WATER USE CONFLICTS IN NORTHERN TANZANIA. A CASE STUDY OF RUNDUGAI RIVER CATCHMENT, PANGANI BASIN HAI DISTRICT

Ntilicha[1], M., Kilungu[2], H. and Munishi[1], P. K.T.

[1]Department of Forest Biology, Sokoine University of Agriculture,
P.O. Box 3010, Morogoro

[2] Department of Tourism and Hospitality, Open University of Tanzania,
P.O. Box 23409, Dar es Salaam, Tanzania

ABSTRACT

Water use conflicts in Tanzania have been identified as serious problems especially in highly populated and land scarce areas. Rundugai river catchment in Kilimanjaro region is one of the areas which are currently experiencing high water use conflicts. The overall objective of this study was to assess water use conflicts in this catchment. Household surveys through questionnaires and focus group discussions were used to collect data from four villages around the catchment. Furthermore, participant observation and secondary data sources were used to supplement information. Statistical Package for Social Sciences (SPSS) program was used to analyze quantitative data whereas content and structural-functional analysis techniques were used for qualitative data analysis. Five types of key stakeholders/actors involved in regulating and negotiating access to water resource were identified including Farmers, Village government, Pastoralists, TEGEMEO water users association and Pangani water basin. Crop production and animal husbandry were the major land uses pursued by local people around the catchment. Water use conflicts among farmers, between farmers and pastoralists were the most serious conflicts identified in the study area. Majority of the respondents believed that population increase, water scarcity, inadequate participation by local community in the management of water resources, irregularity in scheduling water for irrigation were the main causes of water use conflicts in the study area. Logistic regression analysis revealed that the socio-economic factors that significantly influenced water use conflicts in the catchment included age, farm size and gender. This study concluded that farmers versus farmers' conflicts were prominent in the study area and the existing water use conflicts are basically due to human population increase and water scarcity which made local communities to compete for water eventually leading into conflicts. The study calls for integrated approaches in setting appropriate playing ground for different users to develop sustainable conflict management strategies over water use in the area.

Key Words: Water use conflicts; Rundugai Catchment; Hai District

INTRODUCTION

Water is a basic natural resource that sustains life and provides various social and economic needs. It is one of the most important constraints in the sustainable development of Africa's dry lands. It is a vital ingredient in agriculture, livestock husbandry, (agro) industry as well as in domestic activities (Munishi 2000). Yet in many societies water is taken for granted and it is assumed to be an inexhaustible natural resources. For this reason, individual water users are more conscious of using water rather than conserving the resource. Presently, water resource globally is becoming scarce as a result of population pressure, economic activities, institutional arrangements, a changing value system, policies, poverty and general awareness of the stakeholders (Desloges and Gauthier 1996). As a steady increase both in population, agricultural and industrial activities has shown that water as a resource is no longer available on and ad-lib basis (Usman, 2001), and water levels in many parts of the world are low and getting lower (SPORE 1995). Destruction of water sources has resulted into water source discharge to decline resulting into further limited supply (Mbuya, 2004). This situation of limited supply of water has made individual water users to compete for water to meet their basic needs (Nsolomo *et al*. 1997).

A study by Cosgrove *et al.* (2000) revealed that the world population has tripled in the past century and water use for human purposes has increased six-fold. As human population grows, water becomes scarce and, therefore, people compete for this resource to enhance their livelihoods (Anderson *et al.* 1998). Based on assumptions of population growth, projections of development and climate change, the Stockholm Environmental Institute estimated that the proportion of the world's population living in countries with significant water stress would increase from approximately 34% in 1994 to 63% in 2025, including large areas of Africa, Asia, and Latin America. This will impact their lives and livelihood (DID 2001). In Africa, the expanding human population is increasingly intensifying the pressure on the available resources, resulting in conflicts and threats to environment and future livelihoods of the people (GIWA 2004; Payet and Obura 2004). In addition, fragmented planning and management, lack of integrated approaches and conflicting sectoral policies have exacerbated the conflicts over water use (URT 1995). Also, climatic conditions, such as global warming, may worsen the situation.

Conflicts over water resources differ from one area to another due to the fact that water is unevenly distributed, both temporally and spatially. Frequent and regular rainfall in some regions contrasts sharply with prolonged droughts than others. Some regions are blessed with abundant freshwater while others face serious scarcity. Moreover, water resources of the world are not partitioned to match the political borders (Gleick *et al.* 2005). Thus the distribution and use of limited resources can create conflicts at local, regional, and even international level (Gleick *et al.* 2005). Conflict is a function of competing demands and different values attached to resource base by different categories of users. Competition over natural resources such as water has the potential of leading to conflicts among users (Chenier *et al*. 1999). The intensity of conflict over resources may vary from confusion and frustration among members of a community over poorly communicated development policies to violent clashes between groups over resource ownership rights and responsibilities (Chenier *et al*. 1999; Suliman 1999). These conflicts have many negative impacts as valuable resources are diverted to its management at the expense of provision for basic needs (Omosa 2005).

On the other hand, the history shows and future may confirm that water has a strategic role in conflicts among different stakeholders (Gleick 1993). Stakeholders may have different levels of influence on the water resources due to diverse interests and power. Struggle of a stakeholder for a higher water allocation may increase displeasure of the others and in turn they also might start fighting for more water, which could lead to severe conflicts (EC 2005). These stakeholders derive the legal mandate and operational power from relevant institutions for specific water resources that have been placed under their charge (Shaghude *et al.* 2004).

It is commonly assumed that conflict will intensify if not addressed appropriately and timely. Not many conflicts can be easily resolved, hence most authors refer to conflict management rather resolution (Yasmi *et al.* 2006). The successful resolution of national as well as international water conflicts requires understanding of the nature of the conflict and then modelling and analyzing the inherent problems in it. To reach a final agreement concerning how much of the shared water resource is allocated to each party or nation, assistance of procedures or methodologies acceptable to all the parties concerned is very much needed (Nandalal *et al.* 2003). Particularly, improved water resource management, conflict resolution and cooperation could ameliorate such conflicts (*ibid*).

Water is a shared resource which requires a lot of social capital in all aspects of its management. Having diverse users with different and competing objectives and priorities, conflict over water resources is inevitable. Water use conflicts are exacerbated by rapid population growth, lack of awareness, political will, low economic incentives and inadequate and fault institutional arrangements (URT 2003). The Rundugai river catchment in Hai district is not unique to be exempted from these factors and resultant conflicts. However, there is no or only little analysis have been done on these factors and the conflicts they generate. This constrains informed decisions on development plans for sustainable use of the catchment. This study, therefore, seek to fill this knowledge gap.

The information will be useful in designing ecologically sound and socially acceptable management and conservation interventions of water resources. Ecologically sound in a sense that the resource degradation will be halted and socially acceptable in a sense that the interests of all stakeholders will be taken into account in view of minimizing the prevailing conflicts.

The overall objective of this study was to assess the water use conflicts in Rundugai river catchment in Hai District. Specifically, the study assessed the interests, power and positions of different stakeholders of water resources in Rundugai river catchment, the existing types of water use conflicts, the underlying causes of water use conflicts the link between socio-economic factors and water use conflicts and conflict management strategies over water use in the study area.

MATERIALS AND METHODS

Study Area

Hai district (Fig.1) is one of the six districts of Kilimanjaro region in Northern Tanzania. It encompasses an area of 13,000 km^2, lying between latitude $2^0$50'S and 3^0 29'S and longitude $30^0$30'E and $37^0$10'E. Most of the area lies at an altitude between 600m and 750m above sea level. Mean temperature of the area is 20^0C while the average rainfall is 700mm. The soils are mainly alluvial and volcanic in nature. Hai district is made up of 14 wards and 85 villages. The study was conducted in four (4) villages namely Chemka, Rundugai, Kawaya, and Chekimaji surrounding the Rundugai river catchment.

Population

According to the latest population census of 2002 (URT, 2003), Hai district had a population of about 259,958 people. Of these, 132,176 were females and 127,782 males. The district had 85,056 households with 45,000 farmers growing bananas, maize, beans, sunflower, and rice. The major ethnic groups are Wachagga, Wapare and Wamaasai. They earn their living through farming, livestock keeping, fishing and trading.

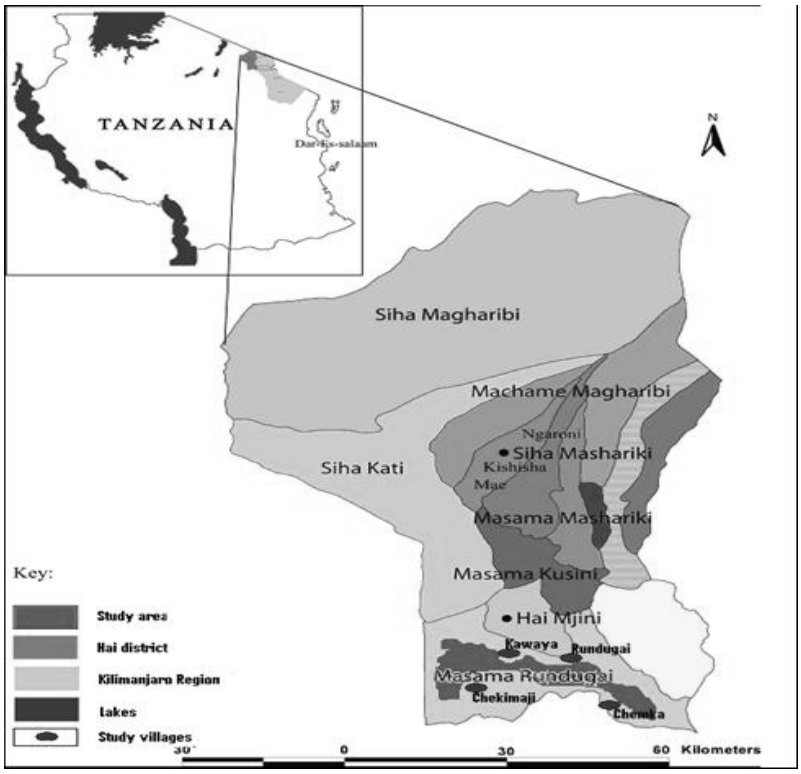

Figure 13: A map of Hai District showing different wards, study villages and study area (Source: Hai District Planning Department, 2006)

DATA COLLECTION

Sampling design and sampling procedures and data collection

Multistage sampling was employed whereby one division out of four in the district was purposively selected based on the presence of water catchment. Four villages surrounding the catchment area were randomly selected. A representative sample of respondents was selected from each selected village. The sampling unit in this study was a household whereby a total of 160 households (40 households in each village) were interviewed. In administering the questionnaires, Boyd, *et al.* (1981) recommended that for a random sample to be representative it should constitute at least 5% of the total population.

Structured questionnaires with both open and closed ended questions were used based on the specific objectives to obtain information on the households. The questionnaires were pre-tested in Masama Kusini ward, three villages namely Mbatakero, Mkalama and Mijongweni to test if the questions were understood and addressed issues under investigation. In each household, the head of the household was interviewed also other members were encouraged to engage in the discussions to supplement the required information. The focus of the survey was to get information on the key stakeholders in water resources and their interests, powers and positions, types of existing water use conflicts, the link between socio-economic factors and water use conflicts. Other information collected through questionnaires included underlying causes of existing water use conflicts and conflict management strategies over water use.

Focus group discussion was used to gather information from key informants. A key informant is an individual who is accessible, willing to talk and has great depth of knowledge about issues in question (Mettrick 1993). The information obtained from key informants is summarized in Table 2. For this study an open discussion was conducted with the District Water Engineer, District Agriculture and Livestock Development Officer, District Natural Resources Officer, Ward Extension Officer, Village Executive Officers and Community based organizations. The aim was to triangulate information given by respondents during household questionnaire surveys and PRA.

Participant observation is distinguished by the fact that the observer (researcher) becomes part of the situation being studied (Kajembe and Wiersum 1998). During data collection process the researcher has an opportunity to compare what was given in the PRA and questionnaire survey with what is the reality on the ground hence supplementing the information collected from other techniques. Participant observation brings the researcher close to the people and makes respondents feel free during the interviews. Participant observation provided the context within which all other methods were applied, and it functioned as an initial medium for learning about social and physical environmental interrelationship.

Data analysis

Quantitative data from structured questionnaires were analysed using Statistical Package for Social Sciences (SPSS version 11.5) (Norusis 1990). The data were first coded, compiled and entered to computer to make them useful for analysis.

Descriptive statistical analysis was employed to calculate frequencies and %ages of different parameters in question. Inferential statistical analysis was done using a Logistic Regression Model to indicate the relationship between water use conflicts as dependent variable and various socio-economic factors as independent variables. Ethnic group, family size, gender, number of livestock, duration of residence, size of farming plots, occupation, education level and age were considered as independent variables that influence the existence of water use conflicts. A linear combination of these independent variables was established for prediction purposes.

The following logistic regression model adopted from Pampel (2000) was used.

$$Yi = \frac{1}{1 + e^{-z}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

Y_i = the i^{th} observation value (score) of the dependent variable representing a linear combination of the independent variables underlying water use conflicts which stand for a non- standardized logistic regression equation. This was then used for prediction purposes. Y_i is a binary variable with value of 1 if the respondent reported existence of water use conflicts and 0 if otherwise.

$Z = \beta_{0+} \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots + \beta_n X_n$

X_1 to X_k = Independent Variables (tribe, family size, gender, number of livestock, duration of residence, size of plots, occupation, education level and age)

β_0 = Constant term of the model without the independent variables,

β_1 - β_k = Independent variable coefficients showing the marginal effects (negative or positive) of the unit change in the independent variables on the dependent variable and these were used in developing prediction equations on the water use conflicts,

e_i = random error term = 2.718.

i = 1,2,3,4----- n (total number of respondents) = sample size i.e. 160 for the purpose of this study),

k = total number of independent variables (k = 9).

From the above, the X values (independent variables) to be included in the model are mentioned as follows: X_1 = Tribe; X_2 = Family size; X_3 = Gender of respondents; X_4 = Number of livestock; X_5 = Duration of residence (years); X_6 = Size of plots; X_7 = Occupation; X_8 = Education level of respondents; X_9 = Age of the respondent in years.

The probability of event not to occur was estimated as: pro (no event) =1- pro (event). The odds ratios represented by Exp (β) from logistic regression analysis were used in explaining the likelihood of water use conflicts in the study area.

Goodness of fit of the logistic regression model was assessed by Model Chi-square which measures how well the independent variables affect the outcome or dependent variable, -2 log likelihood (-2LL) which indicates that the model fits the data reasonably well, and the overall %age of correct predictions where the bigger the %age the better the model.

Proper interpretation of logistic regression results involved examining the Wald statistic (t-value) to see whether the effect of a particular independent variable is statistically significant, sign of effect of the logistic regression coefficient (β) to check whether the increase in independent variable increased or decreased the probability of success (in this case occurrence of water use conflicts in the study area), magnitudes of the similarly measured variables to determine which of the independent variables seem to have a greater influence impact on water use conflict in the area, and the Exp(β) to check how much a 1-unit increase in Xi changes the odds of success (this is because the odds of success is not the same as probability of success).

Qualitative information collected from key informants and participant observations were subjected to content and structural functional analysis. In this case, the recorded dialogue was broken down into smallest meaningful units of information to determine values and attitudes of the respondents (Kajembe 1994). Structural functional analysis was used to explain the way social facts relate to each other within a social system and the manner they relate to physical surroundings. Data from focus group discussions were summarized picking the main points and conclusions reached by the group members themselves (Cooksey and Lokuji 1995).

RESULTS

Key stakeholders, their interests, power and positions in water resources management

In the study, several stakeholders/actors involved in regulating and negotiating access to water resource were identified and grouped into five groups including Local Government Agencies e.g. Village governments, Central Government Agencies e.g. the Pangani Basin Water Office (PBWO), Specific Resource

User Associations e.g. TEGEMEO water users association and General Resource User Groups e.g. farmers and livestock keepers.

Farmers were identified as stakeholders by majority of the respondents, followed by Local government agencies (Village governments), Pastoralists, Specific resource users i.e. Water user associations and finally Central government agencies i.e. basin water offices (Table 1). This can be taken as a ranking by the respondents and is an important consideration when addressing water use conflicts among stakeholders.

Table 1: Key stakeholders of water resources in Rundugai River Catchment

Stakeholders	% of respondents (n = 160)
Farmers (General resource User group)	88
Local Government Agencies i.e. Village Governments	85
Pastoralists (General resource User group)	78
Specific Resource User Associations (TEGEMEO Water User Association)	73
Central Government Agencies i.e. Pangani Basin Water Office (PBWO)	60

On the other hand, different stakeholders have their own interests, power and positions which differ from one stakeholder to another and do have a bearing on conflicts and their resolution (Table 2)

Existing types of water use conflicts

Majority (93%) of the respondents agreed that water use conflicts exist in the study area. The other proportion either did not see any conflicts (6%) or knew nothing (1%) as shown in Table 3. Different types of water use conflict were identified mainly related to use of water resources. Conflicts occur between farmers and farmers, farmers and pastoralists and between farmers and water furrow leaders. About 73% of the respondents acknowledged existence of conflicts between farmers themselves while 44% felt that conflicts were between farmers and pastoralists. Conflicts between farmers and water user associations (furrows leaders) were minimum (12%) implying that no significant conflicts pertaining farmers and furrow leaders (Table 3).

Table 2: Interests, power and positions of stakeholders in water resources management in the Rundugai river catchment

Stakeholders	Interest of stakeholders	Power of stakeholders	Position of stakeholders
Local government Agencies i.e. Village Governments	• Protect and conserve the catchment • Guide policy and legislation • Supervise the distribution of water to farmers in the villages •	• Use environmental village by laws to control all activities undertaken inside the catchment. • Penalty all people who break the environmental by laws in the area. • Control distribution of water use and water use conflicts in the area	• Planting trees • Laws enforcement • Environmental and irrigation education
Specific Resource User Groups i.e. TEGEMEO Water Users Association	• To ensure sustainable use of water resources • To ensure equal supply of water to all farmers • To solve water use conflicts • Regulate and facilitate resource use by other stakeholders	• Control all water utilization among members and negotiate for more in collaboration with other users that abstract water from the same source.	• Laws enforcement • Irrigation education • Formal water distribution arrangements to all users
Central Government Agency i.e. Pangani Basin Water Office	• Water conservation and efficient use of water. • Educate people on importance of water resources	• Conserve/control all water resource by using national water policy and laws in the catchment	• Law enforcement • Conservation through integrated Water Resources Management
General Resource User Groups i.e. Farmers	• Access water for irrigation and domestic use • Participate in water management especially on water conservation	• Use water for agriculture and domestic uses	• Get more water for their uses • Benefit sharing • Farming plots • Own part of catchment for irrigation activities
General Resource User Groups i.e. Pastoralists	• Access water for livestock • Participate in water management especially on water conservation	• Use water for livestock	• Get more water for their uses • Benefit sharing • Grazing plots • Own part of catchment for grazing

Table 3: Water use conflicts in the study area

Response item	% of respondents (n = 160)
Presence of water use conflict	
Yes	93
No	6
I don't know	1
Types of water use conflicts	
Farmers versus farmers	73
Farmers versus pastoralists	44
Farmers versus water furrows leaders	12

Causes of water use conflicts

Majority (86%) of the respondents singled out population increase as the major cause of water use conflicts in the Rundugai river catchment (Table 4). Other causes were water scarcity (85%), inadequate participation by local communities in water resource management (83%) and irregularity in scheduling water for irrigation (74%). Population increase has been brought about by several factors the most important factor being irrigation agriculture (Table 5).

Table 4: The main causes of water use conflicts in the Rundugai river catchment

Causes of water use conflicts	% of respondents (n = 160)
(i) Population increase	86
(ii) Water scarcity	85
(iii) Inadequate participation by local communities in water resource management	83
(iv) Irregularity in scheduling water for irrigation	74

Table 5: Responses on reasons for migration to Rundugai river catchment

Reasons for migration	% of respondents (n = 160)
Irrigation agriculture	70
Livestock keeping	21
Marriage	6
Follow parents	2
Employment	1

Socio-economic factors influencing water use conflicts

The results indicated that three socio-economic factors namely age, size of farm and gender were statistically significant ($p<0.05$) in increasing the odd ratios of water use conflicts by factors of 5850.3631, 21.4436 and 0.0430 respectively while other factors were not statistically significant ($p<0.05$) (Table 6). The goodness of fit of the logistic regression model was found to fit well to the data as shown by the significant value of 0.003 for the constant term (Table 6). The Model Chi-square 116.786 was strongly significant ($p<0.001$) implying that the independent variables explain well the model outcome or dependent variable. The –2 log likelihood (-2LL) value of 31.22 also indicated that the model fitted the data reasonably well. The overall percentage of correct predictions was 95%, which shows a good goodness of fit (Table 6).

Gender

Gender of the respondents had a negative logistic coefficient of -3.15 and odds ratios of 0.0430 (Table 6). This implies that for every decrease in one sex the perception on probability of an event to occur is statistically significant ($p= 0.049$) increase by a factor of 0.0430. Gender impact to the water use conflicts was statistically significant ($p = 0.049$).

Table 6: Logistic regression analysis for socio-economic factors of water use conflicts

	Estimates					
Variables in the Equation	**B**	**S.E.**	**Wald**	**df**	**P-value**	**Exp(ß)**
Ethnicity	-5.41	4.591	3.76	1	0.898	0.6832
Family size	0.47	0.270	3.02	1	0.082	0.6262
Gender of the household head	-3.15	1.600	3.87	1	0.049*	0.0430
Number of livestock	0.02	0.086	0.07	1	0.790	1.0232
Duration of residence	0.09	0.049	3.25	1	0.071	1.0920
Size of farm	3.06	0.924	10.94	1	0.001*	21.2608
Occupation	3.07	1.772	2.99	1	0.084	21.4436
Education level	-2.49	1.346	3.43	1	0.064	12.0993
Age	8.67	2.488	12.15	1	0.000*	5850.3631
Constant	-6.053	3.487	3.01	1	0.003	0.0024

(1) Model Chi-square = 116.786 ($p<0.001$); -2Log Likelihood = 31.221, Confidence Interval = 95%; Negelkerke R squared = 0. 859;

(2) β= Regression coefficient; SE= Standard error of the estimate; Wald= $\beta/(SE)^2$; df = degree of freedom; Exp (β)= odds ratio.

* = Indicates significance at $p<0.05$

It was also observed that most of the households were headed by males than females. In many cases, males engaged more in irrigation agriculture compared to females. This is shown under the Table 7 below:

Table 7: Socio-economic characteristics of the respondents in the Rundugai Catchment Northern Tanzania

Gender	|% of Respondents (n=160)
Gender	
Male	76.9
Female	23.1
Age (Years)	
18-27	30
28-37	17
38-47	32
48-57	9
58-67	7
>67	5

Size of farm

The land allocated for crop production had a positive regression coefficient of 3.06 implying that an increase in farm size increases the chances of water use conflicts. It was observed that a unit increase in farm size increases the probability of water use conflicts by a factor of 21.2608 (Table 6). Land allocated for crop production was statistically significant ($p = 0.001$).

Age

It was observed that most of the households (32%) were headed by people in the age class of 38-47 and relatively few households (5%) were headed by people in the age class of above 67 years (Table 8). In many cases, the age class (38 – 47 years old) constitutes the productive group of the population and mostly involved in the exploitation of water resources.. It was therefore the age group which had the greatest influence on water use conflicts.

From logistic regression the results show that age of the respondents had a positive regression coefficient of 8.67 and odds ratio of 5850.3631 (Table 6). This implies that increase in age increases the odds ratio of perceptions on the conservation of water resources in the catchment area by a factor of 5850.3631.

Other Socio-economic factors influencing water use conflicts

The results indicated that socio-economic factors such as ethnicity, family size, number of livestock, duration of residence, occupation and education level were not statistically significant ($p<0.05$) in increasing the odd ratios of water use conflicts in the area (Table 6)

Respondents suggestions on strategies of reducing water use conflicts

A number of suggestions were advanced as strategies to reduce water use conflicts in Rundugai river catchment (Table 9). About 86% of the respondents would prefer repair water furrows, 85% of the respondents would prefer law enforcement to be implemented, 84% of the respondents would prefer good water distribution among users, 76% of respondents would prefer reduction of the number of livestock and 73% of the respondents would prefer tree planting as the major strategies for reducing water use conflicts. Team work for water users, promotion of irrigation and environmental knowledge, construction of water dams for irrigation were of medium priority. Involvement of old people in conservation of water sources, re-establishment of animal routes and water points were accorded low priority.

Table 8: Strategies to reduce water use conflicts in the Rundugai river catchment

SN	Strategy	% of respondents
1.	Repair water furrows	86
2.	Law enforcement	85
3.	good water distribution among users	84
4.	Reduction of livestock numbers	76
5.	Tree planting	73
6.	Team work for water users	36
7.	Promotion of irrigation and environmental knowledge	27
8	Construction of water dams for irrigation	21
9	Involvement of old people in conservation of water sources	18
10	re-establishment of animal routes and water points	11

Local institutions for regulating and mediating water use conflicts

Majority of the respondents (98%) were familiar with the institutions that regulate water use conflicts in their area (Table 10). Such institutions included village government (75%), irrigation committee (63%), farmers associations (44%), council of village elders (39%) and traditional guards (37%). Recorded water use conflicts resolved by local institutions in the study area shown in Table 11.

Awareness of by laws in water resources management in the study area.

The results show that about 52% of the respondents were aware of the existing by-laws that govern water use in their area. On the other hand about 48% of them were not aware of by-laws governing the use of water resources in the study area (Table 10).

Table 9: Institutions mediating water use conflicts in the Rundugai Catchment

Response Item	% of respondents (n = 160)
Presence of institutions	
Aware	98
Not Aware	1
Don't know	1
Institutions	
Village government	75
Irrigation committee	63
Farmers association	44
Council of village elders	39
Traditional guards	37
Existence of By-laws	
Aware	52
Not aware	48

Table 10: Recorded water use conflicts resolved by local institutions in the Rundugai catchment northern Tanzania

Water use conflicts	Local institutions				
	Village government	Irrigation committee	Farmers (water users) association	Council of village elders	Traditional guards
Farmers versus farmers	2	18	22	3	5
Farmers versus pastoralists	19	9	13	6	7
Farmers versus water furrow leaders	18	6	7	2	-

DISCUSSION

Several stakeholders/actors involved in regulating and negotiating access to water resource were identified in the Rundugai river catchment. Farmers were identified to be majority, followed by village governments, pastoralists, water user associations and finally Pangani water basin offices. In this study, a number of water use conflicts were identified where majority of the respondents admitted the existence of water use conflicts in the study area. However, only 6% of the respondents were not aware of the existing water use conflicts. The common conflicts were between farmers and farmers followed by farmers and pastoralists. Generally, a conflict between farmers and farmers seems to be dominant because of the large number of farmers who pursue irrigation agriculture in the area. Conflicts between farmers and pastoralists prevail because of the large number of animals which migrate from other areas of the district to the catchment especially during the dry season in search of water and pasture for their livestock (Plate 1). The findings are in line with a similar study in the Malagarasi – Muyovozi Ramsar site (IRA 2002) where high migration of pastoralists to the area was reported to take place during the dry season in order to utilize pastures in extensive seasonally inundated grasslands. As large number of pastoralists increase eventually water use conflicts emerge. As a matter of fact, migration increases the population and demand for the resource. Therefore, migration may have a negative impact on the water resource leading to degradation of the catchment. This was also reported in East Usambara by Kessy (1998) who observed that development pressures over resources were caused by among other things increasing human population.

Human population increase was observed to cause water use conflict in the area. It was learnt that large number of people migrate to the area for irrigation agriculture followed by livestock keeping activities whereby this situation may increases demand for water and leading to destruction of water sources. This may in turn lead to water shortage and, therefore, competition between different users which may lead to conflict. Similar findings were reported by SMUWC (2000) where the main water use conflicts were between crop cultivation and livestock keeping in Usangu plains. Water demand for irrigation has been increasing as more land is being developed for irrigated agriculture in the plains. SMUWC (2000) also reported that the human population in Usangu plains has grown from 31,000 in 1948 to its present figure of approximately 210,000 people. However, the period from 1970 to late 1980 was reported to have been the main period of growth in the pastoral population (SMUWC 2000). Water scarcity in Rundugai river catchment was also viewed as another cause of water use conflicts. Several studied have reported that water scarcity has been the major cause of water use conflicts, intensified with the growth of world population and water demand (United Nations 1988; Furtado and Campos 1997; UNESCO, 2002; Carneiro 2004; Mbonile 2005; Sneddon and Fox 2006). Other causes reported to cause water use conflicts in Rundugai river catchment was inadequate participation by local community in water resource management and irregularity in scheduling water for irrigation, for example the absence of regularly schedule for irrigation. Similarly

causes have been reported in Pangani river basin by Mujwahuzi (1999).

Plate 1: Livestock grazing in the Rundugai river catchment

The socio-economic factors influencing water use conflicts identified in the study area included the age of the respondents, size of farm and gender. This study identified that people in the age class between 38 and 47 years old were more involved in the use of water resources compared to other ages. This was because people within this age group were composed of the productive age. This implies that increasing number of people of age class of 38 – 47 years old by one year in the area; increase the chances of conflicts over water resources. The proportion of people with the age of between 48 and 57, 58 and 67 years old were low comparable to that of > 67 years old, probably due to low life expectancy for the latter group.

Households with large farms in the area require more time for water allocations to irrigate their crops. This means few farmers use water for several hours making those with small plots to suffer a delayed water allocation. Also, it was learnt that males and females have different roles and therefore different demands for water resources. This is due to the fact that men mostly use water for irrigation agriculture and livestock keeping while women use water for domestic uses and rarely for irrigations. Women mostly safeguarding the water resource in the area but their involvements in water related issues were very low. In times when water scarcity was high temporally allocation systems were imposed whereby men get more water allocation than women probably due to gender discrimination. This situation resulted in water use conflicts in the area. A report by UNESCO (2000) observed that women played a central and multi-faceted role in the provision, use and safeguard of water but their involvement in water related decision making structures was very low in Zimbabwe.

Village community members were aware of the existing water use conflicts in the area. However, most of them would like to break away from those conflicts. In order to archive that goal a number of strategies were put in place to resolve water use conflicts. Among all strategies proposed, repair water furrows, law enforcement, good water distribution among users strategies are observed to be more effective in addressing a number of conflicts followed by reduction of livestock numbers and tree planting in the area. Team work for water users, promotion of irrigation and environmental knowledge and construction of water dams for irrigation were was medium. However, others strategies including involvement of the elders in conservation of

water sources and re-establishment of animal routes and water points were less effective.

The formal and informal institutions were reported to exist in the study area. These institutions were reported to play a key role in regulating access and utilization of water and to solve water use conflicts in the area. Additionally, the formal and informal institutions reported in this study were similar to those reported elsewhere including Pangani and Ruaha river basins (Mbwilo *et al*., 2003; Mujwahuzi 1999; Maganga and Odgaard 1995). Also, Mbwambo (2000) reported that the informal institutions which were essentially traditional were important in natural resources conservation and played a great role in regulating access and utilization of various natural resources in Udzungwa. Appia-Opoku and Hyma (1999) cited in Mbwambo (2000) reported further that informal institutions present established local system of authority and other phenomena derived from the socio-cultural and historical process of a given society. This study observed that most of the conflicts related to water use were resolved at lower levels particularly water users associations and village government. However, it was learnt that water users association was more involved in resolving conflicts related to water use in Rundugai river catchment. This was attributed to the fact that water users association recorded more resolved conflicts related to water use than other institutions. Boesen *et al*. (1999) and Odgaard and Maganga (1995) also reported that the crucial role played by both formal and informal institutions in natural resources management. The interplay between formal and informal institutions in natural resources management is well captured by Meinzen Dick and Pradhan (2001), who reported about the implications of legal pluralism for natural resource management, noting that many conceptions of property rights have focused only on static statutory law, ignoring the co-existence and interaction between multiple legal orders such as state, customary, and religious laws. For instance, Tanzania has a pluralistic legal system and hence water resources are regulated by different pieces of legislation and institutions, including statutory law, customary laws, Islamic law, etc. Whenever there is scarcity and competition, though, the authorities pretend that the only prevailing law is state law.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The main socio-economic activities identified in Rundugai river catchment included agricultural production and livestock keeping. Water resources were limited to accommodate all needs of the rapid growing population around the catchment. This situation forced local communities to compete for water. The two major conflicts over water use were identified based on their importance. These included conflicts over water use between farmers themselves and between farmers and pastoralists. However, farmers versus farmers' conflicts were more prominent in the study area. The underlying causes of such conflicts were human population increase, water scarcity, inadequate participation by local communities in water resource management, irregularity in scheduling water for irrigation. Gender of the household head, farm size and age of the respondents were found to influence water use conflicts significantly.

The study further concludes that several strategies suggested by respondents in the area are in place to address different conflicts related to water resource use. Additionally, formal and informal institutions play a key role in regulating water use conflicts.

RECOMMENDATIONS

This study recommended the following:

- Much more is needed to call for integrated approaches in setting appropriate playing ground for different users to develop sustainable conflict management strategies over water use in the study area.

- Local communities residing in and around the Rundugai river catchment should be empowered with the roles and responsibilities to participate fully in the management of water resources.

- The existing legislations related to water resources should be enforced.

- There is a need for local government at district level to recognize traditional (informal) institutions as key partners in water resource management conservation in the area. This can be achieved by integrating formal and informal management system as a way of coming up with more comprehensive and strategies of conserving water resources.

- Improvement of water and environmental policy is highly needed in order to reduce or remove the existing water use conflicts.

- There a need to clearly define water rights for farmers and pastoralists in the area..

References

Anderson, J. E. C. and Ngazi, Z. 1998. Marine resources use and the establishment of marine Park. Mafia Island, Tanzania. Ambio 24(7-8):475 - 481.

Appia-Opoku, D. and Hyma, B. 1999. Indigenous Institutions and Resource Management in Ghana. In: *Indigenous Knowledge and Development Monitor* 7(3):15 – 17.

Baran, E. and Jantunen, T. 2004. Stakeholder consultation for Bayesian decision support system in environmental management. In: *Proceedings of the Regional conference on ecological and environmental modelling.* University Sains Malaysia, 15 – 16 September 2004, Penang, Malaysia. pp. 121 -128.

Basnayake, B. M. J. K. and Gunaratne, L. H. P. 2002. Estimation of technical efficiency and it's determinants in the tea small holding sector in the Mid Country, Wet Zone of Sri Lanka. *Sri Lanla Journal of Agricultural Economics* 4:137 - 150.

Behnke, J. and Scoones. I. 1993. 'Rethinking Range Ecology: Implications for rangeland Management in Africa. In: R.H. Jr. Behnke, I. Scoones and C. Kerven [eds]. *Range Ecology at Disequilibrium. New Model of Variability and Pastoral Adaptations in Africa savannas.* Overseas Development Institute and IIED, London. pp. 376 - 382.

Borrini-Feyerabend, G. 1997. Beyond fences: Seeking Social Sustainability in Conservation. IUCN, Gland, Switzerland. pp. 11 - 17.

Boyd, H. K., Westfall, R. and Stasch, S. F. 1981. Marketing Research: Text and Cases. Richard D. Publisher Inc. Illinos. 813pp.

Bucker, D. C. and Ostrom, E. 1995. Human Ecology and Resource Sustainability. The importance of institutional Diversity. *Annual Rev Ecology Systems* 26: 113 - 133.

Buckles, D. and Rusnak, G. 1999. Conflict and collaboration in natural resource management. In: Buckles, D. (ed.). 1999. *Cultivating Peace: Conflict and Collaboration in Natural Resource Management.* International Development Research centre, Ottawa, Canada. pp. 1-10.

Campbell, B. M., Luckert, M and Scoones, I. 1991. Local level valuation of Savannah resources: A case study from Zimbabwe. International Institute for Environmental and Development (IIED), London. 26pp.

Castro, A. P. and Ettenger, K. 1996. Indigenous knowledge and conflict management: exploring local perspectives and mechanisms for dealing with community forest disputes. Presented at the Global e-Conference on Addressing Natural Resources Conflict Through Community Forestry, Jan – Apr 1996. Forest, Trees and People Programme of the Food and Agriculture Organization of the United Nations, Rome, Italy. pp. 1 - 7.

Charnely, S. 1994. Cattle, Commons and Culture: The political Ecology of Environmental Change on a Tanzanian Rangeland. Dissertation for Award of

PhD Degree at Stanford University. pp. 124 - 197 .

Chevalier, J. and Buckles, D. 1995. A Land Without Gods: Process Theory, Maldevelopment and the Mexican Nahuas. Zed Books Ltd, London, UK. pp. 108 - 112.

Cooksey, B. and Lokuji, A. 1995. Some Practical Research Guidelines. Research on Poverty Alleviation. Special Paper No.12. Interpress Tanzania Ltd, Dar es Salam, Tanzania. 54pp.

Cosgrove, William J. and Rijsberman, Frank, R. 2000. *World Water Vision: Making Water Everybody's Business*. London. pp. 13 - 15.

De Pauw, E. 1995. Main Report: Development of Land Use Planning and Land Tenure in Tanzania Technical Support Service Project. TSSI – URT/02T. pp. 12 - 27.

DID. 2001. Access to water in developing countries. [http://www.parliament.uk/post/pn178 .pdf.] site visited on 14/09/2011.

Driscoll, C. 1994. Diversity, dialogue and learning: the case of the Forest and Round Table on Sustainable Development. Dissertation for Award of PhD Degree at Queen's University, Kingston, Canada. 108pp.

EC. 2005. European Declaration for a New Water Culture, Madrid. [www.unizar.es/fnca/euwater/index2.php?x=3&idioma=en] site visited on 23/04/2011.

Falkenmark, M. 1989. "Water availability as carrying capacity determinant: A new factor in third world demography", In: B. Zaba and J. Clarke (eds), *Environmental and Population Change, International Union for the Scientific Study of Population (IUSSP), Derouaux Ordina Editions*, Liege, Belgium. pp. 325 - 347.

FAO. 2000. Conflict in Natural Resource Management (Eds.) Nancy Hart and Peter Castro. Viale Termed di Caracalla 00100. Rome. Italy. 20pp.

Gleick, P. H. 1993. Water and conflict: Fresh water resources and international security, *Int. Security* 18(1): 79 – 112.

Gleick, P., Cain, N., Haasz, D., Henges-Jeck, C., Hunt, C., Kiparsky, M., Moench, M., Palaniappan, M., Srinivasan, V. and Wolf, G. 2005. The World's Water 2004–2005: The Biennial Report on Freshwater Resources. Washington DC, USA. pp. 14 - 16.

GIWA. 2004. Global International Water Assessment in the Sub-Regional Report: Somali Coastal Current, Sub-Region No. 46, 172 p., Kalmar, Sweden. [http://www.giwa.net/publications] site visited on 12/01/2011.

Hardin, G. 1968. The tragedy of the commons. *Science* 162: 1243-1248.

Hiberniansscribe, S. 2005. How is the struggle for water, such as in Ethiopia and Kenya, shaping conflicts in this century?. [http//www."water wars: Ethiopia and Kenya" at Pulitzer center.org] site visited on 12/09/2011.

Huffman, M. 2001. "Peace and Conflicts Impact Assessment Methodology: Evolving Art Form or Practical Dead End?. " Berghof Research Centre for Constructive Conflict management. USA. pp. 213- 216.

IRA. 2002. Baseline Study of Lakes Sagara and Namagoma wetlands and the surrounding environment in the Malagarasi/Muyovozi Ramsar Site. A consultancy report submitted to SIMMOROS project in the Ministry of Natural Resources and Tourism. University of Dar es Salaam, Tanzania. 73pp.

IIED 2001. Drawers of Water II: Thirty Years of Change in Domestic Water Use and Environmental Health in East

Africa. [www.iied.org/agri/proj_dwu.html] site visited on 23/04/2011.

Kajembe, G. C. 1994. Indigenous Management Systems as a Basis for Community Forestry in Tanzania: A Case Study for Dodoma Urban and Lushoto Districts. Tropical Resource Management Paper 6. Wageningen Agricultural University, The Netherlands. 194pp.

Kajembe, G. C. and Wiersum, K. F. 1998. Bridging the gap between indigenous initiatives and externally sponsored forestry interventions. *In: Faculty of Forestry No.67 (*Edited by Chamshama, S.A.O*)*. Morogoro, Tanzania. pp. 95 - 105.

Kasambala. S. P. 2004. Assessment of water resources for food security in Tanzania. An Application of policy dialogue model (PODIUM). Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. pp 18 - 19.

Kessy, F. P. 1998. Conservation and utilization of natural resources in the East Usambaras forest reserves: Conventional views and local perspectives. Tropical Resource Management Paper No. 8. Wageningen Agricultural University. The Netherlands. 168pp.

Kiwasila, H. L. 1994. "Socio-economic study in Mwanza urban: Water supply aspirations and willingness to pay", Research Reports submitted to Messrs Howard Humphreys Consulting Civil Engineers (T) Ltd, Dar es Salaam. 51pp.

Kowero, G., Campbell, B. M. and Sumalla, U. R. 2003. Policies and governance structures in woodlands of Southern Africa. Centre for International Forestry Research. South Africa. 438pp.

Lederach, J. P. 1992. Enredos, pleitos y problemas: una guia practica para ayudar a resolver conflictos. Comision Central menonita. Ediciones clara-Semilla, Guatemala City, Guatemala. 235pp.

Lewis, C. 1997. Conflicts in Conservation. In: *Beyond Fences: Seeking Social Sustainability in Conservation. Volume 2.* A Resource Book (Edited by Borrini-Feyerabend, G.) IUCN, Gland, Switzerland. pp. 62 - 64.

Malta, V. F, Damázio J. M. and Magalhães P. C. 2005. Use of the graph model for conflict resolution in water resources. In: *III International conference on water resources management.* WIT, UK.. 124 pp.

Mayeta, L. 2004. The Role of Local Institutions in Regulating Resource Use and Conflicts in Mpanga/Kipengere Game Reserve, Iringa, Tanzania. Dissertation for Award for MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 150pp.

Mbwambo, J. S. 2000. The role of Local Knowledge and Organization in Sustainable Conservation of Biodiversity: A case study of Udzungwa Mountains, Tanzania. Dissertation for Award for MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. – 62pp .

Mbwilo, A. J. T. 2002. The role of local institutions in regulating resource use and conflict management: The case of Usangu Plains, Mbarali District, Tanzania. Dissertation for Award of MSc. degree at Sokoine University of Agriculture, Morogoro, Tanzania. 134pp.

Mettrick, H. 1993. *Development oriented research on agriculture. An ICRA Textbook.* Wageningen., Netherlands. 287pp.

Milner-Gulland, E. J. and Mace, R. 1998. *Conservation of Biological Resources. Blackwell Science Ltd*., ISBN 0-86542-738-0. Oxford. 404pp.

Minda, L. 2005. How is the struggle for water, such as in Ethiopia and Kenya, shaping conflicts in this century?. [http//www."water wars: Ethiopia and Kenya" at Pulitzer center.org] site visited on 12/09/2011.

Mujwahuzi, M. R. 1999. Water Use Conflicts in the Pangani Basin: An Overview. In: J.O. Ngana (ed.), *Workshop Proceedings on Water Management in Pangani River Basin.* University of Dar es Salaam and Technical University of Norway, Bahari Beach Hotel, Dar es Salaam. pp. 30 - 41.

Mkeya, F. M. 1994. Forest resource use conflicts and their socio-ecological consequences. A case study of Mount Meru Forest Reserve, Tanzania. Dissertation for Award for MSc Degree at Agricultural University of Norway. 126pp.

Moore, C. 1996. The mediation process; practical strategies for resolving conflict. Jossey – Bass Publishers, San Francisco, CA, USA. pp. 35 - 39.

Mpofu, T. P. Z. 1990. Basic Needs of an Environment in Communal Areas. The Save Catchment Zimbabwe. In: *"SPLASH". A News letter for SADCC Soil and Conservation and Land Utilization sector. (Edited by Geoffrey, J. and Taylor Maseru), Lethoto* 9(2): 11.

Nandalal, K. D. W and S. P. Simonovic. 2003. Resolving Conflicts in water sharing*: A systemic approach, Water Resources Research* 39(12): 13 – 62.

Norusis, M. J. 1990. SPSS/PC+ *Advanced Statistics* ^{TM} *4.0 for the IBM PC/XT/AT and PS/2.SPSS* Inc. USA. 373pp.

Odgaard, R. and Maganga, F. P. 1995. Local informal land and water management systems in Ruaha River Basin In: *MWEM (Ministry of Water, Energy and Minerals, United republic of Tanzania) 1995. Water resource management in the Great Ruaha Basin prepared for the Rufiji Basin water office, by joint Danida and World Bank study of Integrated water and land Management.* Tanzania. 259 pp..

Omosa, E. S. 2005. The Impact of Water Conflicts on Pastoral Livelihoods, Wajir District, Kenya. 93pp.

Pampel, F.C. 2000. Logistic regression: A primer. Quantitative Applications in the Social Sciences. Thousands Oaks, CA: Sage. 96pp.

Payet, R. and Obura, D. 2004. The negative impacts of human activities in the Eastern African Region: An international waters perspective. *Ambio* 33: 24-33.

Pendzich, C., Thomas, G., Wohlgenant, T. 1994. The role of alternative conflict management in community forestry. Food and Agriculture Organization of the United Nations, Rome, Italy. 256pp.

Raakjaer, N. J. and Vedsmand, T. 1997. User Participation and Institutional Change in Fisheries Management: A Viable Alternative to the Failures of "Top Down" Driven Control. Ocean and Coastal Management. UK. 278pp.

Ramirez, R. 1999. Stakeholders Analysis and Conflict Management: Alternative Approaches to Conflict management. [http:/www.irdc,ca] site visited on 23/01/2011.

Rieman, B., Peterson, J. T., Clayton, J., Howell, P., Thurow, R., Thompson, W. and Lee, D. 2001. Evaluation of potential effects of federal land management alternatives on trends of salmonids and their habitats in the interior Columbia River Basin. *Forest ecology and management* 153: 43-62. [

Rothman, J and Soderquist, C. 2002. Form Riots to Resolution: Engaging Conflict for Resolution. *The Systems Thinker* 66(13): 221

Shaftoe, D. 1993. Responding to changing times: environmental medication in Canada. Interaction for Conflict Resolution, Waterloo, Canada. 226pp.

Shemwetta, D. T. K., Kajembe, G. C., Luoga, E. J. and Mwaipopo, C. S. 2004. The role of diverse institutions in the rule conformance and generation of conflicts over forest products in Tanzania. In: *Institutions, Incentives and Conflicts in Forest Management: A Perspective. Proceedings of the IFRI East African Regional Conference (Edited by Shemweta, D.T.K., Luoga, E.J., G.C. Kajembe and S.S. Madoffe)*. 12th -13th January, 2004. Moshi, Tanzania. pp. 29 - 39.

Simonovic, S. P. and Bender, M. J. 1996. Collaborative Planning- Support System: an approach for determining evaluation criteria. *Journal of Hydrology* 177(3-4): 237 – 251.

Simonovic, S. P. 1995. "Synthesizing Missing Streamflow Records on Several Manitoba Streams Using Multiple Nonlinear Standardized Correlation Analysis". *Hydrological Sciences Journal* 40(2): 183 – 205.

Stroh, D. P. 2002. "A systemic view of the Israeli – Palestinian Conflict". *The Systems Thinker* 13(5): 2 – 7

Tauris, I. B. 2008. Power and water in the Middle East. The hidden politics of the Palestinian Israeli water conflict [http://www.power and water in the Middle East (1845114647) ZEITOUN - I_ B_ Tauris] site visited on 13/09//2011.

UN. 1999. World Day for Water "*Everyone Lives downstream*" [http://www.unu.edu/media/archives/1999/wwaterday.pdf] site visited on 12/09/2011.

URT 1995. Rapid Water Resources Assessment, Vol. 1, Main Report, Ministry of Water, Energy and Minerals. Dar es Salaam, Tanzania. 150pp.

URT 2003. Population and Housing Census: General report 2002. Central Office, National Bureau of Statistics, President's Office Planning and Privatization. Government Printer Dar es salaam, Tanzania. 203pp.

Warner, K. 2002. Participatory Processes and Conflict Management in Community Forestry in: Oglethorpe, J. A. E (Ed). Adaptive Management: From Theory to practice. IUCN, Gland, Switzerland and Cambridge, UK. pp 83 – 90.

Warner, M. 2000. Conflicts Management in Community – Based Natural Resource Projects: Experience from Fiji and Papua New Guinea. Overseas Development Institute (ODI) Working Paper 135. Portland, London UK. 40 pp.

WWC, 2004. [http://www.gci.ch/en/programs/natural_02.htm www.unesco.org/water/wwap/pccp] site visited on 14/09/2011.

Wolf, A. 1998. Conflict and Cooperation along International Waterways. *Water policy* 1(2): 25 – 265.

Wolf, A. 2000. Indigenous Approaches to Water Conflict Negotiations and Implications for International Waters. International Negotiations: *A Journal of Theory and Practice* 5(2): 104 - 118.

Wolfgram, M. 2000. "Evaluating Resources," Wolfgram Memorial Library. [http://www.muse.widener.edu/Wolfgram-Memorial Library/webevaluation/webeval.htm] site visited on 16/06/2011.

World Bank. 1992. World Development Report 1992. Oxford University Press, New York, USA. 98pp.

Yasmi, Y., Schanz, H. and Salim, A. 2006. Manifestation of conflict escalation in natural resource management. *Environmental Science and Policy* 9: 538–546.

Zaba B. and Madulu, N.F. 1997. "Water Use and Population Change in the Mwanza Region: Mwanza Urban Survey Report", A Research Report, Tanzania.16pp.

Hinrichsen, D., B.; Robey, and Upadhyay, U.D. 1998. Solutions for a Water-Short World, Population Reports, Series M, No. 14, Baltimore: John Hopkins University.

Mbwilo, A. J.; Kajembe. G.C. and Nduwamungu, J. 2003. Resource use conflicts in Usangu Plains. *International journal for Development Ecology* 10:333–343.