Integrated Flood and Drought Management for Sustainable Development in the Kagera River Basin

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Abstract

Integrate Flood Management (IFM) integrates land and water resources development in a river basin, within the context of Integrated Water Resources Management (IWRM), with a view to maximizing the efficient use of flood plains and minimizing loss to life. For flood management to be carried out within the context of IWRM, Nile river basins should be considered as integrated systems. Socio-economic activities, land-use patterns, hydro-morphological processes, etc., need to be recognized as constituent parts of these systems. The aim of this paper is to identify the flood and drought periods in the river basin for future agricultural development and establish functioning integrated measures for flood and drought management in the Kagera Basin, which is one of sub-basin of Nile basin. Digital Elevation Model (DEM) map was used for Kagera river basin delimitation and its patterns (topography, land use and land cover). Impacts of floods and drought on livelihoods of residents were outlined. Survey methods were also used to derive a risk assessment methodology and management plans for hazard prone communities. The flood disaster management strategic plan in the Kagera Basin contains three phases such as prevention and mitigation before the occurrence, response in case of disaster, and rehabilitation after the occurrence. Thus, the most important key strategy is the cooperation and co-ordination across institutional boundaries, noting that the mandates of many institutions will either cover only part of the river basin or extend well beyond the basin boundary. At the core of integration is effective communication across institutional and disciplinary boundaries, which can take place only if there is a perception of common interest. Emphasis was on the adoption of flexible strategies tailored to each flood-prone region (characterized by their various physical, social, cultural and economic aspects) – recognizing the importance of evaluating different options and their relative advantages and disadvantages.

***Key words*:** Adaptation strategy, integrated flood and drought management, Kagera River basin, mitigation measures

1. INTRODUCTION

1.1. Background

Floods are the most common and normally disrupt human activities in floodplains, causing both loss of human life and destruction of property. There is a history of flooding of rivers in Kenya, Rwanda, Tanzania and Uganda which are located in Nile Basins (NBCBN, 2005). There hardly passes a rainy season without flooding events in the floodplains of rivers such as Kagera River.

There is an urgent need to develop an integrated decision support system for flood and drought management in the Kagera Basin. Transboundary water resources pose particularly challenging management problems. When river basin boundaries do not match national political borders, conflicts and problems of management emerge (Ganoulis, *et al.,* 2005).

Rainfall ranges between 900mm in the east and southeast to 1500mm in the north and the northwest volcanic highland areas. With an average of 1250mm per annum, rainfall is generally well distributed throughout the year, despite some spatial and temporal variability.

The eastern and south-eastern regions are more affected by prolonged droughts while the northern and western regions experience abundant rainfall that usually causes erosion, flooding, and landslides (REMA, 2009).

Many recent studies on Lake Victoria basin provide background information highly relevant to the issue of land-use practices, wetlands, waste management, fishing factors, water quality and quantity, sedimentation, limnology and hydraulic conditions (LVEMP, 1996; Campbell *et al.,* 2004; Okwerede *et al.,* 2005). Flood and drought management were studied in the Nzoia River basin (Dulo *et al.,* 2010), and the same study is very urgent and important to other Lake Victoria basins like Kagera River basin. Otherwise this should limit the complete understanding of floodplains, lack of public awareness of the value of water and the inefficient use and management of water in domestic and agriculture purpose (WRPM, 2006). Basically, the survey techniques will mainly focus on identification of flood and drought periods in the river basin for future agricultural development because the economy of East Africa Countries is based on agriculture production (UNEP, 2005).

1.2. Research Problem

The rapid population growth characteristic which is increasing water demand for domestic, agricultural, and industrial purpose is causing water scarcity (Oyebande, 2001). There is a pressure in the world on surface and groundwater management. However, it is very important to improve understanding of different components of hydrological cycle and the spatial and temporal distribution of water now and in the future so as to improve the management and prediction of natural water resources (WaterNet, 2008). Lake Victoria was one of the largest freshwater bodies of the world and plays an ecological, social and economic importance on its surrounding population and the downstream population benefits from it (Muwanga, *et al*, 2006), but recently environmental challenges have been observed in the Lake and flood and drought need to be well managed.

The impact of floods in Africa is extensive (USAID, 2003), causing both loss of human life and destruction of property. Serious damage to the road infrastructure, break out of waterborne diseases and food shortage follow in the affected areas. Climate change is challenging the task of providing sufficient water and food by exacerbating the element of uncertainty and surprise, with increased frequency of water-related events such as dry spells, droughts and floods. Conflicts between competing sectoral uses of water, and between land use and terrestrial ecosystems upstream and downstream aquatic ecosystems, are becoming more common and threaten both the internal and external security of many nations. The scenario looks bleak for Africa with projected shortfalls in agricultural production estimated at 50% due to the effects of expected climate change and variability by the year 2020. For wetter areas like the Kagera River basin, this means more rainfall, increased variability that will impact negatively through increased floods and intra-seasonal droughts.

1.3. Research Objectives

The objective of the research was to identify the flood and drought periods in the Kagera River basin, find out how people cope with floods and droughts, what are the risks involved how they can establish functioning integrated measures for flood and drought management in the Kagera Basin, which is one of sub-basins of Nile basin.

2. METHODOLOGY

2.1 Geographical Characteristics of Kagera River Basin

Kagera River is the longest Transboundary River with its 785 km long formed by 3 headstreams: Akanyaru and Nyabarongo in Rwanda and Ruvubu from Burundi (Vanden *et al*., 1990; LVEM, 1996; Nshimiyimana, 2009). The latter rises in the Southern of Burundi near the northern tip of Lake Tanganyika. Confluencing with the Kagera from Rwanda at Rusumo, then flowing to Uganda in the north, thereby empting into Lake Victoria which is the source of Nile River (NELSAP, 2006). A large portion (67 %) of Rwanda land area is located in the Kagera Basin and drains 90 % of Rwanda national water resources towards Lake Victoria via the Kagera River (Bertilsson and Jägerskog, 2006).

The River is encased in narrow valleys for much of its upper course, but forms broad papyrus-filled swamps in its middle reaches (Nshimiyimana, 2009). In its lower course, below the Rusumo Falls, it expands over large area of the Kagera National Park. The combined surface area of the Kagera swamps is about 1 000 km^2 in Rwanda. A higher altitude swamp occurs in the north of the country: Rugezi Swamp, 80 km^2, tributary of Lake Bulera (Nshimiyimana, 2009).

2.2 Literature Review

2.2.1 Historical flood and drought events in the Kagera River basin

Major flood events occurred in the Kagera River basin during rain seasons like heavy rainy of March, April and May, and short rainy season of September to November, and other floods observed in dry seasons in Eastern Province of Rwanda which is located downstream of Kagera River basin. Compared to other East African countries, Rwanda is less affected by flood as reported in 2007 (http://www.hewsweb.org/floods/).
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Recent floods were observed on 13 May 2010 in Northern part of Rwanda at Musanze District near Volcanoes areas and 2 people died. In this area also flood happened on 16 May 2010 and 4 people died, 40 houses destroyed, 150 ha of crops shifted away as reported by Governor of Western Province (Fig. 1). According to local people interviewed, the same flood happened in 1998. Other flood was observed on 16 May 2010 in North-Western at Rubavu district, Nyundo Sector where 7 people lost their life, 100 residents were destroyed and 87 ha of crops destroyed and many people displaced because of heavy rain. On 19 May 2010, the flood was also observed in Jenda Sector, Nyabihu District where many people displaced and crops removed. In October 2009, floods occurred in Northern part of Rwanda in Musanze District resulting in household's displacement. In the night of 16 November 2009, the river Nyabugogo flooded resulting in maize crop destruction at Kiruhura side (Kigali City). In September 2008, the heavy rains and winds adversely affected 8 among 12 sectors of Rubavu District: Gisenyi, Rubavu, Nyamyumba, Nyundo, Cyanzarwe, Nyakiriba and Kanama (REMA, 2009).

Figure 1: Crops destroyed by flash flood in 2009 on Nyabugogo River and Crops flooded on 16th May 2010 in Northern Rwanda.

Figure 2: Crops flooded and bridge destroyed on 7th Jan 2010, in Migina River which flows to Akanyaru River, Southern Rwanda.

Degradation of environment and ecosystems is not only human-made in the Kagera River basin but also caused by climate disturbances. According to the Rwanda National Adaptation Programs of Action to Climate Change (GOR, 2006), serious floods linked to "El Niño" in 1997-1998 destroyed a large number of agricultural plantations and swamps of Nyabarongo and Akanyaru river basins. From 1999 to 2000, a prolonged drought seriously affected Bugesera, Umutara, and Mayaga regions (low land areas).

2.2.2 Current flood management capabilities

In the Kagera River basin the available capacities on flood management are: *Structural measures* where channels are constructed to avoid landslides, rainwater harvesting, etc; *Non-Structural measures* inter alia erosion control, reforestation and afforestation of hilly and degraded lands, revision of the settlement especially of peoples who live in Gishwati forest to leave for another environmentally sound place, as recommended by the Rwanda Prime Minister after many cases of disasters observed in this natural forest. The third measures is *Do nothing* where Rwandan authorities ask people to displace from flooded prone areas like Gishwati forest to other environmentally sound places but people are still resisting. Note that in Rwanda, flood disaster management is structured as follows:

Flood as well as others disasters (fires, earthquakes, volcanic eruption, etc.) were controlled by Disaster Management Unit recently under Rwanda National Police in the Ministry of Internal Security. Nowadays, disasters are controlled and managed under the Ministry of Disaster Management and Refugee Affairs (MIDMAR). There is a unit called Integrated Water Resources Management (IWRM) which is under the Rwanda Natural Resources Authority in the Ministry of Lands, Environment, Forestry Water and Mines (MINIRENA) and the unit is in charge of hydrological forecast. The Rwanda Meteorological Service which is under the Ministry of Infrastructures (MININFRA) has the mandate on rainfall forecast and the Rwanda Environmental Management Authority (REMA) is working in terms of legal framework and rehabilitation. During floods occurrences different institutions and ministries intervene for support like Ministry of health for health care, Ministry of Defense for life and resources saving, Ministry Information for dissemination and early warning system, Ministry of Finance for financing, Universities and Research Institutions for development of DSS, and Ministry of Agriculture for support of agricultural inputs.

In the department of meteorological service under the Ministry of Infrastructures, down scaled meteorological information and products are given to all stakeholders like seasonal forecasts; monthly updates; ten days updates; and daily forecasts. However, long term average rainfall pattern in Rwanda is also provided by the same office as shown in figure 3 (for at least 30 years rainfall data records).

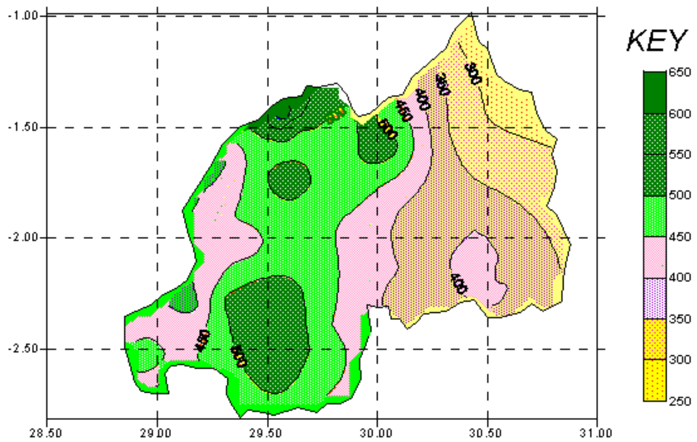

Figure 3: Long term average rainfall pattern in Rwanda.

2.2.3 Risk assessment methodologies

In different countries of Kagera River basin, the Strategic Plan of Action of the National Policy on Disaster Management contains *three phases* in flood disaster management**:** *prevention/mitigation* before the occurrence, *response* in case of disasters, and *rehabilitation* after the occurrence. Implementing mechanisms of the Policy include: Coordination of disaster management based on the following; sharing of information, synergies in programmes, getting together all strategic and technical operations and plans, legislation, planning at the national and provincial levels, followed by sector plans for disaster management, partnerships with international, regional and sub-regional organizations, resource mobilization, and financial management to reduce the costs.

2.3 Data Collection and Analysis

2.3.1 Field survey

Eleven sites were visited during this research and local people and local authorities were interviewed: Kagera (eight sites), Akanyaru (one site), and Nyabarongo (two sites) (Fig.4). The figure shows the map of Rwanda and the investigation was done mostly in the side of Rwanda which occupy the big part of the whole Kagera River basin (Figs. 4 and 6).

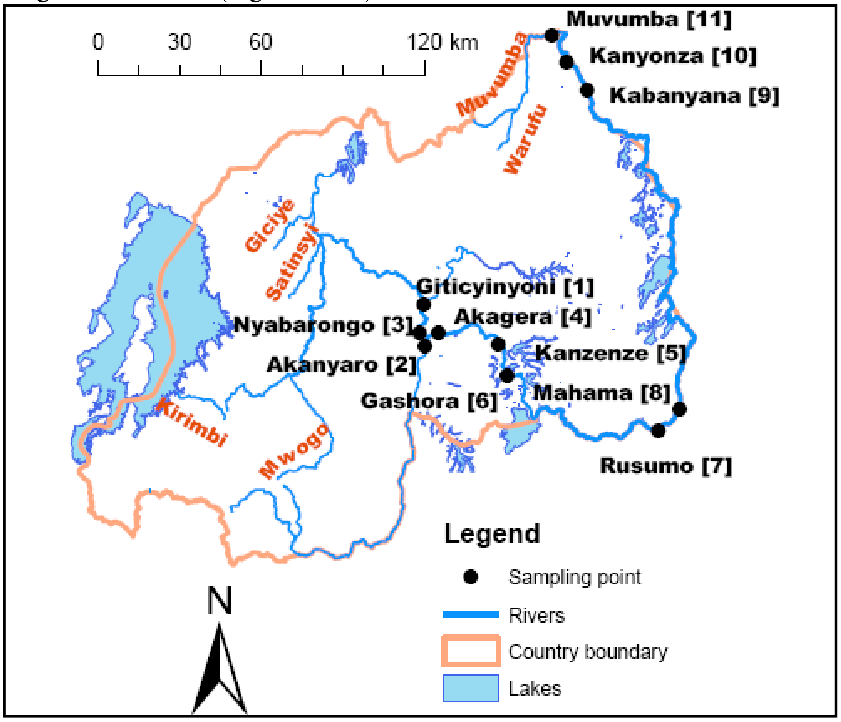

Figure 4: Map of the study area: Kagera River

The interview was done during rain or dry season in the months of April, June, September, October and November 2009. GPS tool has been used to identify and to establish the latitude, longitude and altitude of the sampling point's locations.

2.3.2 Hydro-meteorological information

Climate data in the Kagera River basin have been collected since the colonial times for instance in Rwanda where climate data were collected by Belgians, and in that time the country was a territory of the great Belgian Congo (Dushimire, 2007). The first meteorological station was established in the year 1907 at Save Station, Southern of Rwanda. The hydro-meteorological data are available for more than 50 years in the basin wide.

During the field research reconnaissance and survey, some photos showing where gauging stations are located in the Kagera River transboundary were taken. An example of Rusumo gauging station is shown on Figure 5.

Figure 5: Gauging station installed at Rusumo for water level measurement of Kagera River.

According to NBCBN Group 2 (Flood and catchment Management project), hydro-meteorological stations for Kagera River basin are presented in figure 6 This figure has been presented by NBCBN group 2 during 5th Regional workshop on flood management held in Kenya on 20-23 April 2009.

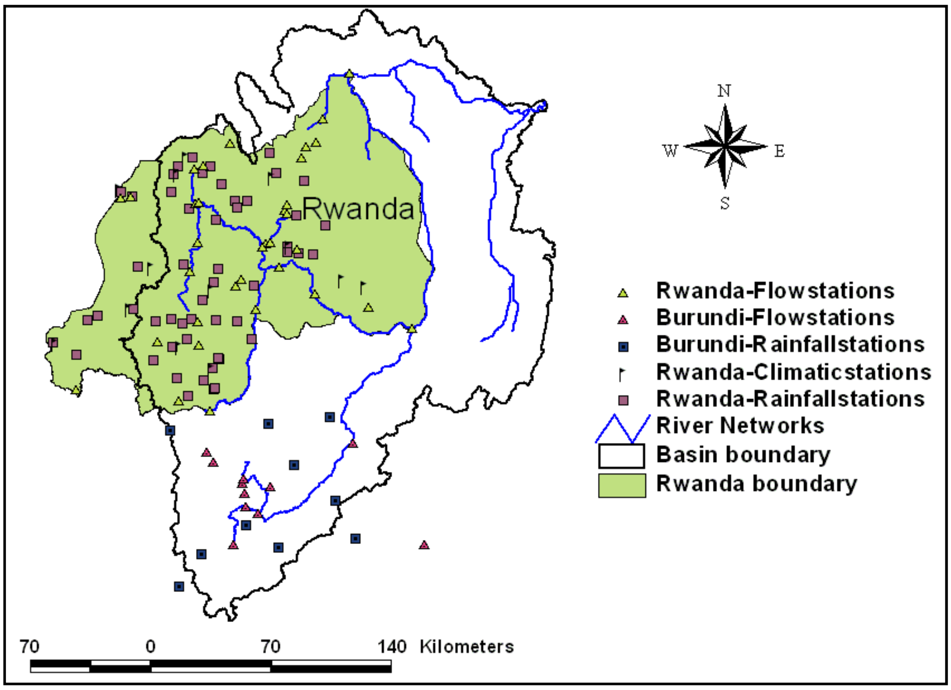

Figure 6: Flow and climatic stations in the Kagera River Basin with Rwanda Insert

3. RESULTS AND DISCUSSIONS

3.1 Floods and Droughts Period and Frequencies

Based on the survey method used for interview to the surrounding people in the Kagera basin, during the research implementation, the flood occurred during the heavy rain season of April and May at the upstream of the catchment and during the dry season of July at downstream of the basin (Tab.1). This means that the time of concentration in the Kagera River basin is around 2 months. The location of sampling sites is shown in the Fig. 4.

Table 1: Flooding and droughting period on the Kagera river basin as monitored in 2009

No	Visited Sites	Flooding period in year	Drought period in year
1	Akanyaru River	April and May	Drought: in July and August
2	Nyabarongo River	April and May	Drought: in July and August
3	Kagera-Mashyoza	April and May	Drought: in July and August
4	Kanzenze	April and May	-
5	Gashora	February to April	Drought occurred in June
6	Rusumo	March-April and November-December	-
7	Mahama	April and December	-
8	Kabanyana-Rutungo	Summer season: July	Drought: in rainy season (March and April)
9	Kanyonza-Matimba	Summer season: July	Drought: in rainy season (March and April)
10	Muvumba- Kagitumba	Summer season: July	Drought: in rainy season (March and April)

The amazing observation that floods occurred during dry season in Kagitumba, is linked to the time used by water flows from upstream (during rainy season) up-to Kagitumba! This very long travel time may due to the topographic condition of Kagera River basin with flat steep and also the wide of the River and basin. Its long of 785 km may also be one of the reasons.

Concerning to the decade floods occurred in the Kagera River basin, and according to the interview of the local people and local authorities, the serious floods which cause many catastrophes like loss of life and property damage happened after each 10years. Therefore, based on these preliminary results, we can assume that the flood frequency in the Kagera River basin should be 10years, but advanced study is needed to check or confirm this assumption based on rainfall long time series available all over the basin.

3.2 Impact of Floods and Droughts to the Human Life

Most commonly negative impacts are upstream and downstream water diversions (Gichuki, 2004), water logging and salinization within irrigation command areas (Khan, 2006). Bad management of water bodies can also harm public health and human capital through the spread of water born diseases with a greater effect on the poor (Ersado, 2005).

Due to the steep relief, western and northern regions of Kagera River basin are prone to landslides and flooding and consequently sensitive to erosion. Heavy rains, floods, and frequent landslides affect the ecosystem negatively through water pollution, invasion of exotic aquatic species, loss of soil fertility by leaching, increase of sediments on arable land and wetlands, and soil erosion. Negative effects of climate change in the Kagera River basin are also driven by increases in temperature, prolonged droughts, and high evapotranspiration.

Due to the occurrence of drought, Kagera River basin has experienced too low river flows and low water levels at different Lakes located in the basin and the hydroelectrical power stations (USAID, 2008). Drinking water levels in Kigali have also been affected due to the reduced intake flow of the Yanze River (USAID, 2008). Local people said that their cows died due to the water scarcity in dry season and their crops get drier.

3.3 Community Based Floods and Droughts Prevention and Mitigation

The primary purpose of the research was to develop flood risk management strategies in partnership with the communities. In partnership with the communities, to develop mitigation measures that fell into the following categories: (i) Actions that could be taken by the communities immediately; (ii) Measures that could be implemented by the communities with technical assistance from external organizations including the District Administration, local disaster management agency and NGOs; (iii) Measures that can be implemented if a small amount of funding and external technical assistance were available to the communities. The main issues raised by the communities during the initial consultations that required funding and external technical assistance were related to frequent loss of crops; lack of clean drinking water during a flood; food and seed storage; and protection of valuables during a flood.

For flood mitigation in the Kagera River basin, the following two measures need to be improved and strengthened for proper flood management: Firstly the structural measures where the constructed channels to avoid landslides, rainwater harvesting, etc need continuous maintenance. Also these infrastructure measures need to be added in the region where they were not planed and where they are not sufficient. This means where their capacity are not enough to drain the available water during heavy rainy season.

Second, non-structural measures need to be strengthened by transboundary counties (Rwanda, Burundi, Tanzania and Uganda) by using different possible options like media and early warning system.
Regarding preparedness and awareness of disasters occurrence (including floods), Rwanda National Police gave telephone numbers to be contacted in case of emergence (floods, fire, or any other accident). These numbers will help in assisting people in danger. This measure could be applied in the whole countries located in the Kagera River basin.

4. CONCLUDING REMARKS

In countries where life of the people is based on the economy of agricultural production, improvement of flood management resources and water conservation may be one of the most important solutions that may lead to increase food security, implies poverty reduction, and environmental protection.
Agricultural Engineers are facing the problem of knowing the periodical flood occurrences (water balance studies) in order to help them to select the type of crops to cultivate in selected land exposed to flood risk to meet their plan of Land consolidation.

This research contributed to this problem by showing the period of flood and drought occurrences. The inhabitants of these areas knew that (Section 3.1), then it is logical that the Agricultural Engineers also know the periods of flood and drought. Based on this information, the plan for both drought and flood can be possible, as do most other local and state governments charged with managing water (Dulo et al., 2010). All efforts are to be inclusive and community based.

To avoid losses occasioned by these disasters there is a need for the approaches and strategies in place to be adaptive and effective to local situation. The following risk assessment methodology needs to be applied in the Nile River countries: prevention/mitigation before the occurrence, response in case of disasters, and rehabilitation/recovery after the occurrence. Some of the mitigation measures were presented in this paper such as structural and non-structural.
The reliability of forecasts can be increased in various ways, such as:

- Improvement of rainfall forecasts;
- Improved catchment modelling;
- Improved channel routing; and
- Improved model updating techniques.

Continued rehabilitation and operationalization of hydro-meteorological stations; and also continue underground water exploration is encouraged in this Kagera River basin for proper future water resources management.

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6. REFERENCES

1. APFM, 2004. *Integrated Flood Management*. Edited by TECHNICAL SUPPORT UNIT. The Associated Programme on Flood Management.
2. Bertilsson, P. and Jägerskog, A., 2006. *Integrated Water, Sanitation and Natural Resources Initiative in the Lake Victoria Region*. Stockholm International Water Institute (SIWI)
3. Burton, J. *Integrated water resources management on a basin level, a training manual*, Canada, 2001.
4. Campbell, L.M., Balirwa, J.S., Dixon, D.G. and Hecky, R.E.. 2004. Biomagnification of mercury in fish from Thruston Bay, Napoleon Gulf, Lake Victoria, East Africa. African Journal of Acquatic Science 29(1):91-96.
5. Churchill, O., 1998. *Expert Blames Lake Victoria Flooding On `El-Nino' Rains*. Maritime Report Special Correspondent, The East African.
6. Drugolecki, A., 2003. *UNFCCC workshop on insurance and risk assessment methodologies in the context of climate change and extreme weather events*. May 12-13, 2003.
7. Dulo S.O, Odira P.M.A., Nyadawa M.O., Okelloh B.N, 2010. *Integrated Flood and Drought Management for Sustainable Development in the Nzoia River Basin*. Nile Water Science and Engineering Journal, Vol. 3, 61-70. April 2010.
8. Dushimire, H.A., 2007. *Water balance of Lake Muhazi*. MSc thesis, National University of Rwanda, Department of Civil Engineering, Butare, Rwanda, 78 pp.
9. Ersado, L., 2005. *Small-Scale Irrigation Dams, Agricultural Production, and Health: Theory and Evidence from Ethiopia.* Policy Research Working Paper 3494. Word Bank, Washington, D.C
10. Ganoulis, J., Murphy, I.R. and Brilly, M., 2005. *Transboundary Water Resources in the Balkans: Initiating a Sustainable Cooperative Networks*. NATO science series, vol. 74, Environmental Security.
11. Gicuki, F., 2004. *Managing the Externalities of Dry Season River Flow: a case study from the Ewaso Ngiro North River Basin, Kenya*, Water Resources Research 40.
12. Khan, S., Tariq R., Yuanlai C. and Blackwell J., 2006. *Can irrigation be sustainable?* Vol. 80, Agricultural water management.
13. Lumbroso, D., Ramsbottom, D. and Spaliveiro M., 2008. *Sustainable flood risk management strategies to reduce rural communities' vulnerability to flooding in Mozambique*. Journal of Flood Risk Management (1) 34–42.
14. LVEM, 1996. *Proposal for review*, LAKE VICTORIA ENVIRONMENTAL MANAGEMENT, October 1996.
15. Muwanga, A. and Barifaijo, E., 2006. *Science and Engineering Series,* African Journal of Science and Technology (AJST). Vol. 7, pp. 51 – 63
16. NBCBN, 2005. *Flood and Catchment Management*. Nile Basin Capacity Building networks, Flood Management Research Cluster.
17. NELSAP, 2007. *Natural Resources Management and Development*. NELSAP Rwanda, Visited in November 2008, http://web.worldbank.org/Rwanda
18. Nshimiyimana, F., 2009. *Heavy metal assessment in Kagera transboundary River*. MSc thesis, National University of Rwanda, Department of Civil Engineering, Butare, Rwanda.
19. Okwerede, L., Kanyesigye, C., Kansiime, F., Byamukama, D., Oyoo, R., Kinobe, J. and Kalibbala, H., 2005. Industrial and Municipal effluents management. Technical report, National Water and Sewerage Corporation, Lake Victoria Management Project. Kampala (Uganda).
20. Oyebande, L., 2001. *Water problems in Africa-how can sciences help?* Hydrological Sciences Journal, vol. 46, No. 6, 947-961.
21. REMA, 2009. *Rwanda Stare of Environment and Outlook Report,* Rwanda Environment Management Authority, Kigali, Rwanda

22. RWANDA, 2007. *Floods*. DREF Bulletin n° MDRRW003, *GLIDE n° FL-2007-000159-RWA,* 26 October 2007.
23. UNEP, 2005. *Connecting poverty and ecosystem services: A series of seven country scoping studies, focus on Rwanda*. United Nations Environmental Programme (UNEP) and the International Institute for Sustainable Development (IISD), Nairobi, Kenya.
24. USAID, 2003. *Famine Early Warning System Network*, FEWS Flood Advisory for Greater Horn of Africa 7 - 9 May 2003.
25. USAID, 2008. *Rwanda Environmental Threats and Opportunities Assessment*. 2008 Update.
26. USGS, 2003. *Drought definitions*. Visited in March 2009, http://ks.water.usgs.gov/waterwatch/drought/definition.html
27. WaterNet/WARFSA/GWP-SA, 2008. *Water and Sustainable Development for Improved Livelihoods.* International conference on 9th WaterNet Symposium, 29-31 October 2008, Johannesburg, South Africa.
28. WRPM, 2006. *Water Resources Planning and Management Project (WRPM).* http://wrpmp.nilebasin.org/ index.php?Itemid=37&id=27&option=com_content&task=vie
29. Zongxue, X.U., Kazumasa, I.T.O. and Jingyu, L.I., 2000. *Risk estimation for flood and drought: case studies*. IAHS-AISH publication, ISSN 0144-7815.

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