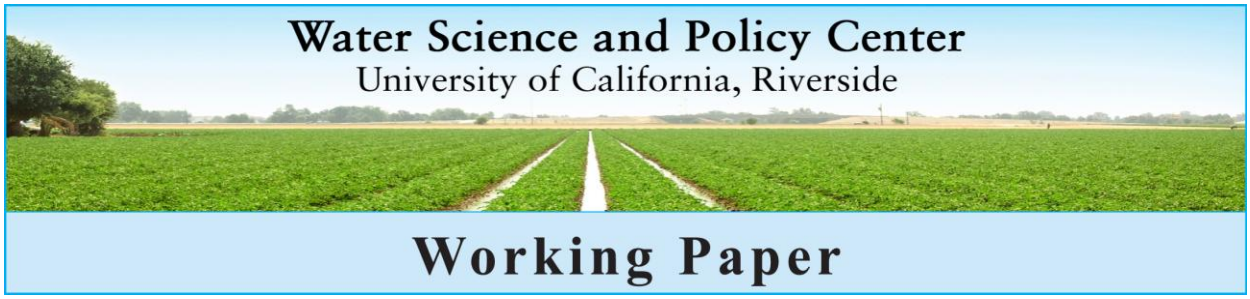

01-1213, December 2013

Process and Performance of River Basin Water Management Decentralization in Sub-Saharan Africa[1]

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[1]The study leading to this paper was co-funded by the World Bank Knowledge for Change Project, and the Water Research Commission of South Africa. It was undertaken by researchers stationed in the Water Science and Policy Center at the University of California, Riverside, and in the International Water Economics and Governance for Africa in Maputo, Mozambique. We would like to thank PEGASYS, South Africa, for enormous efforts and patience in the data collection process.

Process and Performance of River Basin Water Management Decentralization in Sub-Saharan Africa

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Abstract

This paper assesses the decentralization processes and performances of river basin management decentralization in Sub-Saharan Africa, using primary data from 27 river basins in the region. The main findings are that water scarcity is a major stimulus to reform; that water user associations, if not well prepared and trained, may deter the decentralization process; and being part of an existing treaty over an international basin helps foster the process. Conditions improving decentralization performance include: scarcity of water resources, longer period of implementation, bottom-up creation, and appropriate budgetary support of the river basin organization. Findings are relevant for policy in decentralization in remaining river basins across the continent and elsewhere, suggesting important central government interventions and an implementation sequence that would lead to more effective results.

Key words: decentralization, political economy, economic efficiency, institutions, water, river basin, IWRM Sub-Saharan Africa.

JEL Codes: Q25, Q34

1. Introduction

In a recent initiative, the World Bank suggests that "More irrigation and pastoralism could transform Africa's Sahel region" (World Bank 2013). The Sahel, linking Burkina Faso, Chad, Mali, Mauritania, Niger, and Senegal in a harsh water situation, is home to pastoralist agriculture that faces water scarcity threats. According to the World Bank vision, bringing more water to the Sahel will help address food security, allow farmers to move from subsistence to commercialized farming with its indirect positive impacts on local and regional markets, as well as to "protect biodiversity, improve soil fertility, and conserve the environment" (World Bank 2013).

This vision, while focused on the Sahel, is attractive also for any other part of Sub-Saharan Africa (SSA) but raises several challenges and concerns. These challenges include not only the hardware for moving and distributing water from water bodies to the demand sites, but also the software: the institutions that will allow such great plans to be realized. The latter challenge is the more difficult one to address, and it is the focus of this paper.

In response to global water scarcity, river basins in Sub-Saharan Africa have undergone, to various extents, decentralization of water management in the past two decades. Most SSA countries established their water laws in the past 15 years and restructured their institutional and governance framework accordingly. For example, South Africa voted its National Water Act in 1998 and its National Water Resources Strategy in 2002; Zambia amended in 1994 its Water Act of 1970, while Mozambique and Tanzania approved their National Water Policies respectively in 1995 and in 2002, and Namibia voted its Water Resource Management Act in 2004.

As relatively late-comers to the decentralization arena following the Dublin Conference (GWP 2000)[2], SSA countries could have benefitted from previous experiences. However, specific and partial analyses of performance of Integrated Water Resource Management (IWRM) in SSA river basins (at the case study level with different measurement methodologies) have suggested (e.g., Gallego-Ayala and Juizo 2012; Juizo et al. 2006) a wide range of performances in the various basins across the continent. This raises questions about the validity of the measurements and their comparability across basins, as well as their relevance.

While much effort and good will was put into decentralization reforms in many basins in the continent, results have not been uniformly realized. For example, the benefits originated from the implementation of such decentralization processes were taken for granted during the design of the South Africa National Water Act. The decentralization process addressed 19 basins in the country, indicating that it was a major effort. However, slow and uneven implementation of the decentralization process led to unrealized benefits. Ten years after the launch of the new national water policy, only two catchment management agencies have been established and are operational (Inkomati and Olifants-Doorns), while more locally many water user associations (WUAs) do not function properly and the catchment management committees (CMCs) have not given decisional power (Karar 2011).

In some other SSA countries, the process of decentralization in the basin water management institutions could have been more or less advanced than in South Africa, as we can see from analyzing the data collected in the study leading to this paper. Therefore, the a-priori set of basins in SSA countries provides a range of decentralization efforts and performances, and allows us to apply our proposed methodology of decentralization analysis.

In this paper, we address the broader question of decentralization of river basin water management, of which IWRM is an important component. An early global study on the determinants and performances of decentralization processes in river basins (Dinar et al. 2007; Kemper et al. 2007; Blomquist et al. 2010) did not include basins from SSA, mainly because the decentralization process just started at the time their study was conducted. Our study of decentralization in SSA departs from Dinar et al. (2007) and Blomquist et al. (2010) with several adjustments to the empirical analysis, forced on us due to the quality of the data we were able to obtain from SSA basins. Since we use the same theory as in Dinar et al. (2007) and Blomquist (2010), we will not discuss the analytical framework and hypotheses in detail in section 2, but rather refer the reader to the references above. Section 3 describes the data collection and variables construction methods we used. Section 4 presents the components of the empirical analysis we applied. Section 5 presents and discusses the results, and Section 6 concludes and addresses some policy implications.

[2] For more information on decentralization principles see Dinar et al. (2007:852-853).

2. Analytical framework and hypotheses

We follow the analytical framework suggested by Blomquist et al. (2010). The framework identifies and focuses primarily upon four sets of observable variables and suggests hypotheses about the directions by which those sets of variables are associated with the possible success of decentralization of water resource management reforms.

These sets include: (1) Initial conditions and contextual factors; (2) Characteristics of the decentralization process; (3) Central government-local relationships and capacities; and (4) Resource-level institutional arrangements. All these four sets of variables jointly provide incentives and enable the stakeholders' participation in the decentralization. Such involvement is linked to better management decisions that, in turn, lead to increased likelihood of improved resource management.

This framework has already been applied to assess and compare the relative degrees of success and failure of decentralization reforms in river basin management, not including SSA (Kemper et al. 2006; Dinar et al. 2007). We apply the framework in this paper to decentralization in SSA river basins, using a subset of the variables presented in Dinar et al. (2007).

2.1 The hypotheses

For each of the four sets we developed a list of empirical variables that were included in a questionnaire that was supposed to elicit responses from the river basins organizations (RBOs) in SSA. The empirical variables that we refer to in the next sections are discussed below.

2.1.1 Impact of contextual factors and initial conditions

The literature on decentralized water resource management indicates that the outcome of decentralization is partly a function of the initial conditions that prevail at the time a decentralization initiative is attempted (*path dependency*). These initial conditions are elements of the economic, political, and social context of the decentralization effort. Several variables that could capture such conditions are detailed below.

<u>Level of economic development of the river basin region</u> measures the ability of the basin stakeholders to commit financial and other resources necessary to the decentralization process in addition to central government provision of support for the decentralization effort. The literature on decentralized water resource management indicates that successful decentralization must include some degree of financial autonomy (Cerniglia 2003; Musgrave 1997). Sustaining this financial autonomy often depends upon the establishment of some form of water pricing or tariffs, having the users obeying such payments, and having the proceeds remain within or returned to the basin.

Thus, decentralizing management to the basin level, developing and maintaining the institutional arrangements for basin-level management, and implementing any form of financial autonomy imply that some financial resources at the basin level will have to be committed to the decentralization effort. *This in turn implies that basins that have a level of economic development that can sustain those resource commitments are (all other things being equal) more likely to achieve sustainable success in decentralization.*

<u>Initial distribution of resources among basin stakeholders</u> is an important contextual factor in the development and successful implementation of a decentralization initiative. We also refer to the

impact of climate change on the variability of water flows in the basin as a measure of resource availability. This variable has interesting and complex properties, however. On the one hand and more obviously, extreme disparities in resource endowments among basin stakeholders can imperil decentralization success. If some privileged stakeholders anticipate they would be worse off, they are unlikely to support the decentralization process and may even try to derail it. And if other stakeholders are so destitute as to be unable to bring any resources of their own to the decentralization initiative, they may rationally elect not to participate even though more effective resource management would promise to improve their situation in the long run. On the other hand and less obviously, some inequality of initial resource endowments may facilitate action by enabling some stakeholders to bear the costs of taking a leadership role (Ostrom 1990).

Thus, some inequality of resource endowments is not necessarily lethal to a decentralization initiative, and may even facilitate it if better-situated users are willing to lead (Dinar 2009). Extreme inequality, however, may be detrimental or even derail the decentralization effort. The distribution of resource endowments among the basin stakeholders is therefore an important contextual variable affecting the prospects for successful decentralization. *We hypothesize that the relationship between level of inequality of resource endowments and successful decentralization is quadratic, with the greatest positive impact at a certain level of inequality, and lower or negative impacts at both lower and higher levels of inequality of resource endowment distribution.*

2.1.2 Characteristics of the decentralization process

Certain conditions or characteristics of the decentralization process itself may affect the prospects for successful implementation. Two necessary conditions of a decentralization initiative are (a) a devolution of authority and responsibility from the center, and (b) an acceptance of that authority and responsibility by the local or regional units. Whether (a) and (b) both occur will depend in part upon why and how the decentralization takes place.

<u>Top-down, bottom-up, or mutually desired devolution</u> are ways of characterizing the decentralization initiative. In some cases, central government officials may have undertaken resource management decentralization initiatives in order to solve their own problems – e.g., to reduce or eliminate the central government's political accountability for past or current resource policy failures, resolve a budgetary crisis by cutting their financial responsibility for selected domestic policy areas (Simon 2002), or respond to pressure from external support agencies to formulate a decentralization initiative as a condition of continued receipt of financial support. In other cases it is "bottom up" pressure from the stakeholders that leads to the decentralization (Samad 2005). In other cases, the decision to decentralize resource management to a lower and more appropriate level may have been the outcome of a process of mutual discussion and agreement between central officials hoping to improve policy outcomes and local stakeholders desiring greater autonomy and/or flexibility.

Using the data collected, we therefore attempt to identify the motivation and process by which the decentralization initiative came to pass. *All other things being equal, we can anticipate that because decentralization initiatives require active basin-level stakeholder involvement, they are more likely to be implemented successfully if undertaken under the latter (bottom-up) circumstances than under the former (top-down).*

<u>Existing local-level governance arrangements contribute to continuation</u>. The literature suggests that decentralization initiatives are more likely to be accompanied by active involvement of basin

stakeholders if existing community (village, tribe) governance institutions and practices are recognized and incorporated in the decentralization process. This observation has a transactions costs explanation, too: the costs (primarily in terms of time and effort) to basin stakeholders of relating on familiar organizational forms are expected to be smaller than the costs of relating to an additional set of organizational arrangements. In contrast, decentralization initiatives that feature central government construction of new sets of basin-level organizations that are largely separate from existing and traditional community governance institutions may face higher costs in achieving basin stakeholders' participation, resource commitments, and acceptance of decisions as legitimate. This does not mean that no new institutions will have to be created in order to achieve basin-scale management – in fact, new institutions will be needed to promote communication and integrate decision-making across communities within a river basin. *Rather, all other things being equal, decentralization initiatives are more likely to succeed in gaining stakeholder acceptance if they are based upon, and constructed from, traditional community governance institutions and practices (i.e. take account of existing social capital).*

2.1.3 Characteristics of central government/basin-level relationships and capacities

Because successful decentralization requires complementary actions at the central government and local levels, other aspects of the central-local relationship can be expected to affect that success. Accordingly, our study includes a set of political and institutional variables having to do with the respective capacities of the central government and the basin-level stakeholders, and the relationship between them.

<u>The extent of devolution of responsibilities and decision-making</u>. A decentralization policy initiative announced by a central government may be only symbolic, while the central government retains in practice control over all significant resource management decisions. Worse still, a decentralization policy can represent an abandonment of central government responsibility for resource management without a concomitant establishment of local-level authority. In better situations, the central government transfers degrees of both authority and responsibility for resource management to the stakeholders.

These differences in the extent of actual devolution that occurs can be expected to affect the prospects for successful implementation of the decentralization policy. Symbolic or abandonment policies are at best unlikely to improve resource management, and at worst will undermine stakeholder willingness to commit to and sustain the extent of active involvement necessary for successful decentralization. *All other things being equal, we would expect to see greater prospects for success increasing with level of devolution.*

<u>Local-level experience with self-governance and service provision</u>. In any country, the decentralization of water resource management does not occur in a vacuum. The ability of central government officials to strike a balance between supportiveness and intrusiveness, and the capacity of basin-level stakeholders to organize and sustain institutional arrangements, will in part be a function of their experiences with respect to other public services or responsibilities. The ability of central and local participants to perform successfully will depend on the skills and experiences they have developed.

We would expect that water resource management decentralization initiatives are more likely to be implemented successfully in settings where local participants have experience in governing and managing other resources and/or public services – e.g., land uses, schooling, transportation, etc.

Economic, political, and social differences among basin users. In many countries, the distribution of political influence will be a function of economic, religious, or other social and cultural distinctions. But even if it were not for the connection between these characteristics and political influence, the characteristics themselves can affect successful implementation of decentralization initiatives, through their independent effects on stakeholder communication, trust, and extent of experience in interdependent endeavors.

Economic, political, and social distinctions among basin-level stakeholders are likely to affect the implementation of decentralized resource management efforts. *The greater and more contentious these distinctions, all other things being equal, the more difficult it will be to develop and sustain basin-scale institutional arrangements for governing and managing water resources*.

It is important to add that these are empirical, not prescriptive, observations. Central government officials cannot make distinctions among basin-level stakeholders disappear. Nor should central government officials selectively apply decentralization policies only in relatively homogeneous settings.

Adequate time for implementation and adaptation. While it is obvious that longevity of water resource management arrangements may reflect their success, it may be less obvious that their success may depend on their longevity. Time is needed to develop basin-scale institutional arrangements, to experiment with alternatives and engage in some trial-and-error learning. Time is needed for trust building, so water users can begin to accept new arrangements and gradually commit to sustaining them. Time is needed also to translate resource management plans into observable and sustained effects on resource conditions.

The relationship between time and success in water resource management is complicated. On the one hand, we have already said that adaptability is important, as water users need to be able to modify institutional arrangements in response to changed conditions. On the other hand, patience is important too, because a new approach that has not succeeded can simply erode stakeholders' willingness to commit their time and effort to the next reform. *We may observe a curvilinear relationship, in which successful implementation is less likely to be observed among decentralization initiatives that are very young, but could taper off if central government and basin-level arrangements have proved insufficiently adaptable over long periods.*

2.1.4 The internal configuration of basin-level institutional arrangements

Successful implementation of decentralized water resource management may also depend on features of the basin-level arrangements created by stakeholders and/or by the central government.

Presence of basin-level governance institutions may be a prerequisite for successful water resource management. Sustained and effective participation of stakeholders presupposes the existence of arrangements by which stakeholders articulate their interests, share information, communicate and bargain, and take collective decisions. Basin-level governance is essential to the ability of water users to operate at multiple levels of action, which is a key to sustained successful resource preservation and efficient use (Ostrom 1990).

Basin-level water resource management (in other words, a decentralized system) is neither achievable nor sustainable without the establishment and maintenance of basin-level governance arrangements. In the case of SSA, we refer also to situations of rivers that are international in nature. Thus having an agreed upon treaty among the various riparians would

also fall under this category of sub-basin interests. *Because the existence of governance arrangements is a necessary, not sufficient, condition of successful resource management, we should not expect to find success everywhere we find basin-level governance institutions, but we should expect to find failure everywhere they are absent.*

Recognition of sub-basin communities of interest. The water management issues in the basin are viewed differently by the stakeholders that share the resource in various parts of the basin, based mainly on the physical conditions and spatial situation of each group. For example, downstream users' perspectives on water quality differ from upstream users. Users with access to groundwater have different views of drought exposure than surface water users. Municipal and industrial water users do not perceive the value of assured water supply reliability in the same fashion that agricultural water users do (Blomquist and Schlager 1999). Thus, while basin-level governance and management arrangements are essential to decentralized water resource management, the ability of sub-basin stakeholders to address sub-basin issues may be as important. In the case of SSA, we refer also to situations of rivers that are international in nature. Thus, having an agreed upon treaty among the various riparians would also fall under this category of sub-basin interests.

Level of participation of various groups in basin-level decision-making arrangements explains the direction and extent of the decentralization process. Of course, transaction costs of the decentralization process increase as such assurances are institutionalized, since a larger number of stakeholder organizations within the basin will bring greater coordination costs. *All other things being equal, we would expect that successful implementation of basin decentralization has a positive relationship with level of participation of stakeholders in the process.* However, with a diverse and large number of stakeholders, high transaction costs may become a constraint. *Here too, then, a hill-shaped relation of this variable to successful decentralization may be expected, with the absence of sub-basin organizations and large numbers of sub-basin organizations negatively associated with lower success and greater prospects for success in between*.

Information sharing and communication. The importance of information – more particularly, information symmetry – and opportunities for communication to the emergence and maintenance of cooperative decision-making is relatively well understood. In water resource management especially, of which there can be so many indicators of water resource conditions and the performance of management efforts, forums for information sharing are vital to reducing information asymmetries and promoting cooperation.

Since information will not automatically be perceived the same way by all stakeholders, and the implications of information about resource conditions will differ among these groups, it is arguably as important that there also be institutionalized or other regular forums in which basin stakeholders can communicate. *All other things being equal, we expect to find successful decentralized water resource management more likely where information sharing and communication among stakeholders are more apparent*.

Mechanisms for conflict resolution are needed to prevent disagreements from arising. Resource users can and will disagree about how well their interests are being represented and protected, about how well the resource management program is working and whether it is time for a change, about the distribution of benefits and costs, and manifold other issues.

The success and sustainability of decentralized resource management efforts therefore also depend on the presence of forums for addressing conflicts. *All other things being equal, we would expect successful implementation of decentralized water resource management more likely in settings where forums for conflict resolution exist*.

The set of variables and their hypothesized impact on the process and performance of the decentralization in river basin management, as was developed in this section, will be inferred by applying several statistical tests to data collected from 27 river basins around SSA countries. The data collection process and the manipulation of the workable variables are presented in the next sections.

3. Data and variable construction

A survey instrument in Dinar et al. (2005) was modified to collect the data needed for estimating the model equations in Sub-Saharan Africa. It was first pre-tested on three river basin organizations (RBOs) prior to being modified, translated from English to French and Portuguese, and sent to the identified offices of the RBOs in the various states. A total of 27 RBOs in SSA known to have undergone decentralization to various extents are included in the final dataset we analyze. The English version of the survey instrument can be found in Mutondo, Farolfi and Dinar (2014: Annex IV).

3.1. Data collection methodology

Data collection was undertaken by PEGASYS, a consulting firm in South Africa with widely established contacts with water sector agencies in SSA countries. Data collection was completed after several iterative processes of data entry and quality assurance reviews by the authors. Additional rudimentary statistical tests were undertaken to identify, verify, and correct outliers in the dataset. The questionnaires were completed by staff from the basin organizations. All questions, especially those related to performance of the decentralization reform, required objective rather than subjective answers. We intentionally approached local authorities following the reasoning suggested by Alderman (2002), who observed that local authorities appear to have access to information that is not easily captured in official census datasets.

3.1.1 The potential final set of basins included in the study

The basis for the identification of the potential RBOs in SSA was ANBO, AMCOW, and GTZ (2012), which provided a list of 99 basins in Eastern, Western, Southern, and Central Africa (Table 1).

This list of basins was assessed by PEGASYS and revised, based on a set of investigation approaches such as establishing contacts with local NGOs, regional agencies, and known water projects. This process yielded a much more detailed list of 121 basins and their decentralization status (Table 2). As can be seen from Table 2, of the 121 basins, 29 have not started any decentralization activity, and the status of decentralization in 26 other basins was impossible to verify. This left us with 66 basins that went through decentralization or that have not yet completed the decentralization process. Our final sample of 27 basins shows that we obtained a

41 percent response rate. While this response rate is considered barely acceptable in any other place on earth, it is quite significant in SSA.[3]

A description of the 27 basins, the country they belong to, and their status of decentralization are presented in Table 3. The list of the 27 RBOs can be found in Annex 1.

3.1.2 The administration of the questionnaires

For the 66 basins to whom questionnaires were distributed, the strategy for eliciting responses included: introductory emails followed up by phone calls to identify a focal person; shipment of the questionnaire by email; follow-up on progress by email as well as phone; clarification sessions with some respondents about difficult questions; review of the received questionnaires and follow-up on particular responses as needed; translation of the questionnaire into an electronic dataset in Excel. The data collection work was planned for six months (March 2012–September 2012), but actually lasted much longer (March 2012–September 2013) due to communication difficulties that PEGASYS encountered with the respondents.

3.1.3 Quality assurance procedures

The electronic dataset was shared with the researchers as it was established over time. Overall, the research team provided five rounds of feedback to PEGASYS. Feedback included inconsistencies in recording missing values (99999) and 0 values, replacement of string values with numerical values, and correction of some basic physical information of the basin. Once these inaccuracies have been addressed, the dataset was considered complete, even though some variables have not been filled.

Questionnaires in English were translated to French and Portuguese in order to make sure they were accessible and understood perfectly by all surveyed RBOs in Africa. In order to increase the response rate, a follow-up survey was sent to the respondents if they did not respond to the survey within a month, and then continued by a telephone follow-up, if necessary. To ensure the highest possible quality, the research team constituted an iterative process of data acquisition and quality assurance reviews. The process involved the compilation of qualitative and quantitative data from a questionnaire, which the agency that collects the data, PEGASYS, distributed.

All responses were checked both by PEGASYS and a graduate student at University of California, Riverside (UCR), under the supervision of the principal investigators, for errors that could be critical to the study, such as missing answers to questions, or which respondents for one reason or another did not, or could not, answer. In addition to such a check, a further rudimentary statistical test was conducted on most variables, to identify outliers within the given response range and to ensure that values are justified. In all cases, the seemingly errors were brought to the attention of the respondents and, in the case of actual errors and/or mistakes, efforts were made towards correction.

3.2 Variables construction

Our questionnaire consisted of 56 primary questions and 245 primary variables (see Annex 2 and Mutondo et al. 2014). Some of the variables in our data set are naturally correlated to each other.

[3] Another measure of response rate could be obtained from the ratio of questionnaires that were returned to questionnaires that were sent to potential responding RBOs. Eighty-four questionnaires were sent and 27 were filled, which makes the response rate at 32 percent.

We conducted several principal component (PC) analyses in order to capture the information in these variables and to prevent possible multicollinearity, by combining a set of primary variables into one inclusive PC variable in our estimated relationships. Unfortunately, due to the quality of some of the variables in the dataset, the PC analysis did not yield meaningful results and could not be used in our analysis (see footnote 6). We also used several primary variables to create indices to reflect values that are better expressed on a relative rather than on an absolute scale, or to create dummies that capture key aspects of the decentralization process.

4. The empirical framework

We postulate that the characteristics of the decentralization process ($\boldsymbol{P}$)[4] and the level of the decentralization success/progress (S) can be estimated using a set of variables that include: contextual factors and initial conditions; characteristics of central government/basin-level relationships and capacities; internal configuration of basin-level institutional arrangements; and a set of "other" variables, identified as necessary. These groups of variables and their relationships were discussed in Blomquist et al. (2010) and Dinar et al. (2007), and will be used in our study as well. In addition, we use two new variables that have not been explicitly used in Dinar et al. (2007). One variable indicates whether or not the basin in question is governed by an international river basin organization, under an international treaty. International river basin organizations may include many tributary basins, and all constitute the international basin. The second variable measures the likely impact of climate change on precipitation or runoff in the river basin. The assumptions regarding the behavior of the various variables are provided in the following sections.

We are interested in two types of relationships. The first is a relationship that explains a certain phenomenon in the basin, such as specifics of the decentralization process, measured by the levels of $\boldsymbol{P}$. The second is a relationship that explains level of success/progress of the decentralization process, measured by S.

The set of equations used in the estimation of the first relationship takes the following shape:

[1] $\boldsymbol{P} = g(\boldsymbol{C}, \boldsymbol{R}, \boldsymbol{I} \mid \boldsymbol{V}, B, \boldsymbol{X})$

where:

$\boldsymbol{P}$ is a vector of characteristics of the decentralization process;

$\boldsymbol{C}$ is a vector of contextual factors and initial conditions;

$\boldsymbol{R}$ is a vector of characteristics of central government/basin-level relationships and capacities;

$\boldsymbol{I}$ is a vector of internal configuration of basin-level institutional arrangements;

$\boldsymbol{V}$ represents the climatic conditions (precipitation or runoff) in the basin;

B is a dichotomous variable indicating whether or not the basin is governed under an international river basin treaty/organization; and

$\boldsymbol{X}$ is a vector of "other" variables, identified as necessary.

[4] Variables represented by a bold letter indicate a vector.

A general relationship for decentralization success/progress, using the theory developed above is as follows:

[2] $\boldsymbol{S}=f(\boldsymbol{C}, \boldsymbol{P}, \boldsymbol{R}, \boldsymbol{I} \mid \boldsymbol{V}, B, \boldsymbol{X})$

where:

S is a vector of performance indicators of the decentralization in the river basin.

All other variables are as defined earlier.

We have several measures of success and several measures for levels of progress of the decentralization process, as will be discussed in detail in coming sections.

We propose several types of specification of the functional form depending on the nature of the variable ***S***. Based on our discussion in previous sections, one possible way to measure success is by using a dichotomous variable that takes the value 1 when decentralization was initiated and 0 when no decentralization took place in spite of government intent.

A second way of describing success is to measure normatively the extent of achieving several important original goals of the decentralization reform. The success variable was computed as an aggregation of the success ratings over the different reported decentralization objectives, because the KMO-statistic[5] of some individual success objective variables was very low.

A third way of measuring progress of decentralization is by comparing performance between present and the pre-decentralization period. Performance variables may include: level of participation, local responsibility, financial performance, economic activity, etc. By comparing before and after values, we are just comparing change levels of each of the variables included in the comparison of before and after decentralization.

4.1 Empirical specifications of the decentralization process and its performance

The first specification of a relationship we investigate explains whether or not a decentralization process was initiated (equation 1). We expect that it takes some level of the contextual factors (***C***) as well as characteristics of the central government/basin-level relationships and capacities (***R***) to initiate the decentralization. However, we are not sure about the direction of the impact of various internal configurations of basin-level institutional arrangements (***I***). Some existing water user associations may work in opposite directions. We expect that harsh climatic conditions (***V***) will be associated with higher likelihood of establishing river basin organization and existing international treaty or international river basin organization (*B*) that overrules the basin will help also in establishing the domestic RBO. We actually had to use the Linear Probability Model (LPM) approach because of the small number of observations. LPM is not bounded between zero and one, but still captures the intensity of the relationship between the binary dependent and the independent variables.

Several variables could help shed light on the decentralization process. Few are probably of special interest as they contrast observations across river basin decentralization processes

[5] Kaiser-Meyer-Olkin (KMO) statistic predicts if data are likely to factor well, based on correlation and partial correlation. The KMO overall statistic is used to decide whether or not to include a variable in the PC analysis. KMO overall should be .60 or higher to proceed with factor analysis. Variables with KMO statistic lower than 0.60 should be dropped from the PC analysis.

under a variety of situations.[6] The length of the decentralization process, *Years Decentralization*, the transaction costs of the process, measured by several variables such as *Institutional Dismantled*, *Political Cost*, and the level of involvement of the stakeholders, *WUA Involvement*, are a few that caught our attention. Estimation procedures explaining *Intuitional Dismantled*, *Political Cost*, and *Years Decentralization* use an OLS procedure as values of these variables are dummies or continuous. Table 4 summarizes the various equations we specified for relationship 1 (equation 1), and the hypothesized directions of impact of the independent variables, based on the theory developed earlier.

We identified several variables that serve to measure decentralization success or progress. The estimates of relationships using the first two approaches (that were mentioned earlier) to measuring success/progress imply LPM, TOBIT, and OLS estimation procedures. We use the variable *Success over Objective* (calculated as an aggregation of the success over all objectives) to reflect achievement of various goals the decentralization process was aimed to achieve. We applied LPM, TOBIT, and OLS procedure to estimate that relationship as well. Because we are not sure that the values measured are distributed normally, we cannot use GLM, as it may provide biased estimates. Thus we use the TOBIT procedure that assumes a Poisson distribution. Finally, we construct the additional variable, *Problems After*, to explain the performance of the decentralization process. *Problems Before* and *Problems After* are two variables for which we did use principal component. Table 5 summarizes the estimation procedures of the various equations we specified for estimating relationship 2 (equation 2), and the hypothesized directions of impact, based on the theory developed earlier.

5. Results

Our dataset includes a total of 27 RBOs in six countries distributed over two of the four SSA regions (four RBOs in two Eastern African countries and 23 RBOs in four Southern African countries). The other two regions in the continent, Central Africa and West Africa, do not have decentralization experiences or information about it is missing (Table 2). Our sample is quite well balanced, representing nearly 30 percent of the 14 eastern basins and 44 percent of the 23 southern basins that underwent decentralization. We start with a report on the descriptive statistics of the variables participating in the analysis.

5.1 Descriptive statistics

While we based our entire analysis in this paper on the structure suggested in Dinar et al. (2007), due to the reasons indicated in Section 3 we had to revise the measurement of some of the variables and to eliminate several other variables that were not reported because of difficulties of the respondents in SSA basins to assign values to them. This shrunk the usable variables, and reduced the overall number of observations that we could include in the various estimated models. A detailed definition of the variables in our dataset can be found in Annex 2 and Annex 3 (for the variables we created for this paper). The descriptive statistics of the variables that were included in this paper's analysis is presented in Table 6.

Table 6 demonstrates the problems in filling out the questionnaire, as the number of variables with full coverage of the entire set of observations fluctuates between 10 and 27. Of the available information, some of the descriptive statistics indicates that about 40 percent of the

[6] For definition of the variables see Annex 2 and 3.

basins were created through a bottom-up approach. In 80 percent of the basins that started the decentralization process, RBOs were created. In 58 percent of the basins, at least one institution was dismantled during the decentralization process. It is also clear that disputes over water scarcity seem to be more relevant than disputes over allocation. The decentralization process, on average, is about one decade old, ranging between two to 30 years. Decentralization processes in SSA started as early as 1979 and as late as 2009 (according to our sample). Finally, climate change may be impacting 76 percent of the basins through flow variation, and 68 percent of the basins in our sample are part of transboundary river, governed by international treaty.

5.2 Inference of our hypotheses

Following Dinar et al. (2007), we inferred our hypotheses regarding process and performance of the decentralization reform in SSA. Given the few countries in our database, we could not include state-level variables such as wealth, regime, and others. In addition, we lost several observations due to missing values of some of the variables involved.

5.2.1 Performance of decentralization (before and after)

We start by comparing several water management responsibility indicator items before and after the decentralization, using a two-tailed *t-test*. The results of the analysis of four activities (Water administration, infrastructure financing, water quality enforcement, and setting water quality standards) are presented in Table 7.

As can be seen from Table 7, more water management activities at higher decentralized levels have been reported after the decentralization process, compared with the situation before the decentralization. With ranking of water activities varying between 1-5 (with 1 indicating centralized and 5 indicating most decentralized activity), one can see that there was a significant move of responsibilities towards basin-level and a significant reduction of responsibility at the central government (increase in local responsibility was not significant, and the same is true for increase in state responsibility). A significant increase of responsibilities towards basin-level was also reported in the case of infrastructure financing (increase in responsibility at local level and decrease in responsibility in state and central government levels were not significant). A significant increase in responsibility for water quality enforcement at the basin-level was reported (insignificant increase in local responsibility and insignificant decrease state and central government responsibilities were also reported). A significant increase in responsibility at the basin-level was reported for setting water quality standards (no significant changes have been reported for local, state, and central government). As a whole, our sample RBO moved after the decentralization process towards more responsibility at the basin-level for all four water management decision-making activities. At the same time these RBOs show a reduction in the central government responsibility in only water administration and water quality enforcement activities. Compared with Dinar et al. (2007), we introduced in this paper a category of local responsibility (mainly due to the very large size of the basins in SSA, compared to many of the basins in the study by Dinar et al. (2007). However, by 2013, there is still no progress towards increased responsibilities to the local communities, which suggests difficulty in implementing decentralization towards local actors.

We were also able to get assessments of the severity levels of several issues the basins have been facing and to compare the situation before and after the decentralization. Ranking of severity before decentralization: no problem (0); some problem (1); severe problem (2). Ranking

of severity after decentralization: situation worsen (1); situation the same (0); situation improved (1). Means of these assessments for each problem item are presented in Table 8.

Table 8 suggests that before decentralization, except for floods (with mean value of 0.9545), all of the other issues were in the range of "some problem" to a "severe problem." Water conflicts and development issues exhibit the highest level of severity in the sample basins. After decentralization, all the six issues have been either stable or improving, with floods, land degradation, and development issues being closer to 1, indicating that the situation related to these issues tended to improve on average. The situation remains on average the same for water scarcity, environmental problems, and water conflicts.

5.2.2 Determinants of the decentralization process

We use three decentralization process variables that allowed us to use most of the observations in the dataset. The results of the estimated equations are presented in Table 9.

The results in Table 9 indicate very significantly that, regardless of the inclusion of the international treaty and the flow variation over time, all contextual factors included as well as the variables that measure the internal configuration of basin-level institutional arrangements, were significant and follow the expected sign, except the *Creation Bottom Up* variable. The coefficient of the *Political Cost* is positive and highly significant, suggesting that a higher political cost increases the water users involvement, and may lead to the creation of an RBO as a way to establish the new framework for a cooperative use of the resources. The negative sign on the coefficient on *Creation Bottom Up,* while opposite to our initial expectations and previous findings (Dinar et al. 2007) is in line with the anecdotal information provided in the introduction section and in Mutondo et al. (2014), suggesting that the WUAs that have been established in the RBOs were not well prepared to take off the decentralization process, lacking organizational, legal, and technical skills. This result may indicate that some central government involvement is still needed in SSA basins as a way to transfer not only responsibilities, but also skills to manage the resources under the decentralized arrangement. This support of the central government is needed so that the WUA's creation and implementation process is not "manipulated" by dominant groups and therefore is neither equitable nor sustainable. More generally, this finding suggests that *Creation Bottom Up* is a necessary but not sufficient condition for institutional decentralization.

Being under an *International Treaty* improves cooperation and raises the likelihood of an RBO being created and institutions (a water-related ministry) dismantled. At this point, it may seem that an international treaty that coordinates the various parts of the basin located in different countries may serve as a roadmap for a more effective decentralization, and a support tool for users to take the reins of the water resources management in a more stable and accountable setting.

The variable *Disputes over Allocation* has a negative and significant coefficient in the equation explaining *WUA Involvement,* and a positive and significant coefficient in the equation explaining *RBO Created*. These results follow our expectations. They suggest that having insufficient dispute resolution mechanisms leads to disengagement of WUAs; however, it does provide impetus to the creation of the RBO. Indeed having water conflicts before the decentralization was indicated (Table 8) as the most severe problem.

Results for several water-scarcity variables are worth mentioning. *Relative Water scarcity*, *Share of Surface Water*, and *Water Flow Fluctuates*, all are significant and have a positive sign. This suggests that water scarcity in the range observed in our sample leads towards more involvement of the WUAs, more likelihood of creation of the RBO, and dismantling of existing institutions in the process of decentralization.

5.2.3 The decentralization performance

We were somehow limited in our ability to use the data on all variables that are expected to measure and explain decentralization performance. We remained with only two variables that measure performance, *Success Over Objectives* and *Problems After Decentralization*. The results of our regression analyses are presented in Table 10.

Scrutiny of the results suggests that in spite of having a small number of observations, our model is of high explanatory level and significance. All coefficients are significant and with the expected sign, except for *Water Flow Fluctuates* and *International Treaty*, which are not significant. Adjusted R-squared ranges between 0.964 to 0.998, and F-test values are significant at 1 percent and less. The results indicate that higher *Share of Surface Water*, as well as a longer experience with the decentralization process (*Years Decentralization*) enhance the success over the basin's objectives. Lower levels of water scarcity, up to a point, may allow for an easier cooperation and coordination of the users, and for a faster accommodation of the decentralization arrangements. In other words, the absence of an acute problem around water availability facilitates conditions for coordination and a common approach towards basin solutions. A longer decentralization process may indicate the possibility of the establishment and learning of a cooperative behavior, and the stability of the mechanisms to solve disputes. All of that translates into a higher social capital accumulation. Contrary to the previous table, the political cost is highly significant and of a negative sign. It could be entirely possible that sharing the benefits of the decentralization process will result in an excessive level of political costs (through the changes of institutions or the imposition of new duties), which may offset any possible short-term gain. Also, it is not because RBOs are created that problems are solved.

Unlike the equations estimating the decentralization process characteristics, *Creation Bottom Up* has a positive impact on the performance of the decentralization. The fact that a higher-level *Governing Body* fosters the accomplishment of the objectives may be an indication of the need of the higher government levels to be active and supportive during the decentralization process. Having a higher *Budget Per Capita* is an important factor in having less *Problems After Decentralization*, which is an important finding with policy implications. Some other coefficients deserve additional discussion because their coefficients are different in the decentralization process equation (Table 9) and in the decentralization performance equations (Table 10), which was expected, based on our theoretical framework (Tables 4 and 5). *Political Cost* has a positive sign in the process equations, and a negative sign in the performance equation; *Creation Bottom Up* has a (surprising, but justifiable) negative sign in the process equation, and a positive sign in the performance equation; and *Years Decentralization* has a negative sign in the process equation and a positive sign in the performance equation.

6. Conclusion and policy implications

Decentralization efforts in river basins have been seen around the world under various political and institutional situations. African river basins have been joining the decentralization process of

river basins relatively late, initiating the process somewhere in early 1990s. We modified and applied an analytical framework that was originally used in a previous study outside of Sub-Saharan Africa. The dataset we were able to collect consists of about 40 percent of the river basins in SSA that initiated decentralization. We conclude that the analytical framework of water management decentralization we used is robust enough to explain the decentralization process and progress even in the presence of a limited sample. It seems that this framework, when used with a richer dataset and over a longer period of time can be informative to policy makers when designing and evaluating decentralization processes in Africa and other parts of the world.

Some of the variables in our analysis have interesting implications. It appears that the success and stability of the decentralization process depends on the way the new framework distributes the *Political Cost* and compensates those who carried its burden. As for the *Method of Creation*, it seems that a grass-root initiative, despite all the benefits it may capture in terms of legitimacy and use of pre-existing community arrangements is insufficient if not properly supported by government transfers of skills, or know how, budget responsibilities and technical knowledge. The similar impact of *WUAs Involvement* amplifies that conclusion. For SSA this conclusion is probably the most relevant one, with policy implications. Training the WUAs prior to the initiation of the decentralization process is essential for high efficacy of the decentralization. Otherwise the social investment in institutional reforms in the water sector would be wasted. It should be mentioned here that the results of the variables *Method of Creation*, *Creation Bottom-Up*, and *WUAs Involvement*, in a previous study with similar analytical framework applied to regions other than SSA were the opposite, suggesting that in SSA grass-root efforts have to still be nourished.

Interpreting the opposite signs of the coefficients of major variables that are included in estimates of decentralization process and performance equations (*Creation Bottom-Up, Political Cost, Years Decentralization*) could mean that while the implementation of decentralization processes in the water sector in SSA does not guarantee success, on the other hand, factors that improve the performance of decentralization do not necessarily facilitate its implementation. For example, in progress decentralization institutions can have better results than established RBOs suffering from untrained staff and malperformance of infrastructure as well as being disconnected from the stakeholders.

It also appears that the best performances of decentralized basins seem to refer to solutions for infrastructural problems (floods, and land degradation control), while the socio-economic problems, perceived before decentralization (conflicts, development), have been addressed less frequently. This result could be a consequence of the fact that hardware solutions (infrastructure, engineering) are easier to implement than software solutions (stakeholders' participation, dispute resolution forums, etc.). Another interpretation of this last observation is associated with the previously mentioned context that infrastructure could be built by international companies, but when completed and left with local operators, may not function well due to inadequate institutions and preparedness.

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Tables

Table 1: Initial set of identified river basins in SSA by region.

Region	Number of reported river basins
Southern Africa	34
West Africa	30
Central Africa	14
East Africa	21
Total	99

Source: ANBO AMCOW and GTZ, 2012.

Table 2: Distribution of decentralization efforts in various regions of SSA

Country	Basins with decentralization undertaken	Basins with decentralization in progress	Basins with no decentralization	Basin with no information about decentralization
Southern Africa Region				
Angola			7	
Botswana			4	
Lesotho			1	
Madagascar			4	
Mozambique[7]	13			
Namibia		10		
South Africa	2	17		
Swaziland	1	2		
Zambia			3	
Zimbabwe	7			
Subtotal	23	29	19	0
West Africa Region				
Ivory Coast				1
Benin				1
Liberia				1
Cameroon				2
Ghana			4	
Guinée				1
Mali				1
Mauritania				1

[7] Mozambican respondents to our survey indicated that RBOs in that country are established. Compared to the level of development of the RBOs of other African countries, it would probably be more correct to put Mozambican RBOs in the second column, where water decentralization process is "in progress." However, to reflect precisely the survey results, we decided to leave the Mozambican RBOs in the first column.

Nigeria				1
Senegal				1
Subtotal	0	0	4	10
Central African Republic				1
DR Congo			4	4
Equatorial Guinea				1
Gabon				2
Subtotal	0	0	4	8
East Africa Region				
Ethiopia				4
Kenya		5		
Malawi			1	
Sudan				4
Tanzania	9			
Uganda			1	
Subtotal	9	5	2	8
Central Africa Region				
Central African Republic				1
Democratic Republic Congo			4	4
Equatorial Guinea				1
Gabon			1	1
Subtotal	0	0	6	8
Total	32	34	29	26

Source: Modified from PEGASYS, 2013.

Table 3: Details about the basins included in our analysis

	Basins with decentralization undertaken	Basins with decentralization in progress	Basins in Sample	Names of basins included
Mozambique	13		5	Limpopo, Inkomati, Buzi, Save, Pungwe
Kenya		5	1	Lake Victoria
South Africa	2	17	10	Breede-Overberg, Incomati, Olifants/Letaba, Middle Vaal, Upper Orange, Crocodile, Usuthu, Thukela, Mvoti, Limpopo
Swaziland	1	2	2	Komati, Usuthu
Zimbabwe	7		6	Gwayi, Limpopo, Save, Sanyati, Manyame, Mazowe,
Tanzania	9		3	Rufuji, Wami/Ruvu, Internal Drainage
Total in sample	30	26	27	
Total in region (Table 2)	30	36	N/A	N/A

Note: While some similar basin names can be found in different countries, each represent a different RBO, with no physical or institutional interaction between these RBOs.

Table 4: Decentralization process

Dependent Var. / Independent Var.	WUAs Involvement	RBO Created	Institutions Dismantled
Budget per Capita	NI	NI	NI
Creation Bottom-Up	+	+	+
Disputes over allocation	-	+	NI
Governing Body	NI	NI	NI
International Treaty	+	+	+
Political Cost	+	+	+
Relative water scarcity	NI	+	+
Share of surface water	NI	NI	+
Water flow fluctuates	NI	NI	+
WUA Involvement	NI	NI	NI
Years Decentralization	-	NI	NI

NI=Not included

Table 5: Decentralization performance

Dependent Var. / Independent Var.	Success over Objectives	Problems after Decentralization
Budget Per Capita	NI	+
Creation Bottom Up		+
Disputes over Allocation	NI	NI
Governing Body	+	NI
Institutions Dismantled	NI	NI
International Treaty	+	NI
Political Cost	-	-
RBO Created	NI	NI
Relative Water Scarcity	NI	NI
Share of SW	+/-	NI
Water Flow Fluctuates	-	NI
WUA Involvement	NI	NI
Years Decentralization	+	NI

NI=Not included

Table 6: Descriptive statistics of variables included in the analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
River basin part of an international basin	25	0.68	0.4760	0	1
Does water flow in basin fluctuates across the year	25	0.76	0.4358	0	1
River basin resources equitably distributed	25	0.16	0.3741	0	1
Budget per capita	17	6.6131	15.7686	0.1785	66.4250
Forum to solve dispute	23	1.0869	0.4170	0	2
Governing Body	22	4	1.661	1	6
Method of Creation	27	1.5925	0.5007	1	2
Creation Bottom-Up	27	0.4074	0.5007	0	1
Creation Top-Down	27	0.5925	0.5007	0	1
Existence of political cost	25	3.56	1.3868	0	5
Relative water scarcity	17	0.5230	0.3308	0.0864	1.5
Share surface water	23	4.4781	0.9472	1	5
Water Users Association involvement	24	1.6666	1.007	1	5
Year of creation	18	1999	7.3163	1979	2009
Years of decentralization	23	9.4782	6.4938	2	30
RBO created	25	0.800	0.4082	0	1
Institutions dismantled	17	0.5882	0.5072	0	1
Disputes over quality	23	0.5217	0.5107	0	1
Disputes over allocation	23	0.3478	0.4869	0	1
Problems before decentralization (PC variable)	15	2.41e-09	0.9482	-2.3690	2.4236
Problems after the decentralization (PC variable)	10	-1.34e-08	0.9765	-1.1872	1.3384
Success over objectives (redefined)	16	5.4375	1.6720	3	9

Note: The two PC variables, Problems before decentralization and Problem after decentralization can yield negative values at the lowest range.

Table 7: Decision-making in water management at various levels before and after decentralization

Activity	**Before**	**After**	**t-Statistic**
Water Administration			
Local	2.235	2.692	0.8785
Basin	1.611	3.733	6.0498***
State	2.875	3.125	0.3369
Central Government	3.950	2.533	-2.7947***
Infrastructure Financing			
Local	1.917	2.400	0.9659
Basin	1.286	2.714	2.4019**
State	3.222	3.125	-0.1453
Central Government	4.714	4.667	-0.1166
Water Quality Enforcement			
Local	1.500	1.800	0.7069
Basin	1.529	3.273	3.7063***
State	2.750	2.500	-0.4229
Central Government	4.000	3.286	-1.8609*
Setting Water Quality Standards			
Local	1.200	1.000	-0.5311
Basin	1.333	2.333	2.3094**
State	2.083	2.714	0.9073
Central Government	4.600	4.571	-0.1031

Note: ***p < 0.01; **p < 0.05; *p < 0.10.

Table 8: Changes in severity of various water management issue between before and after decentralization

Problem Item	**Before**	**After**	**t-Statistic**
Floods	0.9545	0.7222	1.5396+
Water Scarcity	1.0952	0.4705	3.6246***
Environmental Quality	1.1052	0.2666	3.5794***
Water Conflicts	1.3888	0.2666	4.5825***
Land Degradation	1.0500	0.7500	1.6771*
Development Issues	1.3333	0.6153	3.5257**

Note: ***p < 0.01; **p < 0.05; *p < 0.10; +p < 0.15. We included also coefficients with level of significance of 15 percent to accommodate results that are influenced by the small number of observations.

Table 9: Estimated features of the decentralization process

Estimation procedure	OLS	OLS	LPM	LPM	LPM
Explanatory Variable	WUAs Involvement	WUAs Involvement	RBO Created	RBO Created	Institutions Dismantled
Political Cost	1.1071 (4.41)***	1.1068 (5.00)***	0.4717 (3.32)**	0.5731 (4.79)***	0.2062 (4.04)**
Creation Bottom-Up	-1.0336 (2.19)*	-1.1089 (2.61)**	-0.2495 (3.36)**	-0.3075 (4.90)***	-0.0859 (7.99)**
Years Decentralization	-0.3671 (5.11)***	-0.36361 (5.73)***			
Disputes over allocation	-1.0308 (2.23)**	-0.8469 (1.98)*	0.4499 (3.22)**	0.7309 (4.67)***	
Relative water scarcity			0.9017 (3.16)**	1.1600 (4.84)***	0.9306 (14.08)***
Share of surface water					0.1589 (13.30)***
International Treaty		0.7457 (1.78)+		0.2751 (1.99)+	0.1759 (5.20)**
Water flow fluctuates					0.7785 (11.71)***
Constant	1.6701 3.03	1.0635 (1.75)+	0.8078 (2.97)**	0.5119 (2.15)*	-0.7899 (9.10)**
Number of obs	16	14	11	10	9
F-test	7.42	6.83	5.18	8.4	285.08
Prob > F	0.0038	0.0091	0.0377	0.0302	0.0035
R-squared	0.7295	0.8103	0.7754	0.9131	0.9988
Adj R-squared	0.6312	0.6918	0.6257	0.8045	0.9953

Note: Absolute value of t-statistics in parenthesis. + significant at 15%,* significant at 10%, ** significant at 5% , *** significant at 1%.

Table 10: Estimated decentralization performance equations

Estimation procedure	OLS	OLS	OLS	OLS
Dependent Variable	Success over Objectives	Success over Objectives	Success over Objectives	Problems after Decentralization
Share of surface water	0.5967 (3.39)**	0.5868 (10.37)***	0.5931 (9.74)***	
Years Decentralization	0.1928 (3.18)**	0.1395 (6.31)***	0.1450 (6.21)***	
Political Cost	-1.1042 (7.38)***	-1.0192 (20.25)***	-1.0093 (16.80)***	-1.0715 (8.50)***
Governing Body	0.9838 (6.18)***	0.9541 (18.72)***	0.9483 (15.83)***	
Creation Bottom Up				7.2967 (8.04)***
Budget per Capita				0.9797 (7.79)***
Water Flow Fluctuates		-0.1080 (0.75)		
International Treaty			-0.0120 (0.10)	
Constant	1.6087 (1.2)	2.1236 (4.37)**	1.9694 (4.02)**	-3.6314 (5.31)***
Number of obs	10	9	9	7
F-test	33.71	276.39	233.62	26.84
Prob > F	0.0008	0.0003	0.0004	0.0114
R-squared	0.9642	0.9978	0.9974	0.9641
Adj R-squared	0.9356	0.9942	0.9932	0.9282

Note: Absolute value of t-statistics in parenthesis. + significant at 15%,* significant at 10%, ** significant at 5% , *** significant at 1%.

Annex 1: The final RBOs included in the analysis

River basin organization	Country
Lake Victoria	Kenya
Ara Sul Limpopo	Mozambique
Ara Centro Buzi	Mozambique
Ara Centor Pungue	Mozambique
Ara Centro Save	Mozambique
Ara Sul Inkomati	Mozambique
Komati River Basin Authority	Swaziland
Usuthu River Basin Authority	Swaziland
Breede Overberg Catchment Management Agency	South Africa
Inkomati Usuthu Catchment Management Agency	South Africa
Crocodile West Marico Proto Catchment Management Agency	South Africa
Upper Orange Proto Catchment Management Agency	South Africa
Mvoti to Umzimkulu Proto Catchment Management Agency	South Africa
Middle Vaal Proto Catchment Management Agency	South Africa
Tukela Proto Catchment Management Agency	South Africa
Usutu to Mhaltuze Proto Catchment Management Agency	South Africa
Olifants Proto Catchment Management Agency	South Africa
Limpopo Proto Catchment Management Agency	South Africa
Rufiji Basin Water Board	Tanzania
Wami Ruvu Basin Water Board	Tanzania
Internal Drainage Basin Water Board	Tanzania
Gwayi Catchment Council	Zimbabwe
Manyame Catchment Council	Zimbabwe
Mazowe Catchment Council	Zimbabwe
Mzingwana Catchment Council	Zimbabwe
Sanyati Catchment Council	Zimbabwe
Save Catchment Council	Zimbabwe

Source: PEGASYS (2013:33).

Annex 2: Original variables in the dataset and construction of other

Name of the Variable	Definition	Categories
1.barea	area of river basin in square km	
2.ptotal	total population in the river basin	
3.%rural	percentage rural population in the river basin	
4.precipation	annual precipitation / rainfall in mm	1=100mm-200mm, 2=300mm-400mm, 3=500mm-600mm, 4=700mm-800mm, 5=900-100, 6=1000-1100, 7=1200-1300, 8=1400-1500, 9= 1600-1700, 10= 1800-1900, 11= 2000-2100, 12= 2200-2300, 13= 2400-2500, 14= 2600-2700, 15= 2800-2900
4.evapotransp	annual evapotranspiration in mm	1=100mm-200mm, 2=300mm-400mm, 3=500mm-600mm, 4=700mm-800mm, 5=900-100, 6=1000-1100, 7=1200-1300, 8=1400-1500, 9= 1600-1700, 10= 1800-1900, 11= 2000-2100, 12= 2200-2300, 13= 2400-2500, 14= 2600-2700, 15= 2800-2900
5.wresources	river basin water resources in million cubic meters p/y	
6.countriesshare	number of countries sharing river basin	
7.iyeadecentr	period over which decentralization occurred in years	
8.iyearrbo	year of creation of river basin	
9.iobjectwaterconflict	water conflict as RBO objective	0 = No, 1 = Yes
9.iobjectflood	flood control as RBO objective	0 = No, 1 = Yes
9.iobjectwaterscarcity	water scarcity as RBO objective	0 = No, 1 = Yes
9.iobjectothers1,2,3,	other objective	0= n/a,1 = pollution,2 = water resources management,3 = water quality,4 = hydropower,5 = planning,6 = stabilization of aquifer,7 = conservation,8 = water allocation/ distributiion,9 = development

		schemes,10 = public awareness,11 = resource evaluation,12 = maintenance,13 = water management education,14 = hydrological work,15 = sanitation and water supply,16 = watershed conservation,17 = improve efficiency,18 = navigation,19 = flood control,20 = water scarcity,21 = water conflicts,22 = water utilization,23 = recreation,24 = dam safety,25 = river administration
10.ifloodscale	measurement of success against objectives	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
10.iwaterscarcescale	measurement of success against objectives	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
10.iwaterconflictscale	measurement of success against objectives	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
10.iother1scale	measurement of success against objectives	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
10.iother2scale	measurement of success against objectives	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
11.ibody	governing body of river basin organsiation	0 = “N/A”,1 = “Federal”,2 = “State Authority”’3 = “State owned company”,4 = “Regional Authority”,5 = “Regional Board/Council/Committee”, 6=3 and 5
12.igover-body-selct	selection process of governing body of the river basin - Nominated	1= ‘N/A’ 2= ‘Federal Government’ 3= ‘State’ 4= ‘Local Government’

		5= ‘Users
12.igover-body-selct	selection process of governing body of the river basin - Appointed	1= ‘N/A’ 2= ‘Federal Government’ 3= ‘State’ 4= ‘Local Government’ 5= ‘Users
12.igover-body-selct	selection process of governing body of the river basin - Designated	1= ‘N/A’ 2= ‘Federal Government’ 3= ‘State’ 4= ‘Local Government’ 5= ‘Users
14.icreationrbo	method of RBO creation	0 = “N/A”,1 = Bottom-up”,2 = Top-Down
15.iinstdismantled	institutions dismantled in decentralization process	0 = n/a, 1= Ministry/ Department of Water, 2= Irrigation Boards, 3= Regional Water Authority, 4= Local Authority, 5= River boards, 6= Administration court, 7= UDAH
16.iinewinstitution	new institutions that had to be created in decentralization process	0 = n/a, 1= Ministry/ Department of Water, 2= Irrigation Boards, 3= Regional Water Authority, 4= Local Authority, 5= RBO/ water user associations/ catchment council
17.icostdecentinstitutions	cost of the decentralization process	0 = none, 1=low, 2=low medium 3=medium, 4=medium high, 5=high
18.iforumsyesno	do forums exist for hearing disputes	0 = No, 1 = Yes
19.iissuesresolved	main types of disputes/issues that usually need resolving	0= n/a, 1= water quality, 2=waste disposal, 3= deforestation, 4=erosion, 5=agricultural practices, 6=basin infrastructure, 7=ground water pollution, 8= floods, 9= water allocation, 10= Siltation, 11= water use/ legal/illegal, 12= All, 13=1-2-5
20.iwaterassociations	degree of involvement of water user associations	0= n/a,1 = 0%, 2=25%, 3= 50%, 4= 75%, 5= 100%

20.iwaterassociationsyesno	have water user associations been established	0 = No, 1 = Yes
21.itypesinfrustcanal	quantity of canals in the basin	
before		
25.indprobbfloods	level of flooding problems before establishment of RBO	1 = no response,2 = no problem,3 = some problem,4 = severe problem
25.indprobbwaterscarcity	level of water scarcity problems before establishment of RBO	1 = no response,2 = no problem,3 = some problem,4 = severe problem
25.indprobbenvquality	level of environmental quality problems before establishment of RBO	1 = no response,2 = no problem,3 = some problem,4 = severe problem
25.indprobbwaterconflicts	level of water conflict problems before establishment of RBO	1 = no response,2 = no problem,3 = some problem,4 = severe problem
25.indprobblanddegrad	level of land degradation problems before establishment of RBO	1 = no response,2 = no problem,3 = some problem,4 = severe problem
25.indprobbdevelpissues	level of problems with development issues before establishment of RBO	1 = no response,2 = no problem,3 = some problem,4 = severe problem
25.othername	other problems (before and after) the establishment of RBO	0 = n/a,1 = water mgt issues and authority crises,2 = Env. Awareness,3 = Organization,4 = Hydropower,5 = Water Supply,6 = Drought
25.indprobbother	level of other problems before establishment of RBO	1 = no response,2 = no problem,3 = some problem,4 = severe problem
after		
25.indprobafloods	level of flooding problems after establishment of RBO	-1 = situation worsened, 0 = situation the same, 1 = situation improved
25.indprobbwaterscarcity	level of water scarcity problems after establishment of RBO	-1 = situation worsened, 0 = situation the same, 1 = situation improved
25.indprobbenvquality	level of environmental quality problems after establishment of RBO	-1 = situation worsened, 0 = situation the same, 1 = situation improved
25.indprobbwaterconflicts	level of water conflict problems after	-1 = situation worsened, 0

	establishment of RBO	= situation the same, 1 = situation improved
25.indprobblanddegrad	level of land degradation problems after establishment of RBO	-1 = situation worsened, 0 = situation the same, 1 = situation improved
25.indprobbdevelpissues	level of problems with development issues after establishment of RBO	-1 = situation worsened, 0 = situation the same, 1 = situation improved
25.indprobbother	level of other problems after establishment of RBO	-1 = situation worsened, 0 = situation the same, 1 = situation improved
26.iadmblocal	percentage of water administration decision making at local level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iadmbbasin	percentage of water administration decision making at basin level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iadmbstate	percentage of water administration decision making at state level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iadmbgov	percentage of water administration decision making at government level RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinblocal	percentage of infrastructure financing decision making at the local level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinbbasin	percentage of infrastructure financing decision making at the basin level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinbstate	percentage of infrastructure financing decision making at the state level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinbgov	percentage of infrastructure financing decision making at the government level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ienfblocal	percentage of water quality enforcement decision making at the local level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ienfbbasin	percentage of water quality enforcement decision making at the	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 =

	basin level before RBO	60%-79%, 5 = 80%-100%
26.ienfbstate	percentage of water quality enforcement decision making at the state level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ienfbgov	percentage of water quality enforcement decision making at the government level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsblocal	percentage of the setting of water quality standards decision making at the local level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsbbasin	percentage of the setting of water quality standards decision making at the basin level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsbstate	percentage of the setting of water quality standards decision making at the state level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsbgov	percentage of the setting of water quality standards decision making at the government level before RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iotherblocal26	percentage of decision making for other responsibilities at the local level before the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iotherbbasin26	percentage of decision making for other responsibilities at the basin level before the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iotherbstate26	percentage of decision making for other responsibilities at the state level before the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iotherbgov26	percentage of decision making for other responsibilities at the government level before the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iadmalocal	percentage of water administration decision making at the local level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iadmabasin	percentage of water administration decision making at the basin level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-

		100%
26.iadmastate	percentage of water administration decision making at the state level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iadmagov	percentage of water administration decision making at the government level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinalocal	percentage of water administration decision making at the local level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinabasin	percentage of infrastructure financing decision making at the basin level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinastate	percentage of infrastructure financing decision making at the state level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ifinagov	percentage of infrastructure financing decision making at the government level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ienfalocal	percentage of water quality enforcement decision making at the local level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ienfabasin	percentage of water quality enforcement decision making at the basin level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ienfastate	percentage of water quality enforcement decision making at the state level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.ienfagov	percentage of water quality enforcement decision making at the government level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsalocal	percentage of the setting of water quality standards decision making at the local level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsabasin	percentage of the setting of water quality standards decision making at the basin level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsastate	percentage of the setting of water	1 = 0%-19%, 2 = 20%-

	quality standards decision making at the state level after the creation of RBO	39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.istdsagov	percentage of decision making on setting of water quality standards at the government level after creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iothername	other responsibilities	1 = Quality objectives,2 = Operation and Maintenance, 3 = Management, 4 = Planning,5 = Water Supply
26.iotheralocal	percentage of the decision making for other responsibilities at the local level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iotherabasin	percentage of the decision making for other responsibilities at the basin level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iotherastate	percentage of the decision making for other responsibilities at the state level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
26.iotheragov	percentage of the decision making for other responsibilities at the government level after the creation of RBO	1 = 0%-19%, 2 = 20%-39%, 3 = 40%-59%, 4 = 60%-79%, 5 = 80%-100%
27.wrmibwatertypes	water rights after RBO existence	0 = None,1 = Permanent Rights,2 = Long-Term use concession (> 10 yrs),3 = Short-Term use concession (<10 yrs),4 = Permanent Transferable,5 = Permanent non-transferable
28.wrmibresponsiblerigths	responsibility for awarding water rights before RBO existence	0 = n/a,1 = Federal,2 = National Agency,3 = State/Provincial,4 = Regional Organization,5 = Local Government,6 = River Basin Organization
29.wrmibresponsibleallocation	responsibility for water allocation before RBO existence	0 = n/a,1 = Federal,2 = National Agency,3 = State/Provincial,4 = Regional Organization,5 = Local Government,6 = River Basin Organization

30.wrmibresponsiblemodfore	responsibility for modeling and forecasting water availability before RBO existence	0 = n/a,1 = Federal,2 = National Agency,3 = State/Provincial,4 = Regional Organization,5 = Local Government,6 = River Basin Organization
31.wrmibresponsiblemonit	responsibility for monitoring and enforcement of water quality before RBO existence	0 = n/a,1 = Federal,2 = National Agency,3 = State/Provincial,4 = Regional Organization,5 = Local Government,6 = River Basin Organization
32.wrmiaresponsibletariff	responsibility for collecting tariffs after RBO existence	0 = n/a,1 = Federal,2 = National Agency,3 = State/Provincial,4 = Regional Organization,5 = Local Government,6 = River Basin Organization
53.part-intl-bsn-treaty	river basin part of an international basin	0 = No, 1 = Yes
54.flow-var-flact-overtime	does water flow in basin fluctuate across the year	0 = No, 1 = Yes
55.res-dist-equal-bfor-decentr	river resources equitably distributed	0 = No, 1 = Yes
56.bfor-ben-2-gov	who benefited most before rbo	1 = federal government, 2 = local leaders, 3= commercial farmers, 4 = small farmers
57.res-dist-equal-aftr-decentr	basin resources equitably distributed after RBO	0 = No, 1 = Yes
58.ftr-ben-2-gov	who benefited most after rbo	1 = federal government, 2 = local leaders, 3= commercial farmers, 4 = small farmers

Annex 3: Definition of created variables

Name of the Variable	Definition	Categories
budgetbas	Budget of the basin	
budgetextra	Share budget of the basin allocated by external agency	
budgetperca	The budget of the basin in per capita terms	
formsdispute2	Existence of dispute resolution institutions	
governbody	Governing body of the RBO	Higher values express more centralization: 5=Federal, 4=State Authority, 3=State owned company, 2=Regional Authority and 1=Regional Board/ Council/Committee
methodcrea	The way the RBO was created	N/A = 0, Bottom Up = 1, and Top Down = 2
methodbottom	If the RBO was a Bottom-Up creation	1 = Bottom-Up creation, 0 = otherwise
methodtop	if the RBO was a Top-Down creation	1 = Top-Down, 0 = otherwise
polcost	The political cost of the decentralization process via the creation of new institutions	0 = none, 1=low, 2=medium low, 3=medium, 4=medium high, 5=high
popdensity	Number of people per square kilometer (ratio inhabitants to basin area)	
scarcity1	The ratio between rainfall and evapotranspiration	
sharesw	The share of surface water in the available water resources in the basin	

wuainvol	The degree of WUA involvement and participation	
yearcreation	The year in which the RBO was created	
yearsdecen	The length of the decentralization process	
budgetspent	Variable for budget spent in the basin	fbudgetinvestmentbasin+fbudgetotheractivities+fbudgetom+fbudget waterquality+fbudgetother
inscreatedrbo	dummy if it is a RBO/Water User Association/Catchment Council is created	1 = RBO/Water User Association/Catchment Council, 0 = otherwise
insdismantmin	dummy if a Ministry/Water Department was dismantled	1 = Ministry/Water Department was dismantled, 0 = Otherwise
dispquality	dummy variable for quality issues	1 = water quality or waste disposal, 0 = Otherwise
dispallocation	dummy variable for allocation issues	1 = water allocation or water use/ legal/illegal, 0 = otherwise
budgetsrcs	budget sources	Share of external agency plus share from stakeholders plus share from other sources
budgetsrcspc	budget sources computed by Principal components	principal components of budget from external agency, stakeholders and other sources
budgetagency	Share of budget sources from external agency	
budgetstake	share of budget from stakeholders	
usergroup	Variable for the Existence of user groups computed by principal components	The components are calculated from wrmiusersgroup1 wrmiusersgroup2 wrmiusersgroup3
improvedresp	Improved responsibility computed as a principal component as differences	Before and after variables on water rights, allocation, monitoring, forecasting and collecting tariffs as defined in the original dataset

	between before and after	
increimprovement	incremental improvement variable computed by principal component from before and after	Flooding, scarcity, environmental quality, conflict, land degradation, development issues before and after the RBO
incretasks	incremental tasks computed as a principal component variable	Water administration, infrastructure financing, quality enforcement and standards setting before and after the RBO
problembefore	problems before decentralization computed by a principal component	Floods, water scarcity, environmental quality, water conflicts, land degradation and development issues before the RBO
problemafter	problems after the decentralization computed by a principal component	Floods, water scarcity, environmental quality, water conflicts, land degradation and development issues after the RBO
sectorshare	Sector Use Shares computed as a principal component	existence of irrigation, industrial, domestic, hydropower and environmental uses/applications water users in the basin
successobjective	Success over Objectives computed as a principal component	scale of success over floodscale, water scarcity, water conflict, other objective1 and other objective2
userspaying	Variable for Users' Pay computed as a principal component	percentage of irrigation, industry users who pay tariff and domestic users paying tariff
budgetspent1	budget spent computed as an aggregation	development, investment and water quality budget
maxsector	Maximum number of sectors in the RBO	existence of irrigation, industrial, domestic hydropower environmental uses/applications in the basin
allsector	dummy variable if the basin has all sector	1 = all sector, 0 = otherwise
goodallsuccess	aggregation of the success on floods, scarcity and water problems	aggregation of the success on floods, scarcity and water problems
userspayadd	Aggregation of the users' groups paying the tariff	irrigation, industry users and domestic users paying the tariff