and facilitate statistical analysis. Several formulations of the key question were included at various parts in the questionnaire so that answers could be crosschecked for inconsistency. The questionnaire furthermore assessed the occurrence of irrigation problems and the application of strategies to mitigate them. Both the duration or frequency and the intensity of the inconvenience for each of the features composing irrigation problems and strategies applied were rated on a three-point scale.

2.4 Occurrence of conflicts

Irrigation can be a source of conflict in case of competition for water within a tertiary block, over-use of water causing excess water to spill over in neighboring fields or when irrigation and drainage coincide in the same field canal. For farmers in the study area, averting conflicts is an important objective of water management. In the region, people are however reluctant to admit they were involved in a conflict, so it is difficult to obtain concrete and reliable information on the topic. Therefore, it was chosen to compile a simple yes/no-indicator for the occurrence of conflicts at a tertiary block. Farmers could then be asked questions about the occurrence of conflicts on irrigation management at their tertiary block without discussing their personal involvement. Several questions were added in the questionnaire survey to address this subject. Answers from the survey were completed with information obtained in group-discussions (see further), informal interviews with individual farmers and observations on the field. When at least one of the sources revealed that conflicts occur on a tertiary block, the indicator was put to one.

3. Indicators of collective action

In this paper, collective action is defined following McCarthy et al. (2004) as 'the act of internalizing negative externalities and/or the generation of positive externalities in the use of natural resources'. It manifests itself in certain events or activities or the coordination of these and the rules-in-use that institutionalize them (Poteete and Ostrom 2004). Indicators developed in this paper measure this manifestation for all aspects of collective action at tertiary level in the Office du Niger, which are coordinating the cropping calendar, maintenance of tertiary infrastructure, coordination of water demand at tertiary level and water allocation within the tertiary block.

3.1 Coordination of the cropping calendar

A relatively uniform cropping calendar is considered to be in the common interest of the tertiary block. Still, planting dates at individual plot level are in part determined in function of economic profit (early harvested rice yields high prices), physical constraints (lower located plots have to be transplanted early in order to prevent drowning of seedlings when the rainy season sets off) or financial or labor constraints (which forces farmers to postpone transplanting). Farmers make thus a trade-off between personal constraints and benefits and the common interest. The indicator to evaluate coordination of the cropping calendar is the standard deviation of transplanting dates. Through fortnightly monitoring of the transplanted surface, the transplanting date of each basin is estimated. Standard deviations are weighed against the surface transplanted for each date.

3.2 Maintenance of tertiary infrastructure

Maintenance of the tertiary infrastructure consists in periodic and regular maintenance and is performed through farmers' physical labor. Periodic maintenance implies dredging the canal bed and reinforcing the canal banks. It is considered too heavy a task for physical labor and the need for periodic maintenance is not pressing since infrastructure is recently rehabilitated. Consequently, neglect is pervasive. Regular maintenance consists in cleaning the canal bed of aquatic weeds and is executed more or less frequently depending on the tertiary block. The maintenance level of tertiary irrigation canals is evaluated through fortnightly observations throughout the growing season. Since most often, farmers clean the canal section adjacent to their field independent from each other, maintenance levels can differ considerable in time and space. Therefore, every canal section in between two field canals, the maintenance level is scored on a scale from 1 (good) to 3 (bad). Scores are then averaged for the canal and for the growing season to obtain a single result.

3.3 Water allocation within the tertiary block

Since most of the time, water availability in the tertiary canal covers aggregate irrigation demand, free access to water is the common practice. In periods of peak aggregate water demand or water crisis at secondary level, rules are sometimes devised that coordinate water allocation and avoid crowding. In a more general way, on tertiary blocks where allocation rules are successfully applied, farmers accept the principle that their access to water can be restricted in favor of the common interest, which facilitates coordination of water allocation also outside periods of peak demand. A first indicator of collective action concerning water allocation is therefore a dummy variable 'rules on water allocation' indicating whether yes or no rules are applied, taking into account compliance and the availability of sanctions to ensure their effectiveness. On some tertiary blocks where rules on water allocation are not (effectively) applied, informal consultation to resolve irrigation problems on the spot is however institutionalized. Through this consultation, temporary agreements can be made between two or more farmers of a tertiary block regarding water allocation. A second indicator, 'consultation on water allocation' also a dummy variable, is therefore devised to assess whether yes or no, informal consultation is institutionalized. Both indicators are assessed through group discussions and crosschecked with informal individual interviews and regular observations on the field.

3.4 Coordination of water supply and demand at tertiary block level

Coordination of water supply and demand at tertiary block level consists in tuning water supply to the tertiary block at all moments to aggregate demand. When such coordination takes place, usually, an influential farmer has taken the responsibility to collect information on water demand of fellow farmers, or the latter, when leaving the field, inform the first when water is required. The collective action indicator is a dummy variable indicating whether yes or no, coordination takes place and is based on results from group discussions, crosschecked with informal individual interviews and regular observations in the field.

4. Data collection

For practical reasons, a clustered sampling method was applied. Nine villages were selected in the rehabilitated area of the administrative zones Niono and N'Debougou. In each of the villages, four tertiary blocks were picked ad random, so that the total sample size of tertiary blocks is 36. Agricultural production was evaluated for the total number of plots within the sample of tertiary blocks (299). Easiness of irrigation was evaluated for a sub-sample of 150 plots within the sample of tertiary blocks. Plots were selected ad random, but such that at least one third of plots per tertiary blocks are represented. Summary data on the selected villages and sample are presented in Table 1).

Table 1 Summary data on the selected villages and sample (Number between brackets represent data for the sampled tertiary blocks)

Village	Secon-dary canal	Number of tertiary blocks		Irrigated surface (ha)		Number of plot holders		Number of plot holders per tertiary block		Average plot size (ha)	
Moussa Werè	KL0	26	(4)	479	(105)	94	(45)	3.6	(11.3)	5.1	(2.3)
Kouyan							(28)				
Peguena	KO1	8	(4)	150	(74)	81		10.1	(7.0)	1.9	(2.6)
Coloni	N1	33	(4)	621	(62)	263	(45)	8.0	(11.3)	2.4	(1.4)
Médina	G5	26	(4)	509	(113)	188	(49)	7.2	(12.3)	2.7	(2.3)
Siguivoucé	S6	25	(4)	653	(62)	203	(23)	8.1	(5.8)	3.2	(2.7)
Fassun	S8	17	(4)	300	(75)	103	(28)	6.1	(7.0)	2.9	(2.7)
Medina-Coura	B3	34	(4)	759	(58)	208	(20)	6.1	(5.0)	3.6	(2.9)
Tiemedeli-Coura	B5	34	(4)	451	(65)	208	(34)	6.1	(8.5)	2.2	(1.9)
Kanasakko	BE3	20	(4)	239	(49)	222	(27)	11.1	(6.8)	1.1	(1.8)
Total for sample villages		223	36	4161	(663)	1570	(299)	7.0	(8.3)	2.7	(2.2)
Total for rehabilitated area of Niono and N'Debougou		1042		20 736		6184		5.9		3.4	

For the calculation of the indicators, daily flow rates were measured at the intake of each tertiary block. Additionally, fortnightly observations were done to monitor transplanted and harvested surfaces and evaluate the maintenance level of the tertiary canal. For the questionnaire survey, the responsible farmer for each plot of the sample was contacted for a one-to-one interview. 150 farmers of the sub-sample of plots were presented the complete questionnaire, and 149 a shortened version with only questions on agricultural productivity. A first version of the questionnaire was constructed in French and translated in the local language, Bambara, using the translation-back-translation method (Brislin et al. 1973). This version was adapted after a testing phase using the techniques described in Foddy (1993). Two trained interviewers administered the survey. Separate group discussions with three to six participating farmers took place per tertiary block. Discussions were animated by the researchers using a flexible interview guide and assisted by an interpreter. Finally, triangulation methods were used to validate and complete results from indicators of both collective action and irrigation performance through informal interviews with 40 plot-holders from the sub-sample and regular observations on the field. Data collection for the calculation of the indicators was done for the growing season of 2004. Informal interviews and observations took place throughout 2004 and 2005.

5. Statistical analysis

Descriptive statistics on the indicators of irrigation performance and collective action are generated and mutual correlations within both groups are tested using non-parametric tests. The impact of collective action on irrigation performance is assessed through simple or binary logistic regression models, depending on whether the dependent variable is a scale or dummy variable. The hypothesis tested is that with increasing levels of collective action, performance will improve. The independent variables are the indicators of collective action, which are all measured at tertiary block level. The dependent variables are the performance indicators, of which two are measured at tertiary block level and two at plot level. In the latter case, all units of the same tertiary block share the same independent variables. Statistical analyses are performed with the SPSS computer package.

RESULTS AND DISCUSSION

1. Irrigation performance

Table 2 presents descriptive statistics of the indicators. Average irrigation efficiency is 0.59, a value that is considered low according to the standards put forward by Molden and Gates (1990). Losses are due to excess water delivery to tertiary blocks compared to demand and to excess application to the fields. Variability in irrigation efficiency is however large, ranging from 0.23 to 0.87 and with a standard deviation of 0.18. Agricultural productivity was recorded for 294 out of 299 farmers, since five farmers from the sample could not be located. Reported yields, on average 3.8 t/ha, show also a great variability. They range from 0 t/ha, for two farmers who's crop was devastated by floods, and 6.5 t/ha. From the survey on easiness of irrigation, 11 cases were excluded because of inconsistencies in the answers. A vast majority (86 %) judges irrigation always or mostly easy, implying that on the whole, their primary objective concerning water management is met.

Table 2. Descriptive statistics for indicators or irrigation performance and collective action

Indicator	Descriptive	Number of observations
Irrigation performance		
Irrigation efficiency-average [St. Dev]	0.59 [0.18]	36
Agricultural productivity-average [St. Dev] (t/ha)	3.8 [1.2]	294
Easiness of irrigation-% always or mostly easy	86 %	139
Occurrence of conflicts-% yes	53 %	36
Collective action		
Standard deviation of planting dates-average [St. Dev] (days)	18 [6]	36
Tertiary infrastructure maintenance-average [St. Dev]	1.62 [0.35]	36
Rules on water allocation-% yes	19 %	36
Consultation on water allocation-% yes	53 %	36
Coordination of water supply and demand-% yes	31 %	36

Nevertheless, irrigation problems do occur (Table 3). About 64 % is confronted with irrigation problems, and the frequency and/or duration and intensity are considered rather high. On the other hand, three quarters of that group mentions only one type of problem, which might explain why in general, irrigation is still deemed easy. Next, about 91 % of interviewed farmers apply one or more strategies to mitigate irrigation problems, with a frequency and/or duration that are rather high. The intensity of the disturbance is however scored quite low. Among the factors determining easiness of irrigation, some relate to aspects external to the tertiary block, such as water supply at secondary level, and have thus no connection with collective action. Nevertheless, the problems and strategies mentioned most frequently do consider collective action problems. Indeed, among the problems, high aggregate water demand at tertiary level primes. Given that peak water requirements at tertiary block level are largely met by supply, this indicates a failing in coordination of water allocation. Likewise, the most frequently applied strategies are to negotiate access to water with other users, and to stand guard to prevent the latter from interrupting irrigation, which can also be avoided through coordinating water allocation. Finally, on about half of the tertiary blocks, conflicts on water management occur. From the informal interviews and group discussions, it appeared however that many grades exist as to the frequency, seriousness and duration of conflicts. The dummy indicator might thus be too crude a measure for adequately assessing conflicts.

Table 3. Details for factors determining easiness of irrigation

Particular	Times mentioned (%)	Average score for frequency/duration[1]	Average score for intensity[1]
Type of irrigation problem			
Low water availability at secondary level	26	0.67	0.74
Unfavorable topographic position of the field	14	0.68	0.80
High aggregate water demand at tertiary level	33	0.58	0.66
Other	9	0.63	0.72
Total	64	0.64	0.73
Strategy to mitigate irrigation problems			
Contact water bailiff to send more water	23	0.81	0.57
Clean the tertiary canal	9	0.89	0.67
Stand guard to the field so that other water users cannot interrupt irrigation	71	0.88	0.42
Negotiate access to water with other water users	79	0.86	0.39
Total		0.86	0.51

[1] For those who mentioned the problem or strategy; put on a scale of 0 to 1, with a higher score indicating a higher frequency/duration and intensity

Most performance indicators are not mutually correlated (Table **4**), meaning that the various aspects of performance vary independently from each other. This implies also that the impact of collective action can be different for the various aspects of performance. Easiness of irrigation and the occurrence of conflicts are the exception. The probability that farmers judge irrigation never easy is significantly larger on tertiary blocks where conflicts occur. Indeed, irrigation problems are often a source of conflict.

Table 4. Correlations among indicators of irrigation performance

	Irrigation efficiency	Easiness of irrigation	Occurrence of conflicts
Easiness of irrigation	Mann-Whitney = 832.5; p = 0.059		
Occurrence of conflicts	Mann-Whitney = 131.5; p = 0.346	Pierson χ^2 = 4.926; df = 1; p = 0.026	
Agricultural productivity	Spearman's ρ =-0.018; p = 0.761	Mann-Whitney = 1096; p = 0.922	Mann-Whitney = 9564.5; p = 0.650

2. Collective action

The period in which transplanting takes place on a tertiary block ranges from one to more than three months. In an extreme case, some fields were already being harvested on the moment others were transplanted. On most tertiary blocks, transplanting takes place within two months, with often a concentration in one or two decades, translating in an average standard deviation of planting dates of 18 days (Table 2). Even though farmers believe that it is important to have their cropping calendars more or less in line within a tertiary block, transplanting dates are thus rather dispersed. The average score for tertiary infrastructure maintenance is 1.62. The standard deviation is 0.35 and scores range from one, for the perfectly maintained canals, to only 2.06, whereas the maximum score is three. The fact that most canals have a score around the average is that variation in maintenance level within a canal is rather large. In addition, all of the canals are more or less well maintained on at least some sections. A good score for tertiary infrastructure maintenance does however not always reflect farmers' efforts. Some canals of the sample have not yet been colonized by certain weeds, so that regular maintenance is hardly necessary. On about one third of tertiary blocks, water supply and demand are coordinated. Rules on water allocation within the tertiary block are effectively applied on about one fifth of tertiary blocks from the sample, and on half of them, informal consultation is institutionalized. This leaves almost one third of tertiary blocks where water allocation is not coordinated at all.

Table 5. Correlations among the indicators of collective action

	Spread of planting dates	Tertiary infrastructure maintenance	Rules on water allocation	Consultation on water allocation
Tertiary infrastructure maintenance	Spearman's ρ = 0.081; p = 0.639			
Rules on water allocation	Mann-Whitney = 79.0; p = 0.368	Mann-Whitney = 76.5; p = 0.325		
Consultation on water allocation	Mann-Whitney = 131; p = 0.346	Mann-Whitney = 160.5; p = 0.975		
Coordination of water supply and demand	Mann-Whitney = 70; p = 0.020	Mann-Whitney = 125.5; p = 0.685	Pierson χ^2 = 1.084; df = 1; p = 0.298	Pierson χ^2 = 0.749; df = 1; p = 0.387

Again, the various aspects of collective action are not correlated (Table 5), which implies that that tertiary blocks with high levels of collective action for one aspect are not necessarily better off to attain the same for other aspects. As an exception, tertiary blocks where the opening of the tertiary canals is coordinated show a significantly smaller standard deviation of planting dates. Rather than a causal relation between these two, there is probably a third factor, such as the number of farmers on the tertiary block, which determines both. This is however not further investigated in the scope of this paper.

3. Impact of collective action on irrigation performance

Table 6 to Table 9 present the results of the regression models predicting irrigation efficiency, agricultural productivity, easiness of irrigation and the occurrence of conflicts as a function of collective action. The results are quite different for each of the models, which is logic since few of the performance indicators are mutually correlated. Irrigation efficiency can be explained best by the indicators of collective action. The most significant variable in the model is coordination of water supply and demand, with higher efficiencies when such coordination occurs. Then follow the standard deviation of planting dates and consultation on water distribution, while the effect of the other variables is not significant. The coefficients for the standard deviation of planting dates and consultation on water allocation indicate that increasing levels of collective action result in lower efficiency. The effect is however small, and at best suggests that collective action on the cropping calendar and water allocation cannot improve irrigation efficiency. The probability that irrigation is always or mostly easy and that conflicts occur, are only for a small part determined by the indicators of collective action. Easiness of irrigation is related to coordination of water allocation within the tertiary block. Where consultation and particularly rules on water allocation are present, the probability of irrigation problems decreases significantly. In fact, all except one of the farmers indicating irrigation is never easy are located on tertiary blocks where no such rules are applied. This result suggests that by increasing collective action for water allocation, irrigation problems at the individual level can be solved. In the model predicting the occurrence of conflicts, the standard deviation of planting dates and application of rules on water allocation have the largest effect, even though not significant. Finally, the model predicting agricultural productivity using indicators of collective action is not at all significant.

Table 6. Results of simple regression model predicting irrigation efficiency; $R^2=0.44$; n = 36

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	S.E.	Beta		
Constant	0.581	0.168		3.460	0.002
Spread of planting dates	0.011	0.004	0.395	2.691	0.012
Average maintenance level tertiary canal	-0.109	0.072	-0.216	-1.500	0.144
Rules on water allocation	-0.055	0.073	-0.125	-0.757	0.455
Consultation on water allocation	-0.134	0.057	-0.387	-2.375	0.024
Coordination of water supply and demand	0.186	0.057	0.494	3.260	0.003

Table 7. Results of simple regression model predicting agricultural production; $R^2=0.01$, $p = 0.576$, n = 294

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	S.E.	Beta		
Constant	4.483	0.540		8.308	0.000
Spread of planting dates	-0.001	0.013	-0.004	-0.071	0.943
Average maintenance level tertiary canal	-0.267	0.233	-0.070	-1.146	0.253
Rules on water allocation	-0.161	0.197	-0.058	-0.816	0.415
Consultation on water allocation	-0.257	0.161	-0.110	-1.600	0.111
Coordination of water supply and demand	-0.064	0.171	-0.023	-0.375	0.708

Table 8. Results of logistic regression model predicting the probability that irrigation is always or mostly easy; Nagelkerke R^2 = 0.15; % correctly predicted = 86; n = 139

Variable	B	S.E.	Wald	Sig.	Exp(B)
Constant	1.104	2.209	0.250	0.617	3.018
Spread of planting dates	-0.035	0.048	0.543	0.461	0.965
Average maintenance level tertiary canal	0.275	0.986	0.078	0.780	1.317
Rules on water allocation	2.568	1.102	5.427	0.020	13.044
Consultation on water allocation	1.158	0.553	4.391	0.036	3.183
Coordination of water supply and demand	0.436	0.655	0.443	0.505	1.547

Table 9. Results of logistic regression model predicting the probability that conflicts occur; Nagelkerke R^2 = 0.18; % correctly predicted = 67; n = 36

Variable	B	S.E.	Wald	Sig.	Exp(B)
Constant	-1.315	2.520	0.272	0.602	0.268
Spread of planting dates	0.101	0.067	2.221	0.136	1.106
Average maintenance level tertiary canal	-0.016	1.104	0.000	0.988	0.984
Rules on water allocation	-1.522	1.141	1.780	0.182	0.218
Consultation on water allocation	0.024	0.859	0.001	0.978	1.024
Coordination of water supply and demand	-0.276	0.839	0.109	0.742	0.759

An important implication of these results is that when studying collective action, the choice of indicators is important, especially when the objective is to formulate recommendations on how to enhance collective action. Focusing on aspects that matter less for performance can waste valuable time and resources. In the Office du Niger irrigation scheme, the aspects of collective action that stand out are coordination of water supply and demand and water allocation within the tertiary block, which have an impact on irrigation efficiency and easiness of irrigation respectively. Given the rapid rate of expansion of the irrigated area, water might become a limiting factor in the near future, so that irrigation efficiency gains importance. In addition, when using less water at tertiary block level, the proportion of farmers facing irrigation problems when allocation is not coordinated might also increase. Coordination of water supply and demand and water allocation within the tertiary block should thus be the primary focus when enhancing collective action. Until now, most programs are directed towards tertiary infrastructure maintenance. Indeed, neglect of maintenance easily strikes the eye, but it matters less for irrigation performance in the over-dimensioned canals of the Office du Niger. Similarly, the stretching of the cropping calendar is often cited by farmers and the irrigation scheme's management and field staff as a primary cause for low irrigation performance, but the relation is not confirmed in this research.

CONCLUSION

This paper investigated the impact of collective action on irrigation performance at tertiary level in the Office du Niger irrigation scheme. Performance is measured using indicators that take into account the perspective of both farmers and managers of the irrigation scheme and are irrigation efficiency, agricultural productivity, easiness of irrigation and the occurrence of conflicts. Indicators of collective action measure its implication in practice and are coordination of the cropping calendar, tertiary infrastructure maintenance, coordination of water allocation and coordination of water supply and demand at tertiary block level. The main conclusion is that not all aspects of performance are affected by collective action, and when they do, not by all aspects of collective action. The choice of indicators when studying collective action is thus of primary importance. In the Office du Niger, coordination of water supply and demand and coordination of water allocation affect efficiency and easiness of irrigation respectively. Given the increasing importance of these aspects of performance, they must form the primary focus of efforts to enhance collective action.

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