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Putting research knowledge into Action: The missing link for sustainability of Lake *Tana* Ecosystem, Ethiopia.

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Abstract

There is always a trade-off between environmental protection and development in most dynamic and complex ecosystems. Therefore, understanding the big picture of the human environment nexus, with its complex interactions is essential. Despite the positive impact on the country's drive towards food security and poverty alleviation, development activities that have been taking place around Lake Tana catchment are casting doubt on the sustainability of the region. Unless timely, protective policy intervention measures put in place, there might be a serious environmental degradation which ultimately ends up with a complete collapse of the whole ecosystem. The paper tries to analyze the importance of integrating different knowledge systems and transferring research knowledge into policy framework and immediate intervention in the Lake Tana ecosystems by which researchers, policy makers at governmental level and user groups at community level can achieve desired outcomes through the sustainable resource use, development and application of innovative approaches.

Key words*:* knowledge systems, knowledge integration, sustainability, Ecosystem, Lake Tana, Ethiopia.

JEL Code: Q27, Q25, Q28

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1. Introduction

Lake *Tana,* located in north-west Ethiopia, is the second largest freshwater lake in Africa. It accounts for 50 per cent of the total inland water area of Ethiopia and feeds the Blue Nile River, which contributes about 85 per cent to the total flow of water in the Nile. It is important in ecological and economic terms, and it has both local and global significance. Lake *Tana* is selected by the Ethiopian government as one of the potential Growth corridor for development and reducing food insecurity problem. As a result, there are tremendous development activities that are taking place in and around the Lake Tana. Yet, despite the potential positive impact on the country's economic growth and alleviating poverty, these development activities are casting doubt on the sustainable use value of the Lake and its surrounding ecosystem.

Ecosystem sustainability is of growing concern to ecologists and other scientists who study the cumulative global impact of widespread environmental change and to social scientists attempting to develop policies to sustain the production of goods and services for a growing human population (Goodland, 1995). Therefore, understanding the big picture of the human environment nexus, with its complex interactions in and across ecosystems as well as in and across human systems, is essential if policy and action responses are to contribute to the goals of sustainable development and improved human well-being (UNEP, 2011). So far, long-term maintenance of ecosystem health is in conflict with the short-term interests of many stakeholders and policymakers (Bavinck. M. et al., 2005).

On the other hand, knowledge generation, synthesis and exchange are fundamental aspects of managing the future sustainability of natural resources, particularly healthy ecosystems (VCMC, 2002). On this regard, management of natural resources cannot afford to be the subject of just any single body knowledge such as the Western science, but it has to take into consideration the plurality of knowledge systems. Application of scientific research, local knowledge and incorporating the views of all relevant actors contributes both to the equity, opportunity, security and empowerment of local communities, as well as to the sustainability of the natural resources (Getz *et al.*, 1999).

The overall objective of this research is to throw light on and aims at providing a preliminary review of the major traits that cast doubts to the sustainability of the Lake Tana ecosystem and lesson learnt across the globe that witnessed unsustainable development activities leads to a complete or partial collapse of ecosystems. The study also highlights the importance of integrating different knowledge systems in an effective policy formulation and implementation process which ultimately leads to a sustainable ecosystems development and conservation.

2. Research Methodology

2.1 Description of the Study Area

Lake Tana is located in the country's north-west highlands at 12° 10′ 0″ N, and 37° 20′ 0″ E. The lake is natural and covers 3,000-3,600 Km^2 area at an elevation of 1,800m.a.s.l. It is approximately 84 km long, 66 km wide and has a volume of 28, 000 Mm^3, which makes it the largest in Ethiopia. The lake is a shallow, on average about 9 m and maximum 14 m. It is surrounded by densely inhabited area of 806, 545 residents (Tesfahun, Demissie 2004).

Lake *Tana* is an important source of fish both for the people immediately around the lake and elsewhere in the country (Berhanu et al, 2001). Its unique and isolated landscape includes forested islands, immense and varied wetlands and high mountain areas. The region is renowned for its biodiversity, and it is also the home of churches and monasteries dating from the 14^{th} to the 16^{th} century. Ninety per cent of the area's rapidly growing population of 2.5 million people depends on subsistence agriculture for their livelihoods. The productivity and sustainability of mixed farming practices depend on ecosystem goods and services, which rely on the functional integrity of the watershed's ecosystems- rivers, wetlands, lake, forests, pastures and soils.

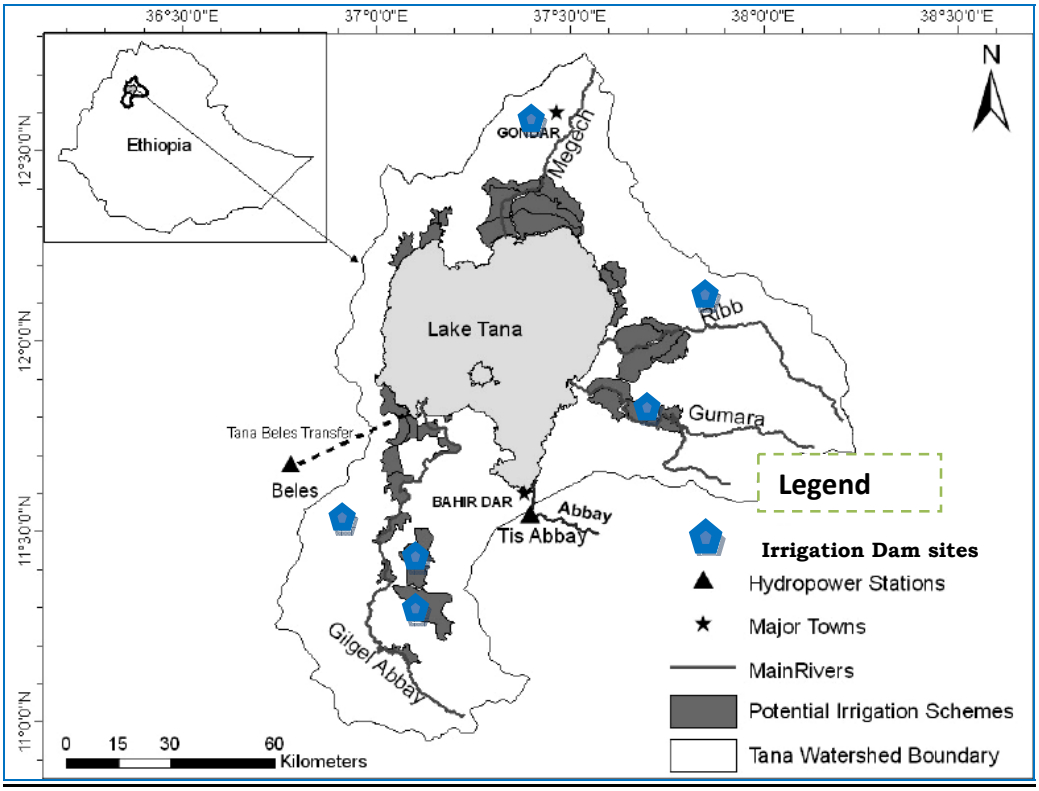

Fig1: The Lake Tana watershed and development activities

2.2 Research Methods

In order to acquire the data with regard to the research objectives, primary as well as secondary data were employed. Data for this study was drawn from personal observation, key informant interview, a series of focused group discussions and reviewing of relevant policy documents.

3. Result and Discussion

3.1 The status of world's Ecosystems

The ecosystems on which we depend are not static; change is constant in nature. For millennia, the Earth has been transformed by advance of glaciers, volcanic eruptions, and the clash of continents. But today, human beings are the most powerful force of environmental change (MA, 2006). The Millennium Ecosystem Assessment (MA), an international synthesis that analyses the state of the Earth's ecosystems reveals that, over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber and fuel.

This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth. The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of: the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people. Some 60 percent of the ecosystem services examined in the Millennium Ecosystem Assessment-including fisheries and fresh water-are being degraded or used in ways that cannot be sustained. Global ecosystems conditions and trends show that, 50-80 per cent of original mangrove lost in costal ecosystem (Burke *et al*., 2000), 50 per cent of world's wetlands lost during the 20th century has been recorded in freshwater ecosystem (Revenga *et al*., 2000). Unless human attitudes and actions change, the degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to reducing global poverty and achieving the Millennium Development Goals (MA, 2005; 2006).

3.2 Learning from others as a development and policy guide: What happened to other lake ecosystems around the world?

Lake Alemaya/Haromaya/ Ethiopia

The Alemaya lake in the Ethiopian highlands originally covered more than 175, 140 ha but had shrunk to 87, 910 ha (which is 50% of the original) in 1985 and to a mere 58, 600 ha (33.5% of the original) in 2002. It is now believed that the lakes have all but completely dried up. The loss of the lakes, which were a source of drinking water, irrigation and fisheries, has affected the livelihoods and well-being of more than 550, 000 people in the Ethiopian towns of Haromaya and Harar. Preliminary research seems to suggest that serious siltation has been a major factor in the destruction of the lakes. A dramatic increase in urban and rural settlements is also believed to have put tremendous pressure on natural resources in the area, including water resources (RCMRD, 2005). Increasing irrigation and domestic water use change in the local climate, and changes in the surrounding land cover are believed to be the causes of Alemaya's demise (Setegn et al., 2011).

Lake Chad, Africa

Lake Chad, once one of Africa's largest freshwater lakes, has shrunk dramatically in the last 40 years. In 1963, the lake covered about 25,000 km^2. Today it is one-twentieth of that size. The size of Lake Chad has gone from 30,000 km^2 to 3,000 km^2 in 40 years, according to some sources - from 25,000 km^2 to less than 1,500 km2 between 1966 and 1997(Coe M.T et al.,2001). Major irrigation projects were built in the 1980s, which made use of the two main rivers, Chari and Longone, which supplement the lake. Increased irrigation demands are said to have significantly decreased the flow of water into the lake; some speculating that the irrigation demands, which increased a phenomenal four times between 1983 to 1994, have accounted for a 50% decrease in the lake's water level (Noury, 2009).

Aral Sea, Asia

Formerly one of the four largest lakes in the world with an area of 68,000 Km^2, the Aral Sea has been steadily shrinking since the 1960s after the rivers that fed it were diverted by Soviet Union irrigation projects. By 2007 it had declined to 10% of its original size (Philip M et al., 2008). The region's once prosperous fishing industry has been essentially destroyed, bringing unemployment and economic hardship. The Aral Sea region is also heavily polluted, with consequent serious public health problems. The retreat of the sea has reportedly also caused local climate change, with summers becoming hotter and drier, and winters colder and longer (U.S. Geological Survey, 2007). The shrinking of the Aral Sea has been called "one of the planet's worst environmental disasters"(Daily Telegraph, 2010).

3.3 **The State of Lake *Tana* Ecosystem**

Lake *Tana* Ecosystem has a global significance on which a huge livelihood, economic and socio-cultural groups are highly dependent. Lake *Tana* is also one of 250 lakes identified by Lake Net as having globally significant biodiversity. Lake *Tana* catchment is selected by the Ethiopian government as one of potential Growth corridor for development and reducing food insecurity problem. However, despite the positive impact on the country’s drive towards achieving food security, Growth and Transformation Plan (GTP), these development activities that has been taking place in and around Lake Tana Ecosystem are casting doubt on the sustainability of the region.

Vijverberg, J., et al, 2009 summarizes the major treats as follows; despite the limited direct human influences on Lake Tana, both wetlands and surrounding catchment area have already been seriously damaged by human activities and most of the original forest has disappeared. The littoral region and wetlands of the lake are currently under severe degradation by the local inhabitants. Especially the area covered by papyrus has been decreasing recently (Teshale et al., 2001) by the ever growing human population. The local community is harvesting papyrus reed roots during low water level to use it as fuel wood. Farmers are cultivating the wetlands when the water is retreating. The abundance of endemic *Labeobarbus* species in Lake Tana decreased dramatically with ca 75% in 10 years time (1991–2001). The destructive fishing operations during the spawning season (August–September) in river mouths and upstream on the spawning grounds in combination with alteration and destruction of spawning habitats may lead to extinction of 7 of the 15 endemic labeobarbs.

In the outflow of the Blue Nile from the lake, a large dam (Chere chera) has been constructed, resulting in increased silt load and turbidity of lake water and reduced water levels. The withdrawal of lake water for generating hydroelectric power and irrigation in combination with the predicted increased variations and progressive decrease of rainfall over the years is expected to cause severe water level fluctuations and reduced water levels in the coming decade. Conversely, Bahir Dar is a rapidly growing town, a six times population increase up to 1,800,000 inhabitants is expected in the next 50 years (Teshale, 2003). The current practice of discharging untreated industrial and domestic waste into the lake will have adverse effects on the quality of the lake water. Furthermore, pollution from agricultural sources as fertilizers, insecticides and herbicides are recently increasing.

Construction of four more major dams around the major tributaries of Lake Tana particularly at *Gumara*, *Ribb*, *Megech*, and *Gilgel Abay* are underway (see Fig 1). Tana-Beles power generation (estimated 460MW) by diverting water from the Western shores of Lake *Tana* through a canal (12km) in the western part around *Kunzila* and connected to *Beles* river is inaugurated in 2010. The project is expected to serve the country for the next 25 years (starting from March, 2010) without any major interruption.

A recent study shows that future development will exacerbate pressure on the lake. If all the planned development occurs, the mean water level of the lake Tana will drop by 0.44 meters (m), and the average surface area will decrease by 30 square kilometers (km^2) (i.e., 1%) and up to 81 km^2 (i.e., 2.6%) during some dry seasons. There will be prolonged periods of several years during which water levels will be much lower than they would be naturally. If environmental flow requirements (estimated to average 862 Mm^3y^{-1}) are maintained in the reach containing the Tis Issat Waterfall, the mean water level of the lake will reduce by a further 0.37 m and the average lake area will reduce by an additional 26 km^2. Without careful management these changes are likely to have severe ecological and social consequences (Mccartney, et al., 2010).

As a result of these treats and research evidences coupled with global climate change and environmental degradation, there is a speculation that Lake Tana could shrink drastically in size within two or three decades. Then the system may no longer able to support life and have an impact on the livelihood of the local people which ultimately affects the country's drive towards achieving the Millennium Development Goals (MDGs). Threats to Lake Tana and its catchment area have also serious implications for environmental and human security in Ethiopia and other riparian communities.

Therefore, keeping the health of Lake *Tana's* ecosystem for sustainable resource utilization and socioeconomic development of the local community in particular and the wider population in general, should be the priority agenda. However, the progression of degradation inside a lake often takes place on a wider and deeper scale than is apparent. If the seriousness of a lake problem is realized in time by scientific means, resource conservation and restoration measures may produce some promising results. Often, however, the symptoms of degradation remain unnoticed for a long period of time because of their incremental nature, and the introduced conservation and remedial measures may be too little too late. The level of ecological and water quality degradation may have already reached crisis proportions, suddenly leading to instant loss of ecosystem sustainability (ILEC, 2007).

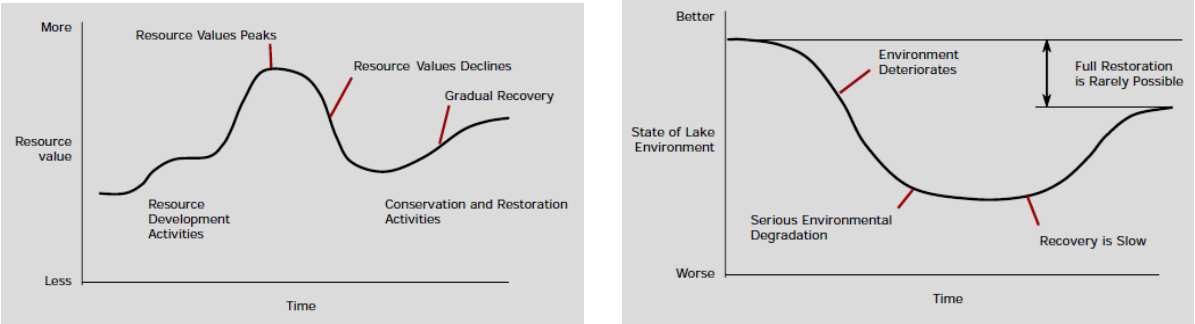

Fig 2: Changing Resource Values and Resulting Environmental State of a Hypothetical Lake, (ILEC, 2007)

As we see from the figure 2, once a lake ecosystem reached a serious environmental degradation, recovery is slow and full restoration is rarely possible. Especially, for the poor nations like Ethiopia where economical, institutional and technological capacity to reclaim the environment is untenable, it will be very difficult to preserve valuable environmental resources effectively. According to the Environmental Sustainability Index (ESI, 2005) which quantifies the likelihood that a country will be able to preserve valuable environmental resources effectively over the period of several decades, Ethiopia, ranks 135th out of 146 countries with a score of 37.9 which is the least score among the 40 NEPAD (New Partnership for Africa's Development) member countries just above Sudan (with ESI score of 35.9). Even when we compared with the 21 countries that are more than 50% Deseret**,** 15 countries scored from 39.8- 56.7. The ESI score also evaluates a country's potential to avoid major environmental deterioration (Esty et al., 2005).

3.4 Understanding knowledge systems perspectives for the Lake Tana Ecosystem Management and governance

Natural resource governance cannot be dealt through the dichotomous division between scientific and indigenous knowledge systems; rather we need to explore diverse systems of knowledge triggered by specific configuration of political interests and cultural formations (Ojha et al., 2007). Knowledge related to natural resources and their management is stored in the mind and means of so many stakeholders and institutions, and in formal and informal ways that it is, ideally, hard to assess the legitimacy and dominancy of knowledge of one individual or knowledge communities to others. When stakeholders with diversity of interests, knowledge and power interact and collectively learn it is likely that there would be a synergy to develop social practices for the management and use of natural resources (Banjade et al., 2007).

Particularly transferring knowledge into action in ecosystem management appears to be a messy process which involves a complex series of interactions between the decision makers, producers and users of research. The problem of natural resource management and governance as perceived by government planners, policy makers, and researchers is quite different from the problems of primary concern to the users, who are trying to secure access to sustainable livelihood options by optimizing the use of their resources. This is because; decision makers, researchers and users inhabit different worlds (Caplan, 1979). Whilst researchers may revere theories and concepts, decision makers want concrete evidence which is relevant and easy to understand. And whilst researchers often take years to complete research studies, decision makers want answers quickly (Mitton, et al., 2007). Each side also speaks its own, highly technical language (Choi, et al., 2005).

Therefore, understanding different knowledge systems is imperative to manage and govern natural resources in a sustainable manner without compromising the needs of the future generation. According to Ojha, et al., 2007, practices of natural resource governance are shaped by knowledge systems of, and deliberative interfaces among, diverse groups of social agents that tend to vary both in terms of knowledge and other aspects of differentiation. Therefore, in terms of knowledge perspectives, five types of social actors were identified to better understand their perspective towards the Lake Tana Ecosystem (See Fig 3).

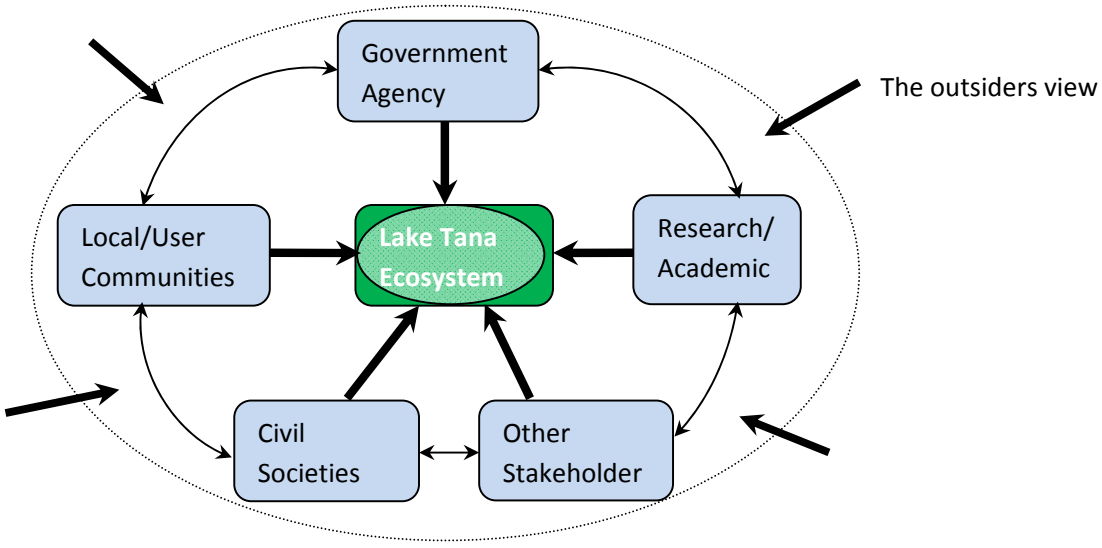

Figure 3: Key components of Knowledge System clusters of the Lake Tana Ecosystem (*Modified and adapted to the local context after, Ojha et al., 2007)*

Government agencies are ministries and administrative units at different level who are mainly involved in the formulation of policy, legislation, implementation, monitoring and evaluation of natural resource management and governance processes. Mostly these agencies are confronting with conflicting objectives towards natural resource management and utilization. Particularly, in the Lake Tana ecosystem, development goals are usually contradicting with the conservation goals. For example, Ministry of Agriculture and Rural Development with a broad objective of boosting production and marketing for food security and poverty alleviation, is trying to insist the farmers in the Lake Tana watershed to use improved agricultural technological packages particularly, fertilizer and pesticides. On the other hand, Environmental Protection Authority (EPA) and Institute of Biodiversity Conservation (IBC), with conservation and protective goals are striving to minimize the stress on the ecosystem through proposing the delineation of buffer zones, integrated watershed management approaches around the Lake Tana. Generally, these agencies have their own knowledge perspective to see and act accordingly towards managing and governing the Lake Tana Ecosystem. Government officials are typically unaware themselves of the conflicts and confusion caused by the contradictory goals, regulations, procedures, and plans of their various agencies to mange natural resources.

Local/user communities and research/academic institutions are believed to be the sources of indigenous and scientific knowledge systems respectively. Indigenous knowledge and resource use practice has been defined as a cumulative body of knowledge and beliefs handed down through generations by cultural transmission about the relationship of living beings, (including human) with one another and with their environment (Gadgil et al, 1993). Indigenous knowledge is also local knowledge unique to a given culture or society, mostly it contrasts with the international knowledge system generated by universities, research institutions and private firms. It is regarded as the basis for local level decision making in agriculture, pastoralism, natural resource management, and a host of other activities in rural communities staying very close to the nature (Farooquee et al., 2004). Local knowledge systems have been found to contribute to sustainability in diverse fields such as biodiversity conservation and maintenance of ecosystems services, tropical ecological and bio-cultural restoration, sustainable water management, genetic resource conservation and management of other natural resources. Local knowledge has also been found useful for ecosystem restoration and often has ingredients of adaptive management (Panday, 2002).

Special interest groups such as (civil societies and other stakeholders like UNESCO) range from those favoring development of resources to those favoring preservation as cultural heritage. Civil societies have the potential to promote equity, democracy in natural resource management and governance by facilitating and advocating discussions and negotiation among local users, decision/policy makers, and other stakeholders at different levels. Their responsibilities may include articulating the needs of the weak, working in remote areas, changing the attitudes and practices of local officials and nurturing the productive capacity of the most vulnerable groups of society (Chandhoke, 1995).

Very importantly, the outsiders views on Lake Tana Ecosystem is quite different from the insiders where the system encompasses the sources of Blue Nile, and one of the centers of global biodiversity. At international level for instance, the vision and aspiration of Egypt, Sudan and other riparian countries is always to see the constant inflow of Nile River throughout centuries. They wish not to see any development activities that threaten the hydrological cycle in the Nile Basin.

Though, understanding of these knowledge systems is not as such too difficult, accommodating the views, goals and interest of government agencies, researchers, local users and special interest groups is a challenge and complex in integration, because they have different perspectives and are operating in different contexts.

3.5 Knowledge integration for policy formulation and implementation

The current un-sustainability state of the Lake Tana ecosystem might be either as a result of poor policy and management that could not integrate development and conservation in a sustainable manner or knowledge gap that integrate the policy makers, researchers and local users.

Basically, the integration of different knowledge systems into existing sustainable development goals, and natural resource management policies at international, national and local/user level will have a practical implication for sustainable use value of the lake ecosystem. This integration could occur in a variety of configurations: among science disciplines; across spatial and temporal scales; from science through policy, management, and education; and among knowledge providers, users. Effective management of the important environmental problems we face today requires integration of all of these interests (Bowden, 2002).

In political science or organizational analysis, decision-making processes are conceptualized as being informed by various types of information, including, in some cases, scientific evidence. Two general assumptions underlie policymaking. One is that governments, researchers or user groups possess, or can develop, sufficient knowledge on their own to form the basis for policy. The second assumption is that the world in which we live can be represented in simple models. However, it is found both assumptions untenable. Academics, policymakers and users have to interact 'to get the picture right'. In addition, they have to put the diversity, complexity and dynamics of governance issues right on the table (KOOIMAN, J. 2005).

Therefore, involving multi-stakeholders and incorporating their views, agendas and interest in policy framework will facilitate knowledge exchange and integration. Stakeholders often do not explicitly recognize the ways in which their knowledge and understanding frame their perspectives on common pool resource management policy. Knowledge about laws and institutions may be seen as providing both constraints and opportunities for common pool resource management, because this knowledge forces stakeholders to consider resource uses that are compatible with these wider policy processes (UNEP, 2011).

Conversely, involvement of an increasing array of stakeholders in natural resource management has created conditions for conflict and the processes of negotiations will inevitably lead to governance solutions. The emerging diversity of stakeholders has also given rise to the potential for pooling of diverse knowledge traditions in the practice of natural resource governance. But the actual deliberative interface has often been negatively affected by conflicts among different knowledge systems that have developed historically (Ojha et al., 2007).

As a matter of fact, knowledge has to be exchanged and translated among stakeholders in order to formulate better policy and implement successfully. Though, mutual understanding between researchers, experts and decision makers is often hindered by jargon, language, experiences, and presumptions about what constitutes persuasive argument, there should be a mechanism to link knowledge to action which requires open channels of communication between researchers, experts, decision makers and local communities but also requires that participants in the resulting conversation understand each other's context (Cash w., et al., 2003).

4. Conclusion and the way forward

Ggenerally the problem in the Lake Tana ecosystem is expected to worsen in the coming few years as population, hydropower and irrigation demands, and other development activities continue to increase. The analysis also reveals that there are global and regional research evidences that indicates the foresee treats for the Lake *Tana* Ecosystem possibly will have unprecedented impact on the region's social, economic and environmental conditions. Unless timely, protective policy intervention measures put in place, there might be a serious environmental degradation which ultimately ends up with a complete collapse of the whole ecosystem.

Development is a necessary condition for the survival of developing countries like Ethiopia. However, development should not be unsustainable to worsen the existing conditions. It has to be planned and implemented without affecting the sustainability of natural resource base, livelihood of the local community and the long-term economic development and the countries drive towards attaining food security and poverty alleviation. More importantly, the recent environmental catastrophe of the Aral Sea (Asia, by 2007 it had declined to 10% of its original size); Lake Chad (Africa) and Lake Haromaya (Ethiopia) should be a lesson and a guideline for any development activities in general water resources development in particular.

Conservation of natural resources through sustainable ecosystem management and planned development is the key to our secured future. There is a need to integrate research, ecosystems conservation and development to ensure sustainable resource use and livelihood security for the wider community in the Lake Tana catchment. Policy-makers need to develop policies and practices that distinguish between situations where conservation and development goals are compatible and situations where there may be conflicts.

Regarding Lake Tana, some researchers points out the need for more research to inform policy, I personally recommend more of policy intervention to protect the Lake Tana ecosystem from its foreseen treats and speculations, because the research knowledge that have been produced concerning Lake Tana coupled with the global and regional catastrophe that witnessed the disappearance of ecosystems are more than enough to inform policy. Therefore seeking an innovative ways of saving the Lake Tana ecosystem from a foreseeable treats and speculation is very imperative for those who have a stake in the Lake Tana catchment.

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