Resolving and prevention of shared water resources conflicts

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Abstract

International shared water resources conflicts can be resolved through negotiation and arbitration. The negotiation and arbitration must be supplied with decision aiding tools and management plans for the shared water resources so as to come up with workable framework that can be used to prevent future water resources conflicts in the riparian countries. Various methodologies in literature have been given for conflict resolution with consideration to hydrological, environmental, economic, legal and political factors. Because of the complex nature of conflicts and cooperation, currently with the development of technology, computer and model applications are used to assist decision-making during conflicts and cooperation. In this paper, potential resolving and preventive alternative methods and/or experiences have been presented so that we can properly formulate and implement suitable policies, strategies and actions to avoid occurrence of water-based conflicts and their adverse consequences in Africa. As an example, conflicts and cooperation on some shared river basins in Africa (Nile river basin and SADC region rivers) have been highlighted. Learning from experiences from other parts of the world, it was recommended to incorporate game theory technique in water resources conflicts and cooperation in the African river basins for equitable and fair utilization and management of shared water.

1. Introduction

Water exists in liquid, solid and gaseous states and is transported in a closed system (hydrological cycle), which encompasses the earth, and its atmosphere. The cycle has many processes, which occur continuously and composed of many interrelated cycles of continental, regional and local extent and therefore is enormously complex and intricate. The distribution of water resources throughout the earth is as follows: Surface water is 0.017%, subsurface water is 0.619%, icecaps and glaciers is 2.147%, and Oceans is 97.217% (Bras, 1990). Clearly, the oceans and icecaps dominate as sources of water. Water is important for life and was the source of early civilizations that grew around watercourses. Flora and fauna of the earth depends on water. Water in its existence or transport may go beyond political or administrative boundaries. Examples are rivers, lakes or aquifers, which are shared between countries. In this work, emphasis will be on the river as a trans-boundary water resource through learning from various experiences on shared water resources in other parts of the world. A river basin is part of the hydrological cycle and bounded by a drainage divide, occupying a network of channels that transport upstream drainage water and sediment to lower regions. Basins drain to outlet points that lead to other drainage basins until the flow reaches the ocean or a closed basin. This chain of drainage basins is known as a drainage system or river basin system. The primary function of the drainage basin in the water cycle is collecting and delivering runoff to rivers that flow to the ocean or sea, lake, or closed basin.

1.1 Recent trends in Africa

In some cases river water systems forms the territorial boundary of countries. In case of change of shape and position of river channels over time, will result into conflicts (e.g. disputed ownership between Namibia and Botswana of the Sedudu/Kasikili Island in the Chobe river that was decided by the International Court of Justice in the Hague)(Ashton, 2003). Indeed the recent floods in Mozambique are a result of actions by upstream riparian countries in managing the water resources of the Zambezi river. If proper predictive procedures were put in place and information shared among the riparian countries the adverse effects of the floods could have been reduced or eliminated completely. Between 2001 and 2002 a number of discourse workshops have taken place towards establishment of an International discourse on developments in the Nile river basin (Nile Discourse, 2002). So unless the neighboring countries jointly develop a formal framework to resolve such types of anticipated conflicts in territorial sovereignty or disasters, cases of water related conflicts can be expected to

continually occur in future. Moreover, since water is important for many aspects of life (agriculture, industry, transport, well being of people, etc.) therefore water issues touches lives of people and hence vulnerable to conflicts between sharing states. Water can also be a source of disasters, which may claim life and property, pollution and outbreak of diseases. Moreover, when we have water shortages, this brings stress to people, agricultural and industrial activities. Because of ecosystem dependence on water, any alteration of the water resources may have significant impact on the ecosystem. The same applies when water is shared. Therefore, water resources have to be managed to lessen problems and conflicts.

2. International shared water resources

International shared rivers, lakes and aquifers account substantially as source of world's freshwater supply. Bennett et al. (1998) cited that international river basins account for almost 47% of the earth's land area, and are also primary source of fresh water in some countries. Also, numerous aquifers lie under the borders of neighboring countries. Worldwide, more than 200 international river systems exist. About 150 of these water basins are shared by two (2) countries where non-comprehensive bilateral agreements are common. Three (3) or more countries share the remaining 57 water basins. Of them, 11 basins are shared by more than six countries (Table 1). In the 57 trans-boundary water basins involving three (3) parties or more, it is difficult to find comprehensive basin-wide treaties. Most water basins shared by three (3) or more nations are managed according to bilateral or trilateral treaties or initiatives, which are subject to a limited scope of cooperation (Just et al., 1998).

Table 1: Trans-boundary river basins shared by three or more riparian countries

No.	Number of riparian countries	Number of rivers	Name of rivers
1.	3	31	
2.	3	2	Incomati, Maputo
3.	4	9	
4.	4	1	Limpopo
5.	4	1	Orange
6.	5	2	La plata, Elbe
7.	6	4	Chad, Volta, Ganges-Brahmaputra, Mekong
8.	7	2	Amazon, Rhine
9.	8	1	Zambezi
10.	9	2	Niger, Congo
11.	10	1	Nile
12.	17	1	Danube
Total		57	

International rivers are also the primary freshwater source in some countries. Table 2 below shows an example of countries dependence of water supplies to trans-boundary water resources. The figures have been cited from Population Action International (1993).

Table 2: Countries depending on river flow from other countries for more than half their renewable water

No.	Country	% of renewable water supplies originating outside borders
1.	Egypt	97
2.	Netherlands	89
3.	Cambodia	82
4.	Syria	79
5.	Sudan	77
6.	Iraq	66

3. Conflicts and cooperation in international trans-boundary water resources

Almost 40% of the world's population lives in international river basins, being dependent on the cooperation of the countries sharing the basin for water supply and quality. The sharing of trans-boundary water resources may result in one or more of the following four different types of drawbacks:
(1) Exploitation of water resource (river) by an upstream country affects a downstream country (unidirectional). For example, water shortages, floods and pollution.
(2) A situation similar to above but damage occurs also in the upstream country (complex unidirectional). For example, reclamation and replanting of wetlands and coastal mangroves.
(3) A group of countries contribute to and suffer from the damages (regional). For example, water shortage, pollution and services.
(4) Worldwide, most countries are affected in one-way or another (global). For example, pollution, global warming and acid rain.

These are among the causes of conflicts in trans-boundary water resources. Differing interests and priorities between riparian countries on the use of water resources mainly spearhead conflicts. Such conflicts are like: Israel and the Palestinian over a shared aquifer that lead to armed confrontation; Turkey with Syria and Iraq, when it built dams upstream on the Euphrates; Egypt fears appropriation of the waters of the Nile by Sudan, Ethiopia and other riparian countries; between India and Bangladesh over the Farraka barrage located in between in the Ganges River; between Thailand and Vietnam based on Thailand's plan to divert water from the Mekong river system for irrigation purposes. The obvious solution to the conflicts can be seen as cooperation between water resource sharing states. Various degree of cooperation exists such as full harmonization of policies, joint expenditures, rule-based framework, continuous exchange of information, and continuous joint decision-making (i.e. policy coordination). Some degree of cooperation threaten independence and self-ruling, and some require voluntary and self-enforced participation. In trans-boundary water resources the degree of cooperation is influenced by hydrology, economic, legal and political factors. These factors can be best collectively covered by technical know-how. Incentives to cooperate and the magnitude of cooperation are further enhanced by the externalities experienced in the absence of joint management, external water resource opportunities. Political stability and international image can also encourage cooperation. This presentation gives an overview of general concepts on trans-boundary conflicts and cooperation on water resources issues, with special attention to the Nile river basin and Southern African Development Community (SADC) region shared rivers as described later.

3.1 Legal tools to resolve conflicts

When governments choose domestic water related policies, they face a trade off between the cost of scarce water resources and economic gains in water intensive sectors, especially the agricultural sector. If policies are not bilaterally (or regionally) coordinated, then neither government takes account of the spillovers of its policies onto the other country. Such policies may affect other countries sharing water resource or otherwise reflecting one or more of the above four drawbacks. However, when governments pursue common regional resource policies, all can potentially attain a higher level of welfare relative to the uncoordinated case. Internationally, it is accepted to utilize the Helsinki Accord/Agreement of 1966 in the resolution of conflicts on shared non-navigable waters (Helsinki Rules, 1966). The follow up of international agreement on trans-boundary waters is covered under United Nations (UN) convention on the Law of non-navigational uses of 1997. All in all these legal protocols are to facilitate resolution of international conflicts involving trans-boundary waters through peaceful means.

3.2 New technologies as tools to resolve conflicts

Various literatures give methodologies for conflicts resolution with consideration to hydrological, environmental, economic, legal and political factors. Because of the complex nature of conflicts and cooperation, currently with the development of technology, computer and model applications are used to assist decision-making during conflicts or cooperation. Table 3 shows classification of operational research (OR) methods according to the number of decision makers and objectives as used in decision-making processes.

Table 3: Classification of OR methods according to the number of decision makers and objectives.

	Objectives	ONE	MULTIPLE
Decision makers	ONE	Most operational research methods	Multiple criterion decision making
	MULTIPLE	Team theory	Game theory

One common approach to conflict resolution is through negotiation as cited by Thiessen et al. (1992). OR assisted case examples are: Bennet et al. (1998) uses an interconnected game approach to model water disputes in Central Asia and the Middle East by linking disputes with other issues (e.g. water allocation in one basin and pollution control in another); Netanyahu (1998) addressed the issue of uncertainty and analyzed the economic framework for international policy coordination; Brill et al. (1998) proposed a model based on the theory of optimal control to drive optimum solutions in conveying water from various sources (aquifers, recycling, wastewater treatment or desalination) to users (agriculture and urban) depending on spatial distribution in Israel-Palestinian cooperation. Others include; Okada et al. (1992) focused on conflicts involved in allocation of the total emission loads to be reduced to respective pollution sources (US & Canada) of acid rain, and proposes a cooperative game theory approach to the resolution of the conflict; Thiessen et al. (1992) addressed the negotiation process required when there are multiple decision makers with conflicting objectives to reach a mutually acceptable and preferred agreement. The game theory provides a mathematical process for selecting an optimum strategy (i.e., an optimum decision or a sequence of decisions) in the face of an opponent who has a strategy of his own. The theory application details are given in Just et al. (1998), Netanyahu et al. (1998) and Bennett et al. (1998).

4. Examples of shared water conflicts and cooperation in Africa

4.1. NILE river basin

The Nile river basin in Africa has two main branches (Fig. 1.); Blue Nile and White Nile. Blue Nile originates in Ethiopia while White Nile is mainly from Lake Victoria. The Lake Victoria is shared by Kenya, Uganda and Tanzania. Over 80% of the runoff of the Nile originates from the Blue Nile system. The Nile river flows northwards and discharges into the Mediterranean Sea. The river is the longest in the world and has a basin area of more than 3,349,000 sq. Km. The Nile river basin also includes environmental features like swamps in Sudan, which give significant water loss through evaporation. There are ten countries, which make up the Nile river basin. Some of the countries have only a small part of their area within the basin, whilst others are virtually entirely within the basin. All the countries contribute differently to the basin and have different needs for the water and other resources of the basin. The ten countries of the basin are: Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. Water uses in the basin includes hydropower generation, irrigation, water supply, industrial and recreation.

4.1.1 Conflicts

Many conflicting issues exist over the use of the Nile water. Like, development of small and large-scale irrigation schemes in Sudan have taken place without riparian countries' cooperation and hence with little consideration to impacts on either downstream or upstream countries. These schemes consumes a heavily water from the Nile river. Also Egypt, the most downstream country with very little rainfall, depends entirely on the water of the Nile for hydroelectric power generation, domestic, irrigation, leisure and industrial water supplies. Egypt with no alternative sources, growing population, and claiming historical rights is contentious about the use and management of water in the Nile river basin. Egypt and Sudan being the biggest users of Nile water, set agreements without considering other countries (Nile Agreement, 1929; 1959). Also Sudan and Ethiopia argue for potential use of Nile water in the future. Although other countries in the basin did not have major needs of Nile water, the need for agriculture and industry development to match with growing population has been realized, and international cooperation could assist this. All countries in the basin see water as a catalyst of development and economic growth and therefore look for cooperation of all riparian countries in the Nile river basin.

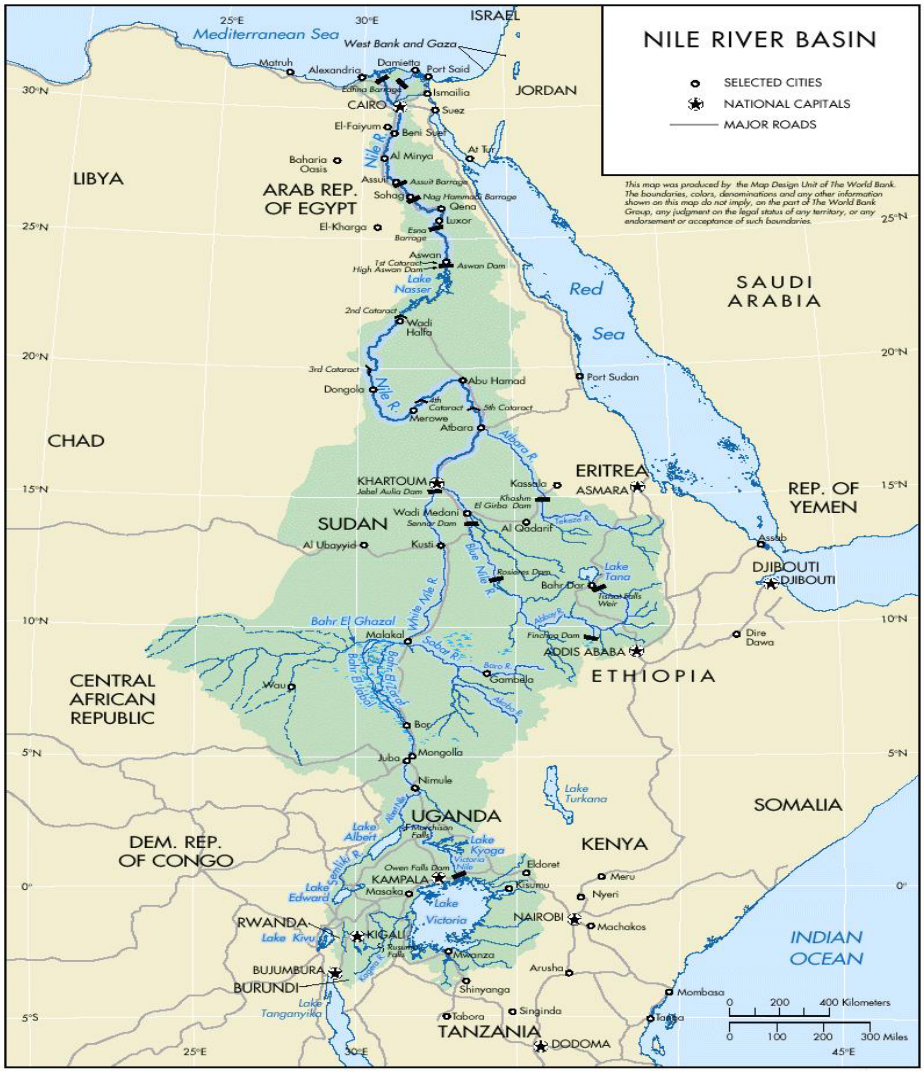


Fig. 1. The Nile river basin and its riparian countries.

4.1.2 Cooperation

Nevertheless, although conflicting interests exists, recently several efforts have been made to avert them and institute international trans-boundary management of water resources, so as to improve efficiency and minimize the negative impacts of water use in the Nile river basin. Several Nile river water agreements have been made between riparian states. One such early cooperation (partial) in the Nile river basin is that of Egypt and Sudan, where a water balance study gave useful results in determining the potential water yield of Swampy regions (Machar marshes, Bahr El Jebel, Bahr El Zeraf and Bahr El Ghazal) in the upstream reaches of the basin (Nile Agreement, 1959; Bras, 1990). The study revealed high water losses. Consequently, channelization and drainage study was initiated in order to decrease water losses and increase annual water yield into Lake Nasser (and the Aswan high dam system) in Egypt, which is the main water-storage facility for both countries. Of late, the Nile Basin Initiative (NBI) was launched in Dar es Salaam in February 1999. The NBI is a regional partnership within which countries of the Nile basin have united in common pursuit of the sustainable development and management of Nile waters. For the first time in history, all Nile basin countries have expressed a serious concern about the need for a joint discourse. NBI is a transitional arrangement until a permanent legal framework is in place. The NBI supersedes the disbanded Technical Cooperation Committee for the promotion of the development & environmental protection of the Nile basin (TECCONILE). The NBI seeks to harness the tremendous potential of the Nile for the benefit of the people of the basin, both now and for generations to come. Possible development projects under

consideration include: hydropower development and interconnection, irrigation and drainage, environmental management, river regulation, drought and flood control, and water use efficiency improvements. Following a complex nature of these projects for equity of utilization of water and benefits, a game theory may help to reach a consensus. A Council of Ministers (COM), the highest decision making organ, governs the NBI. COM is made up of water affairs Ministers of the Nile basin states. Chairmanship is rotated annually. The Nile Technical Advisory Committee (TAC), which is made up of senior officials from the riparian countries supports the COM. The International Consortium for Cooperation on the Nile (ICCON) provides financial support for Nile development. Its objective is to seek coordinated and transparent financing for cooperative water resources development and management and other related projects in the basin. Within this forum, Nile riparian countries will seek funding pledges for projects from bilateral, multilateral and possibly private funding agencies (The Nile Basin Initiative Secretariat, 1999).

4.2. SADC Region Rivers

About four major river basin systems are shared on the SADC region (Fig. 2). These are Limpopo river which is shared between South Africa, Botswana, Zimbabwe and Mozambique; Incomati and Maputo rivers, which drain from South Africa, with Swaziland and Mozambique as downstream users; and Orange river, which covers the whole of Lesotho, (including the Vaal river basin) half of South Africa, a small part of southern Botswana and southern part of Namibia. In line with the SADC overall objective for attainment of an integrated regional balanced economy, equity and mutual benefit for all member states (SADC shared watercourse systems Protocol, 1995), three areas of economy development have been identified. These are poverty alleviation, food security and industrial development. In order to achieve these goals, sufficient availability of water throughout the region is a must. Since water is life, sufficient availability of water will ensure food production, hygiene, industry, power generation and environmental diversity.

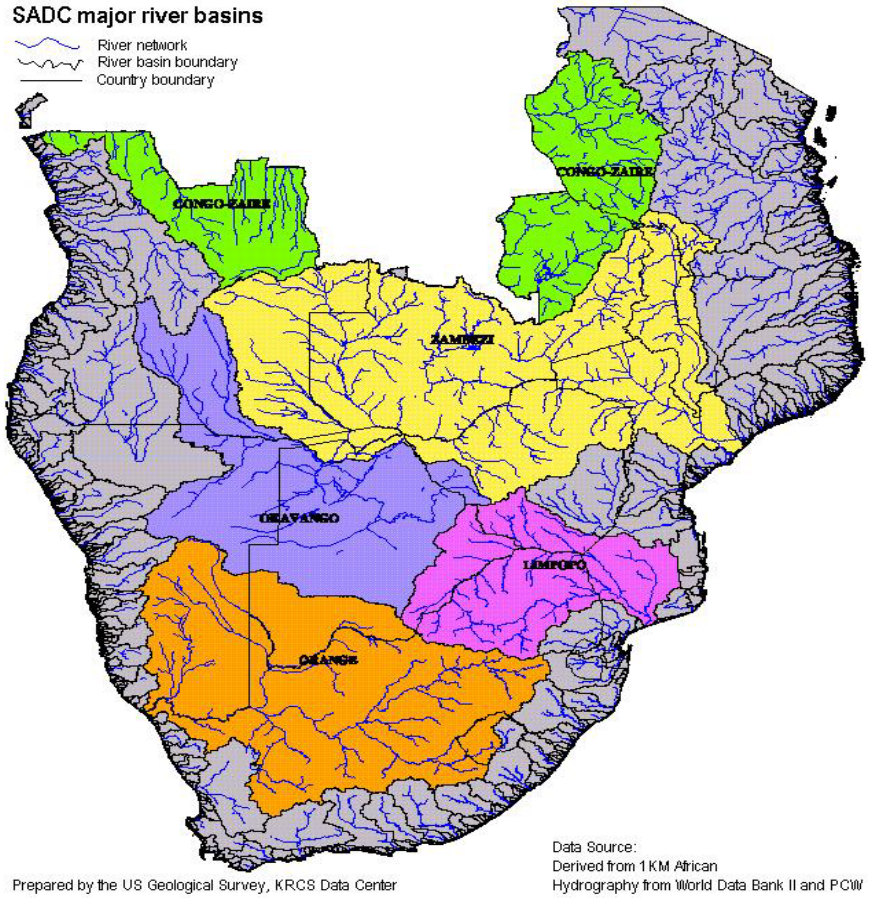


Fig. 2: Major river basin systems and shared river basins on the SADC region

4.2.1. Conflicts

Basson (1999) gives an overview of elements of potential conflicts on shared water resources and suggestion for improved cooperation between the various users of water in the SADC region. The summary of which was presented by van der Watt (2003) and reproduced hereunder: Central to the potential conflict is the population growth of the area and consequent shrinkage of water per capita for domestic needs and economic growth, with social and environmental impacts. Incompatible priorities and perspectives between countries regarding the use of water could also lead to conflict, particularly as the point of full resource utilization is reached. Mozambique, as the most downstream country of the three shared river systems, has already expressed concern on several occasions about upstream developments. One complaint is that reduced freshwater flow into the ocean has caused damage to coral reefs and prawn banks in Mozambique, and seawater intrusion into some rivers. Following increasing water use in riparian countries in the Limpopo river such as in South Africa for irrigation (about 50% of all water uses in the river), mining, industrial and domestic use and in Botswana and Zimbabwe, this affects the most downstream Mozambique with interest in expanding irrigation and domestic water supplies.

The Incomati river basin (of which the Sabie river is an important tributary) flow through Swaziland into Mozambique and the Maputo river basin (of which the Usutu and Pongola rivers are important tributaries) flow through Swaziland into Mozambique. Following increasing population along the upper reaches of the Sabie river and its need for expanding irrigation and domestic water, would impact water resources and supply in Mozambique. Mozambique also complained on the lack of effectiveness of flood control at Pongolapoort Dam in South Africa. Incompatible legislation and technological approaches may also lead to misunderstanding, suspicion and different perspectives between countries concerning the efficiency of water use and resource management. It was also noted that effluent return flows and highly saline mine pumpage, are exerting a significant impact on the water quality of the Vaal river downstream of urban centers. The water quality along the lower Orange river is still good but the transfer of water from the Senqu river (upper Orange river in Lesotho) to the Vaal river, combined with lower-quality flows from the Vaal river into the Orange river as well as irrigation return flows are having an adverse effect on the water resources of the Orange river.

4.2.2. Cooperation

Since South Africa is involved in most of shared major SADC region rivers, it has cooperated and signed agreement with other riparian countries. Bilateral agreements exist between South Africa and its neighbour states on the management of their respective shared watercourses, which lead to a Protocol on shared watercourses in the SADC region (1995), followed by an agreement between the government of Botswana, Lesotho, Namibia and South Africa on the establishment of the Orange-Senqu river commission (van der Watt, 2003). For equitable apportionment of water to Mozambique and to maintain ecology of the river in the Limpopo river, international cooperation with respect to the management of this watercourse system is overseen by the Limpopo Permanent Technical Committee, representing South Africa, Botswana, Zimbabwe and Mozambique. In respect of the Incomati basin, bilateral regulatory authorities have existed between South Africa and Swaziland, and between South Africa and Mozambique respectively. In respect of the Maputo basin, a tripartite technical committee formed the point of contact between the three countries involved. These agreements have now been merged into the Incomaputo Agreement on water sharing, which was signed at the World Summit on Sustainable Development in Johannesburg in August 2002. Several bilateral agreements and instutional arrangements on the Orange river have been entered into between South Africa and its co-basin neighbours. These include the Lesotho highlands water commission, the agreement on the Lesotho highlands water project and the trans-Caledon tunnel authority, between South Africa and Lesotho, the permanent water committee between South Africa and Namibia, and the joint permanent technical committee between South Africa and Botswana.

The bilateral agreements culminate in (but are not replaced by) an agreement between all four countries (South Africa, Lesotho, Botswana and Namibia) to establish the Orange-Senqu river commission. The basic objective of the commission is to provide technical advice to the four parties on the development, utilization and conservation of water resources in the river system. As observed, the Protocol on shared watercourse systems in the SADC region provides a much wider base for a comprehensive multi-sectoral approach to international cooperation. As noted by van der Watt (2003) some key elements towards facilitating the goals of the Protocol, in which South Africa could play a

leading role, are the harmonization of strategies and concerted efforts at basin, national, regional, sectoral and international level, with recognition of water as a key, but limited, natural resource. To ensure equitable sharing of the resource, there is a need to identify and agree upon water-use priorities and allocation criteria – in particular, trade-offs between users. This study sees that the game theory can assist on reaching the fair decision among the riparian countries. Moreover, there is a need to pro-actively address the situation of water requirements exceeding the availability of water, and attention needs to be given to specific interbasin water transfer considerations.

5. Contribution of Hydrology and Water resources management analyses to conflicts and cooperation

The purpose of those engaged in facilitating negotiation is to identify, if possible, alternatives that all parties will find acceptable. Without knowing the relative preferences among all the negotiation issues for each party in conflict it may not be possible to identify whether or not any mutually acceptable alternative exists, and if more than one exists, which of them are most satisfactory to all parties involved in the conflict. Preferences are highly depended on certain benefits from the exploitation of water resources that mainly depends on hydrological factors. Therefore, use of negotiation models should be viewed as part of total negotiation support environment, which includes other decision support systems and professional mediators. Analysis of hydrological phenomenon at different scales is important for understanding the role of land surface processes in the regional or global atmosphere and hydrology. Consequently, will provide inputs to negotiation process models and enable to set appropriate and equitable methods to manage trans-boundary water resources. Example is work of Sheer, Baeck and Wright in 1989, who used a water balance simulation model as a context model in a negotiation over various proposed water distribution management policies. The results of the simulations were made available to the participants of the negotiation process shortly after each proposed decision was suggested. This rapid feedback helped facilitate the negotiation process (Thiessen et al., 1992).

Also, many ecological processes are regulated by the quantity and the time wise distribution of river flow. Major alterations in hydrologic regimes are likely to result in modifications of freshwater ecosystem. Those alterations may be influenced by either developments in the river basins or climate change or natural morphological changes, which may affect water quantity or quality or territory boundary. As a result may affect shared water resources and territorial sovereignty thereby crop up conflicts and/or impair net benefits among riparian countries. Therefore, comprehensive interdisciplinary studies to bridge gaps are a must for trans-boundary water resources. Such studies will also be of help in case of emergence situations like natural disasters and failure of man-made systems, pollution control, irrigation management, analysis of consequences of water resources projects (Environmental Impact Assessment - EIA, Cost Benefit ratio - C/B), and climate modeling for identifying the importance of some regions for regulating globe climate. Moreover, because water demands are dependent on human behavior that is very complex and understanding its dynamics is at a relatively low state of development, attempts to model water demand should be subject to constant monitoring and revision (Parker et al., 1995). It was also cautioned about the use and misuse of the models with consideration to inappropriate training users, crosschecks and other scrutiny of model output or answers, and conditions quite different from those under model development.

6. Conclusions and recommendations

Conflicts arise due to different perceptions of the value and use of water under different socio-cultural backgrounds and therefore should be negotiated. Through negotiation assisted by multiple objective decision making methods, equitable and fair use of water resources can be achieved. Also, this can give a room for collective ideas and a common base of interests in exploitation of water resources or improving the use of existing schemes and identifying reserves not yet exploited. This study has observed the usefulness of game theory techniques in water resources conflicts and cooperation although still development and research is carried out. This kind of approach may also be applied in the Nile river basin and in the SADC region shared rivers for equitable and fair utilization and management of their water, also for other parts of Africa.

Emphasis should be on research and development, where new inputs to negotiation can be realized or will give room for improvement of existing methods or come up with new one. In this case a kind of networking is vital where exchange or sharing of hydrological information pertaining to the shared

water resource can be facilitated. Because of technological development, use of complex models as management tools has grown, but these has to be used with care besides being acceptable in conflict negotiations. Also, due to financial and technological limitation of under developing countries to handle costly trans-boundary cooperation projects, this calls for international agencies support in terms of expertise and financial requirements.

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