Equitable Allocation of Water: Effectiveness of River Basin Game

Wilfred Clement Kayombo[1], Prof. Siza. D. Tumbo[2],

[1]Regional Irrigation Advisor, Economic and Productive Sectors, Mbeya, Tanzania,
[2]Professor, Department of Agricultural Engineering and Land Planning,
Sokoine University of Agriculture, Morogoro, Tanzania

***Abstract*—A dialogue approach was utilized using the River Basin Game (RBG), a tool that aids decision-making process. The aim was to assess effectiveness of RBG in facilitating Equitable Allocation of Water (EAW) by comparing communities with and those without RBG. Structured questionnaire was adopted, and data analysed using Statistical Package for Social Sciences (SPSS), Cross tabulation designs and test statistics. Key findings indicated that communities with RBG had implemented 66.6% of strategy to improve local water management institutions. However, despite significant differences in improving intakes ($P<0.01$), and reduction in number of Livestock ($P=0.04$) there was no significant difference in implementing strategies on improving performance of infrastructure and water saving for EAW. RBG was effective in creating awareness and improving local water management institutions. There is a need to intensify use of RBG and explore possibilities of promoting it for sustainable management of river water resources in small river basins particularly in developing countries like Tanzanania.**

***Keywords* — Component, Rufiji River Basin, Sub-catchment, River System, Decision Making Process, Sustainable.**

I. INTRODUCTION

Water is a basic natural resource, which sustains other resources and provides for various needs but is unevenly distributed. Often, we cannot find water in the right place, at the right time, and in the right quantity and quality. Giving proper regard to this, the second World Water Forum acknowledged the pivot role that integrated water resource management (IWRM) plays in the process of sustainable development. The term “integrated” embraces planning and management of water resources: conventional and non-conventional (De Wrachien and Fasso, 2002).

IWRM requires that there should be awareness and equity in water management. Recent studies (Kayombo, 2016, Sokile et al., 2003 and Kossa et al., 2006) have shown that most farmers in improved traditional irrigation schemes are diverting and conveying more water than required. EAW is a step forward towards an integrated approach; it takes into account the economic, social and ecological factors as a whole and aims for a balance (McCaffrey, 2001). In the context of small river basins, which are major sources of water for, among others; irrigation and livestock sectors in Tanzania, deliberate participatory efforts are needed to enable stakeholders be part of the decision making process.

There are several constraints and potentials for intersectoral water management in Tanzania (Kashaigili et al. 2003). Major driving factors are a growing population, economic development, improved living standards and increasing demands that call for the need to improve EAW. According to GWP (2000) meaningful participation occurs when local water users come together to formulate supply, management and use choices. To change the distribution of water between sectors in river basins needs the resolution to among others; establish a strategy for water allocation. The approach may either be top down or bottom up depending on the execution process. Since 2002 (Lankford et al., 2004 and Lankford and Sokile, 2004) Mkoji subcatchment, has implemented a bottom up approach using a dialogue tool, the River Basin Game (RBG). This is a role-playing board that has a physical representation of a catchment with upstream and downstream intakes. Participants attempt to hoard glass marbles, acting as flowing water, as they seek to gain a livelihood, often depriving downstream users of their ‘water’. By the end of the game, participants have a good understanding of what is going on, what needs to be targeted and what solutions might be considered. The game becomes highly animated. The play is followed by discussions on lessons learnt from the play, what needs to be done, by whom and how to bring together various institutions to assist in improving EAW.

RBG was invented by Bruce Lankford and initially developed as a teaching tool for students in 2000 at the University of East Anglia (Mabiza, 2006). In 2002 RBG was proposed by the project: Raising Irrigation Productivity and Releasing Water for Intersectoral Needs (RIPARWIN) as a new approach in the country that would involve water users in conflict resolution and finding solutions to problems brought about by dwindling water supplies. The aim of this approach was to create a harmonized environment for water users from different sectors to come together and talk about how to share water. In Mkoji sub-catchment several river systems used and others that did not use the RBG. Investigating and comparing the use of RBG strategies in communities with and without RBG can give a picture on the extent of EAW, hence the effectiveness of RBG in facilitating EAW. The objective of this study is to present the effectiveness of RBG in facilitating implementation of strategies on EAW, which may help in managing small river basins effectively

Fig 1: Role Playing using the River Basin Game

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II. RESEARCH METHODOLOGY

Selection of the Study Area

This study was done in 8 villages and 4 river systems of Mkoji subcatchment namely: (a) With RBG; Mahongole, and Mwatenga (Mlowo river), and Mambi and Luhanga (Mambi river). (b) Without RBG; Ilongo and Nsonyanga (Mkoji river), and Igurusi and Mpolo (Mpolo river) (Fig. 2). Selection of the area was based on the fact that the area used the RBG since 2002. In addition the area is characterized by intersectoral water uses that include irrigation, livestock, hydropower and fisheries.

Research Approach

The study took a quantitative approach with an extensive use of key informant interviews, and secondary data. People's perceptions and behaviors in sharing water resource, at river scale, were investigated. There was therefore a need to analyze the uniqueness of the case being studied in order to systematically examine the processes that brought forth the present water allocation practices. This was done by investigating communities with and without RBG in Mkoji subcatchment of the Great Ruaha River.

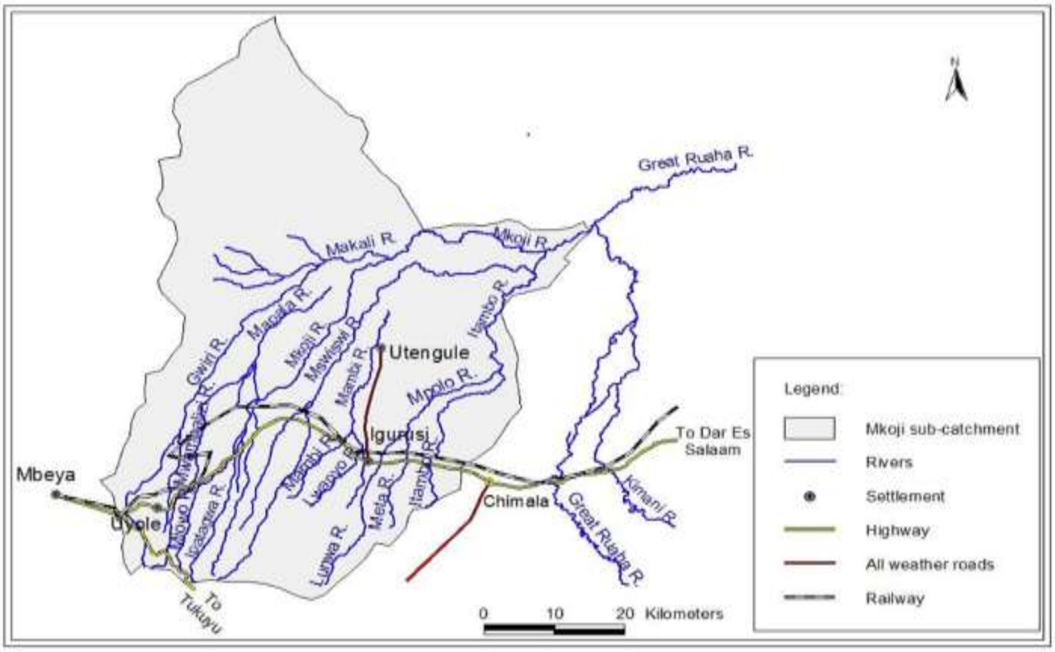

Figure 2: Small River basins in Mkoji subcatchment, Source, SWMRG (2006)

Data Collection

Multistage sampling procedure and simple random sampling technique was used to select the sampling units. Reconnaissance survey was conducted to provide a general picture, so as to identify and categorize stakeholders in relation to the study area. During reconnaissance, four small rivers namely; Mpolo, Mkoji, Mlowo and Mambi were selected. Structured questionnaires were used to collect data on implementation of RBG strategies. A representative sample size of 130 out of 2600 households (5%) of the total households under study was adopted.

Key Informant interviews were used to enrich the information obtained from the questionnaire survey. A checklist of open-ended questions was used. In this regard, key informants included the following; River basin water officers, Tutors from Igurusi Agriculture Institute, district officers, village leaders, and ward officers.

Secondary data was obtained from Sokoine University of Agriculture, District water office and Igurusi Agriculture Institute. Online databases and documents were also visited.

Techniques of data interpretation and analysis

Descriptive statistics

Descriptive statistics; means, percentages and frequency of variables were calculated using SPSS. Results were used to construct frequency distribution tables important to simplify interpretation of the results.

Developing scales for EAW

The respondents were asked questions to ascertain their perceptions towards EAW. The responses were recorded in a Likert-style format (Trochim, 2006) as follows: Respondents were asked questions on statements relative to the study that required the following responses, of which each were coded the scale in parenthesis; strongly agree (1); agree(2); undecided(3); disagree(4) or strongly disagree(5). Adding up the scores for the same statements combined the total scores for each statement. Statements with the highest and lowest scores were taken as statements that were accepted or rejected outright by respondents, to compose the scale that was actually used for determination of the perceptions. Responses were grouped into 3 categories namely: Positive, neutral and negative. Statements with intermediate scores were left out since they connoted chances of not being decided.

T-statistic

T-test procedure (Paired t-test) in SPSS was used to compare the means of the intended variables of the two communities. This was necessary because most variables were alphabetic and the test procedure required the variables be numeric.

III. RESULTS AND DISCUSSION

RBG strategies for EAW

Diverse strategies were arrived at during RBG role plays in Mambi and Mlowo communities, which were categorized into three major strategies basing on similar fulfillments. Table 1 shows the major groups and related activities.

Table 1: Major RBG strategies for communities with RBG

Na	Strategies	Related Activities
1	Improve local water management institutions	Water users association, Water schedules and By laws
2	Improve performance of infrastructure	Construction of modern intakes; Maintenance of infrastructure and reduce number of unnecessary infrastructure
3	Improve water saving	Reduce farm size & number of livestock, Grow high value crops & crops that demand less water, Diversify irrigated agriculture

Results in table 2 show comparison of the strategies whereby strategies developed by Mlowo and Mambi communities differed. Mlowo communities developed 87% of the total strategies while Mambi communities developed 60% of the total strategies. However, both communities developed most of the strategies.

Table 2: Comparison of strategies developed by communities of Mambi and Mlowo river systems

Na	Strategy	Mambi river	Mlowo river
1	Reduce farm size	√	X
2	Grow alternative drought resistant crops	√	√
3	Plant fast growing, short duration varieties e.g. Waiwai rice variety	√	X
4	Diversification to other livelihood supporting activities	√	√
5	Form an irrigation and livestock water use association	X	√
6	Implement defined water schedules	X	√
7	Implement defined bylaws to control water abstraction	X	√
8	Improve water saving; decrease farm size and livestock	√	√
9	Canal cleaning	√	√
10	Construct drainage systems	X	√
11	Dig wells to harvest water	X	√
12	Establish and use cropping calendars	√	√
13	Use improved seed varieties	√	√
14	Construct modern intakes	X	√
15	Decrease unnecessary infrastructure	√	√

√ = developed the strategy, X= did not develop this strategy

Barreteau (2003) believes that games and model simulations help set clear boundary conditions and condense complex issues in both space and time, suggesting long-term issues can be readily captured. The current study assessed effectiveness of RBG, a role playing game and results were as follows;

Improve local water management institutions

Formation of WUA: The study revealed that, majority of local communities, with and without RBG, were implementing strategy to form WUA. Table 3 shows more than 61% of communities with and without RBG implemented strategy to form WUA for irrigation and livestock communities. This indicates that community with and without RBG had some arrangements for organised water management. Despite the higher responses for communities without RBG than communities with RBG, most of the irrigation schemes had WUAs. In addition out of Mambi, Mlowo, Mpolo and Mkoji river systems it was only the Mlowo WUA, which was constructed by both livestock and irrigation communities. Thus there are chances that RBG may have influenced implementation of WUA for Irrigation and livestock communities in Mlowo River system.

Water schedules: The current study revealed that WUA in communities with RBG used water schedules more than communities without RBG. Table 3 shows that 83.6% of communities with RBG and 71.7% of without RBG used water schedules. The difference of the positive responses was significant (P=0.037). Moreover, there were more negative responses in communities without RBG than with RBG. Since communities with RBG had a WUA, which operated at river scale, it is plausible that they performed better in river water scheduling. Apart from this, office registers in Mahongole village office revealed that the schedule for water allocation was as follows: Monday and Tuesday; Motombaya intake, Wednesday and Thursday; Langwira farm, Friday; Mhwela village, Saturday and Mwatenga village, Kilambo village and NARCO on Sunday. The results suggest that water users may have improved water distribution. Therefore it is plausible that RBG was effective in facilitating implementation of water schedules. These results are supported by Hagmann and Chuma (2002) who argued that role playing games help key participants understand key natural and social processes (Hagmann and Chuma, 2002).

Bylaws: Implementation of rules (bylaws) for regulating water schedules was higher in communities with RBG. Table 3 shows that 85.2% of communities with and 73.5% of communities without RBG implemented bylaws. Implementation of bylaws did not differ significantly between communities with and without RBG (P=0.083). However, the higher positive responses in communities with and higher negative responses in communities without RBG suggest that it is plausible RBG was effective in facilitating implementation of water schedules.

Table 3: Responses to improvement of local water management institutions in Mkoji Subcatchment

Approach	Response	With RBG		Without RBG	
		Frequency	Percent	Frequency	Percent
Formation of WUA	Positive	50	61.8	35	71.4
	Undecided	7	8.6	3	6.1
	Negative	24	29.6	11	22.5
	Total	81	100	49	100
Implementation of water schedules	Positive	61	83.6	33	71.7
	Undecided	3	4.1	3	6.5
	Negative	9	12.3	10	21.8
	Total	73	100.0	46	100.0
Bylaws for managing water	Positive	69	85.2	36	73.5
	Undecided	3	3.7	3	6.1
	Negative	9	11.1	10	20.4
	Total	**81**	**100.0**	**49**	**100.0**

Improve performance of infrastructure for EAW

In this context improved performance of infrastructure refers to improved intakes, maintenance of infrastructure so as to improve water sharing between water users/uses.

Improved intakes: The study revealed more improved intakes were constructed in communities with RBG than without RBG. Table 4 shows that 72.8% of communities with RBG and 57.1% of communities without RBG constructed improved intake structures. Moreover, the negative responses for communities without RBG were higher than those for communities with RBG. There is a significant difference in implementation of the strategy to "construct improved intakes" between communities with and without RBG ($P<0.01$). These results explain that institutions with RBG were more effective in improving infrastructure for partitioning water than communities without RBG. The results suggest despite improvements in institutions, improved intakes enhance water management. Besides presence of improved intakes, field observations revealed that there were five improved intakes, for communities with RBG and one for communities without RBG. Improved intakes in communities with RBG were; Ipatagwa, and Motombaya and Langwira intakes of Mlowo river system, and Rwanda Majenje and Majengo intake of Mambi river system, while communities without RBG had one improved intake (Meta-lunwa intake) of Mpolo river system. However, key informant interviews revealed that these intakes were constructed before 2002.

Inefficient canals: The number of inefficient canals was highly reduced in communities with RBG than without RBG. Table 4 shows that 44.4% of communities with RBG and 36.7% of communities without RBG reduced number of infrastructure. There was no significant difference in reduction of number of inefficient canals ($P=0.21$). Apart from this, most of the respondents in both communities had higher negative than positive responses. This suggests that RBG may not have been effective in reducing number of canals.

Maintenance of infrastructure: There was a high involvement in maintenance of infrastructure in communities with and without RBG. Table 4 shows that about 71.0% of communities with and without RBG responded positive to maintenance of infrastructure. However, there was no significant difference in response to maintenance of infrastructure. Despite the high perceptions in maintenance of infrastructure, these results suggest that it is plausible RBG was not effective in facilitating maintenance of infrastructure.

Table 4: Response to improvement of performance of infrastructure in Mkoji Subcatchment

Approach	Resp.	With RBG		Without RBG	
		Frequency	Percent	Frequency	Percent
Improved intake structures	Yes	59	72.8	28	57.1
	No	21	26.0	20	40.8
	Missing	1	1.2	1	2.1
	Total	81	100.0	49	100.0
Reduction in number of canals	Positive	36	44.4	18	36.7
	Undecided	8	9.9	5	10.2
	Negative	37	45.7	26	53.1
	Total	81	100.0	49	100.0
Maintenance of infrastructure	Positive	58	71.6	35	71.4
	Undecided	8	9.9	7	14.3
	Negative	15	18.5	7	14.3
	Total	**81**	**100.0**	**49**	**100.0**

Improve water saving for EAW

Farm size: Communities without RBG had reduced farm size more than communities with RBG. Table 5 shows that 43.8% of communities without RBG and 41.0% of communities with RBG perceived implementation of reduction in farm size to be high. However, there was no significant difference in implementing reduction in farm size (P=0.11). From these results it is suggested that both communities had not effectively reduced their farm size. There are chances that RBG was not effective in promoting water saving through reduction of farm size.

Livestock: There was a high reduction in number of livestock in communities with and without RBG. Table 5 shows that 51.3 % of respondents in communities with RBG and 52.1% in communities without RBG perceived reduction in number of livestock to be implemented. Perception to lower rate of implementing reduction in number of livestock was more significant in communities with than without RBG (P=0.04). Basing on these results it is plausible RBG was effective in facilitating implementation of the strategy to "reduce number of livestock". However, key informant interviews and field observations showed that there was a government order that obliged all livestock keepers to reduce their herd to a maximum of 50 per household. This could have positively influenced responses on the number of livestock. It is plausible that respondents were reluctant to indicate the real number of livestock that they owned.

Crops that demand less water: Field observations showed that the major farming activity in the area was wet season paddy farming. Table 5 shows that about 35.1% of communities with RBG and 43.8% of communities without RBG responded to grow crops that demanded less water. There was no significant difference in response to grow crops that demand less water (P=1.00). However, field observations revealed that there were few farmers who had embarked to growing cassava in Mambi and Mlowo river systems. It is plausible that the RBG has not been effective in implementing the strategy to grow crops that demand less water.

High value crops: Most of communities with and without RBG were not involved in growing high value crops. Table 5 shows that 15.6% of communities with RBG and 12.5% without RBG had implemented strategy to grow high value crops. Despite these results being too low yet there was no significant difference in growing high value crops (P=0.716). However, field observations revealed that there were few farmers who had started picking up Paprika farming. This is a crop in the Solanacea family that is scientifically known as Capsicum annum. The crop is a raw material for spice industries. Field observations revealed that irrigators in Mambi river system especially Rwanda Majenje irrigation system were replacing rice fields with Paprika. Paprika fetched higher income than any other crop in the area; about 1200/= per kilo and one acre gave about 40 bags (@30 kgs) and is used as a domestic vegetable and as a raw material in spice industries (Igurusi ward extension officer, personal communication).

***Fish farming*:** Majority of the communities with RBG were implementing fish farming than communities without RBG (Table 5). However the high responses to implementation of fish farming were not significant. During surveys the current study observed that it was uncommon to find fish farming in the area. However, Mambi river system was taking up fish farming, which replaced paddy fields. Since 2004 Mambi river system has invested on 40 fish ponds as a strategy to save water and there is a high potential for fish farming in the area. (Mambi Village Executive Officer, personal communication).

Table 5: Responses to improvement of water saving in the Mkoji subcatchment of GRR in Tanzania

Strategy	Response	With RBG		Without RBG	
		Frequency	Percentage	Frequenc	Percent
Reduction of farm size	High	32	41.0	21	43.8
	Moderate	22	28.2	17	35.4
		24	30.8	10	20.8
	Total	78	100.0	48	100.0
Reduction in number of livestock	High	40	51.3	25	52.1
	Moderate	11	14.1	11	22.9
	Low	27	34.6	12	25.0
	Total	78	100.0	48	100.0
Grow crops that demand less water	High	27	35.1	21	43.8
	Moderate	36	46.7	19	39.6
	Low	14	18.2	8	16.7
	Total	77	100.0	48	100.0
High value crops	High	12	15.6	6	12.5
	Moderate	31	40.3	17	35.4
	Low	34	44.1	25	52.1
	Total	**77**	**100.0**	**48**	**100.0**
Implement fish farming	High	18	22.4	10	20.8
	Moderate	15	18.8	9	18.8
	Low	47	58.8	29	60.4
	Total	**80**	**100.0**	**48**	**100.0**

IV. CONCLUSION AND RECOMMENDATION

The main objective of the study was to determine the effectiveness of RBG on facilitating equitable allocation of water in Mkoji subcatchment of the Great Ruaha River in Tanzania. The previous chapter presented this information. This chapter presents the conclusion and recommendations.

Conclusions

The following conclusions are made from the current study:

(i) Averages of nine strategies were identified in RBG that was executed in three scenarios and can be categorized into three main categories all that aimed at EAW namely: improve local water management institutions, improve performance of infrastructure and improve water saving so as to release more water for intersectoral needs

(ii) Communities with RBG differed significantly in implementing strategies on improvement of local water management institutions and performance of infrastructure for EAW, thus RBG seemed effective in implementing these strategies.

(iii) Improvement of fish farming was significantly higher in communities with than without RBG. Generally there was no significant difference in improvement of water saving and performance of infrastructure, which may imply that there are chances RBG was not effective on strategies to improve productivity of water and performance of infrastructure during the current study.

Recommendations

The study recommends the following:

Communities with RBG

(i) Although communities with RBG already provide a platform for being involved in water management at river scale there is a need for this to be geared towards intensification of sustainable EAW.

(ii) Any planned interventions which provide water from rivers, must cooperate with the communities in this context.

(iii) Efforts have to be made to encourage investment on awareness education and more RBG scenarios should be used, hand in hand with other strategy to review and shape plans for implementing EAW. Moreover local best awareness education practices such as traditional meetings, local government meetings, and family groups should be encouraged.

(iv) RBG strategies need be developed by specific water use groups to suit their environment and not copied from any other communities. Thus communities, which benefit from a common river, should organize themselves for their own good.

(v) Communities with RBG should intensify actions on improving EAW. Activities that emerged from the RBG should be investigated in detail so as to judge their role in promoting water conservation and income generation in local communities that share small river basins.

Communities without RBG

(i) As the strategies for improving EAW take place, communities without RBG should learn from those with RBG. They should promote EAW by encouraging inter-river water use negotiations for planning on how to improve EAW.
(ii) A gap exists on performance of EAW between communities. It is proposed that there is a need to bridge this gap and raise awareness of communities without RBG.
(iii) Future investment for water development should base on a process of stakeholder dialogue that incorporates tools and methodologies for EAW. Research into possibilities of improving river scale water management in communities without the RBG is necessary.
(iv) Awareness on the need for sound EAW should be created in communities without RBG starting with the strategically potential local leaders e.g. village leaders, leaders of traditional groups, and water management leaders.
(v) A WUA should be formed at river scale in communities without RBG. This would bring together all stakeholders.
(vi) The GVT should embark on dissemination of RBG approaches in development of water sharing technologies.

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