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Feature article

THE BLUE NILE RIVER BASIN: THE NEED FOR NEW CONSERVATION-BASED SUSTAINABILITY MEASURES

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SUMMARY: The Blue Nile *(Abay)*, one of the most famous international rivers, has its origin in the Ethiopian highlands. The river passes across different geographical zones and serves different land users in the upper and lower Nile riparian countries — Ethiopia, the Sudan and Egypt, respectively. Although the Blue Nile basin contributes 86% of the total annual discharge of the Nile, Ethiopia has not built big hydro-electric power installations or modern dams in this river basin. On the other hand, the river carries the country's valuable natural resources to the lower riparian countries while the Ethiopian people suffer from recurrent drought and famines. Ethiopia's efforts to divert its waters have brought confrontations with the lower Nile riparian states. Through the building of big dams and canals, enormous amounts of water and soil nutrients are utilised by the Sudan and Egypt. In recent years, however, farmers in Egypt have not been getting sufficient water and soil nutrients as before, due to environmental deterioration along the Blue Nile basin. Based on three selected sites, water resource development projects are proposed to be implemented in Ethiopia through conservation based sustainability measures. It is suggested that political stability, understanding and environmental rehabilitation measures taken by all countries of the Nile river basin are urgently needed if water resources are to be utilised on sustainable basis by the lower and upper Nile riparian countries alike.

INTRODUCTION

Water is one of the most important natural resources and life-supporting systems. This indispensable resource is, however, misused in many countries either through poor land-use systems and inappropriate agricultural inputs or through the process of industrialisation. Due to lack of sustainable development, water resources in the Blue Nile basin are neither planned properly nor managed carefully, which has led to the destruction of natural and human

environments in the region. Upreti (1994) defines sustainable development as "the management and conservation of the natural resource-base, and the orientation of technological and institutional changes in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations".

Which countries and groups of people benefit most from the Blue Nile basin? Why has Ethiopia not diverted water from the Blue Nile and why has this river basin become the source of conflict in the region? How can water be shared among the riparians and at what price? What will be the long-term environmental consequences on the Blue Nile basin if the present land-use continues; and how can regional co-operation and understanding be established on the basis of ecological, legal, institutional and moral principles in the region? In this article, attempt will be made to answer these questions in an interrelated manner by providing some basic factors that have led to the environmental problems facing those riparian countries in the management of the Blue Nile river basin and proposing sustainable development and water resource use through the conservation of natural and human landscapes and habitat (biodiversity).

The paper is based on the author's field work in some weeks in 1984, 1991 and 1994 along the Blue Nile river basin, participation in an international course on the hydrology of the Nile river and studies of relevant literature.

THE GEOGRAPHY OF THE BLUE NILE RIVER BASIN

There are eight major rivers in Ethiopia. Six of these are either boundary and/or trans-boundary rivers while two are confined within the country. The Blue Nile is one of the most important rivers in the country. It flows north from temperate and humid Ethiopia to semi-arid and arid conditions in the Sudan and Egypt (Fig. 1). The Blue Nile originates as a small spring (called Gilgel Abay), about 100 km south of Lake Tana, in the volcanic mountains of Ethiopia that have steep relief and ridges that rise up to 3000 m altitude. Before *Gilgel Abay* reaches Lake Tana, it passes through a large flat land. Many rapids occur on smoothed and resistant rocks, conditions which are favourable for hydro-power generation.

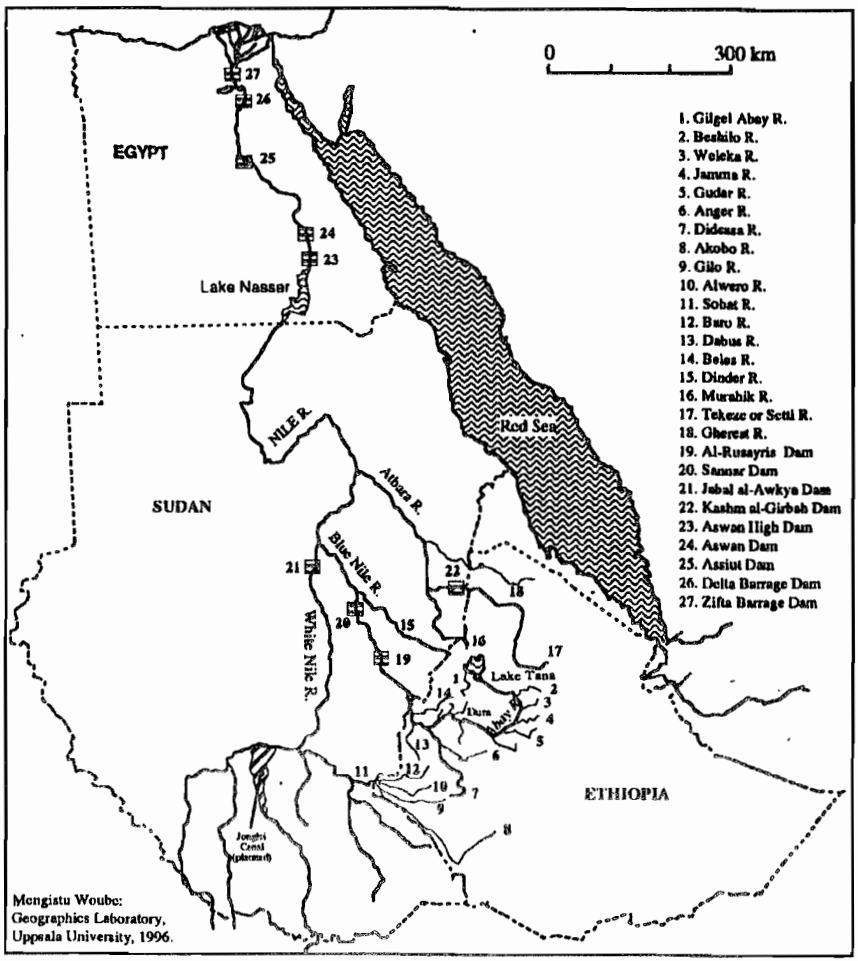

Fig. 1. Map showing the Blue Nile and White Nile river basins with existing dams and reservoirs. Neither dams nor reservoirs exist in Ethiopia.

Lake Tana is a creator lake (Ethiopia's largest) situated in the north-east part of the Blue Nile basin and it covers an area of about 3,150 km^2. The catchment area of Lake Tana sub-basin, including the Lake, is 17,500 km^2. It is 78 km

long, 67 km wide with a maximum depth of 14 m. The mean annual outflow is about $4x10^9$ m^3 yr^{-1} or about 127 m^3 s^{-1} (Admasu Gebeyehu, 1989). The main tributaries, other than *Gilgel Abay* are Gumara, Ribb, Magech, Infranz and Gedla. *Zege* is one of the coffee-tree peninsulas, *Dek* and *Daga* are the main islands. Many churches and monasteries are located in these places. According to Mohr (1961), recent lavas cover the peninsulas and islands, and lacustrin sediments occur all round the Lake Tana basin. There are also lagoons and swamps on all sides of Lake Tana, that have resulted from hydrological and land-use changes.

Gilgel Abay passes over Lake Tana and outflows at Chara-Chara cataract in the eastern part of the Lake. In the outlet, the river is called Blue Nile (*Tikur Abay*). From the outlet, the river runs in a south-easterly direction. As we go down from the outlet, the river becomes wider and even deeper. Due to high vegetation density (e.g., papyrus), swamps in some places can be observed and in places where water flows in narrow topography, the velocity of the floods increases, which makes it extremely difficult to cross the river.

Thirty five kilometres from the outlet of Lake Tana, the Blue Nile river reaches *Tiss Isat* Falls or Smoke of Fire (Fig. 2). Here, the water flow goes in different directions due to the topographical characteristics and vegetation patterns. The morphology of the water flow varies considerably depending on the season. In the rainy season (June to September) when heavy rainfall falls on the region, the amount of water is much larger and covers wider areas (as seen in Fig. 2). This huge amount of water can be stored on the Blue Nile plateau to be used during the dry season before it passes *Tiss Isat* Falls and reaches the high evaporation climatic regions. During the dry season the water discharge is much reduced.

From this great and beautiful falls, the Blue Nile follows the bed of a deep gorge and borders five administrative regions. Five hundred kilometres from its source, the Blue Nile reaches an altitude of 490 m in the Sudan. It encounters on the way many rushing torrents (Fig. 1) until it finally joins the White Nile and emerges as the main Nile river in Khartoum.

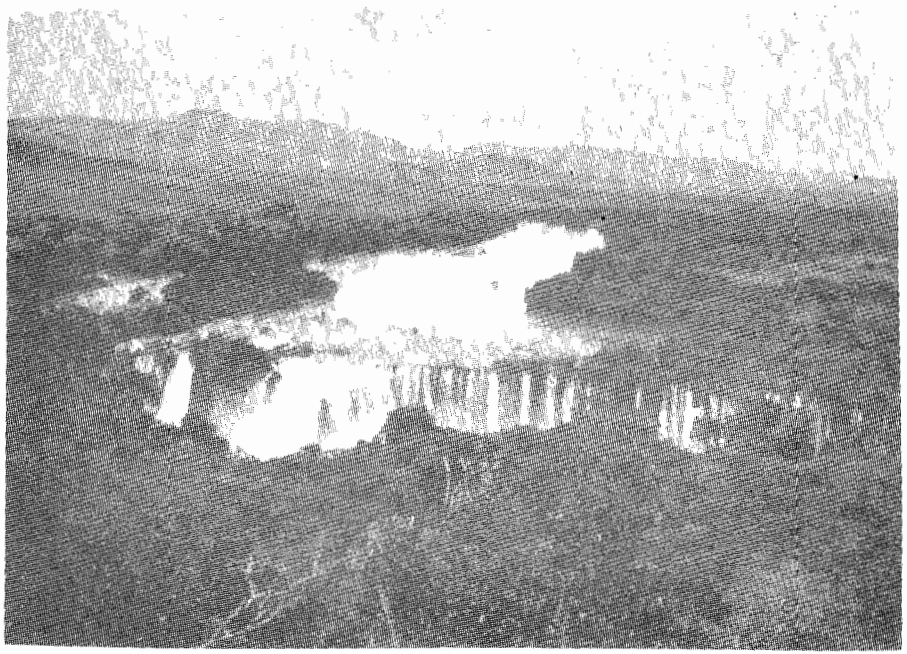

Fig. 2. *Tiss-Isat* Falls on the Blue Nile below Lake Tana. Photo was taken during the rainy season by the author.

The Blue Nile gorge is one of the largest and deepest in the world comparable to the Grand Canyon in the United States. It passes several rapids, tumbling through volcanic and sedimentary rocks (Fig. 3). Its river basin covers 201,346 km^2 or 16.6% of the total area of the river basins in Ethiopia (re-calculated from Zewdie Abate, 1994, p. 29). Its annual discharge amounts to $50x10^9$ m^3 yr^{-1} or 1600 m^3 s^{-1} on the 935 km below the Blue Nile outlet at Rosaries (Admasu Gebeyehu, 1989). About 85% of the total annual discharge of the upper river Nile comes from the Blue Nile, Tekeze (Atbara), Baro and Akobo rivers in Ethiopia and only 15% comes from the East African source areas of the White Nile (Whittington *et al.*, 1994). The low amounts of water from the latter river is due to surface evaporation and evapotranspiration (from aquatic vegetation) losses. Also, much of the water remains in the Marchar marshes

along the Jonglei canal areas (Sudd region) in Southern Sudan (Conway and Hulme, 1992). About 80% of the water passes to Khartoum during the rainy season and declines to 20% in April, before the next rainy season (Godana, 1985). The reasons for the alternate enormous torrential and shrunk flow of waters are mainly the concentration of high amounts of rainfall and low evaporation during the rainy season, low amounts of rainfall and high evaporation during the dry season (on the lower altitudes), deforestation and the high speed of the river due to topographic characteristics.

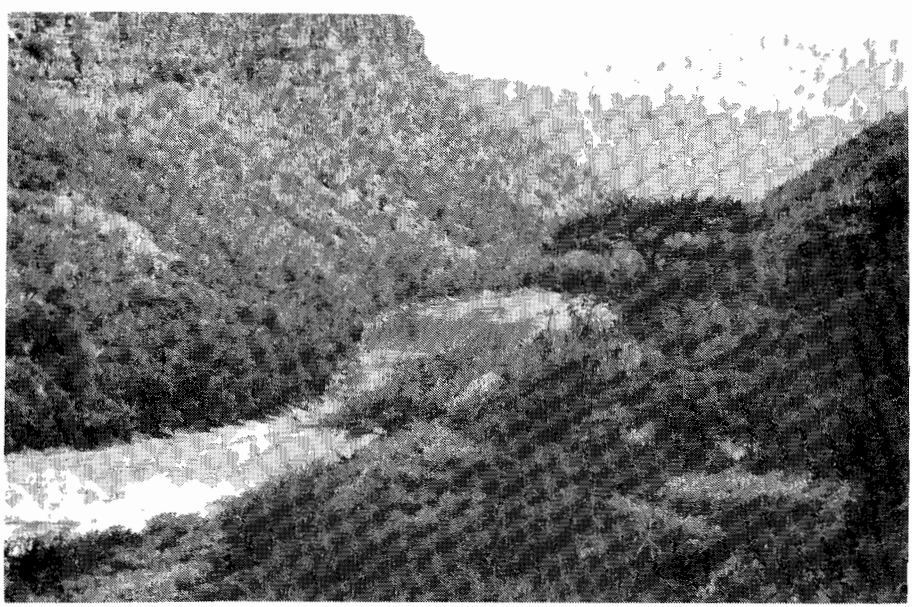

Fig. 3. Blue Nile river passing through a narrow trough-like gorge. The materials on both sides of the river are bedded various types of sedimentary rocks such as limestone, sandstone, variegated shale and gypsum. Many streams and rivers tumbledown from the mountains and hills, thundering through gorges and enter the Blue Nile river. (Photo was taken by the author during the dry season in 1991.)

THE BLUE NILE RIVER BASIN AS A SOURCE OF LIFE

At least ten ethnic groups (1.3 mill. people) live along the Blue Nile basin. They are ox-plough farmers, nomads, pastoralists, hunters, gatherers, slash and burn-cultivators, fishermen, and traders. In the alluvial soils, farmers cultivate two crops a year and perennial crop farming is also practised. During the dry season, pastoralists and nomads move their cattle along the tributaries and the Blue Nile river, which creates conflicts among the different land-users. Due to deforestation along the river basin, the Blue Nile gorge has become a major source of wood and grass for construction materials, fuel-wood and charcoal production. Most wild animals now seek refugee along this important gorge.

Due to its geographical features, the Blue Nile has been a frontier for nationalists, anti-colonialists and anti-government groups. During the Ethiopian war with Italy (1936–41) for instance, the resistance groups used the Blue Nile gorge as an important strategic place to fight the Italians. Whenever conflict emerged between the central governments and the people in the region, the Blue Nile gorge has been used for defence. Moreover, the geography of the Blue Nile basin has created cultural differences (languages, religions, ethnic groups, economic systems, etc.) and problems of infrastructural development. Although the Blue Nile provides 68 GWh yr^{-1} (average) of electricity (from the *Tiss-Isat* Falls) to the towns of Bahir Dar and Gondar, neither big hydro-electric power installations nor industries, reservoirs or modern dams are built in Ethiopia. The main reasons are financial, geographical and political constraints. In the Sudan and Egypt however, the water resources from the Blue Nile have been more exploited through modern irrigation systems and dams.

ENVIRONMENTAL DETERIORATION

While it may be said that the Sudan benefits from the Blue Nile basin (its eastern part is totally dependent on the basin), Egypt is a creation of this great river. Without water and indispensable soil nutrients from the Blue Nile basin, the civilisation of Egypt would not have been possible. Ethiopia looses its enormous quantities of fine silts from the more largely bare mountains in the country. At the expense of the natural resources from Ethiopia, Egypt was said

to be the "bread basket" of the Roman Empire. However, the present soils in Egypt are poor in Nitrogen, Iron, Zinc and Magnesium. Following population increase (about 3% per annum) and soil deterioration, Egypt is poised to reclaim more land to maintain production, but seepage, salinization and high evaporation reduce on the average 10% of the agricultural production every year (Kishk, 1986). Egypt now needs more and more water and soil nutrients for her new reclaimed arid lands to feed its rapidly growing population. However, these huge demands can not be met since the country receives little water from the White Nile. The absence of annual deposits of Nile alluvium is due to the Aswan High Dam in Egypt (Kishk, 1986 and 1993). It is also said that vegetation changes in Ethiopia and the construction of dams in Sennar, Al-Rusayris, etc. in the Sudan have reduced the amount of water and soil nutrients.

The changes in vegetation patterns result in land degradation along the Blue Nile basin, due to the collapse of sustainable environmental management systems, institutional networks and food security. These situations in turn cause unexpected floods and reduce soil nutrients both in the upper and lower Nile riparian countries. The cutting of trees for firewood and charcoal is a growing cause of deforestation. Due to population increases fallowing is no longer possible. As the result, intensive cultivation occurs (often without fertilisers) and soil nutrients are washed. Another problem is overgrazing associated with inadequate management of grazing land which is aggravated by inadequate watering points (Mengistu Woube and Sjöberg, 1994).

The root causes for the mismanagement of resources are lack of land-use planning, population increase, high taxation and poor agricultural and price policies. In order to feed themselves and the urban population, the rural people in the Blue Nile basin are increasingly forced to exploit the natural resources. In addition, due to lack of alternative energy sources, building materials, etc., the entire population in this river system is dependent on the natural vegetation of the area (Mengistu Woube, 1994). The physical and human environments in the region are, thus, in crisis. It can be concluded that vegetation changes from highland Ethiopia have brought a profound impact on the physical and human environments both within Ethiopia and in the lower Nile riparian countries.

How long can the Ethiopian physical environment provide its resources freely to the lower Nile riparians, while the Ethiopian people suffer from shortage of water and food due to severe droughts, famines and poverty? Ethiopia has been assisted with food by international communities, but none of these have given significant assistance to the country to divert its many rivers to the development of agriculture and hydro-electric power installations. Ethiopia is said to be the potential "water tower" of North-eastern Africa, but except for the Awash (one of the main rivers), almost all are yet to be exploited. The dilemma is that Ethiopia is unable to divert its water resources from the Blue Nile, Lake Tana and other rivers to the agricultural and human settlements and to construct hydro-electric power installations. Rural electrification can reduce the cutting of trees for fuel or can save the use of animal dung which otherwise could be used to improve soil fertility. Rural electrification would also provide power for agro-processing industries, water lifting for irrigation, etc.

Though a nation-wide afforestation programme was introduced in the 1970s and 1980s, it did not bring significant changes (Mengistu Woube, 1986 and 1995). Afforestation and reforestation programmes can only be implemented successfully when alternative energy sources (hydro-power, solar and wind energies) are provided to the people. Potentially, the bare land can be re-covered with vegetation quickly since the Blue Nile basin in Ethiopia has sufficient rainfall (1224 mm annually), favourable climatic and soil (mainly Nitosols, Ferralsols, Vertisols and Alluvial soils) conditions. Afforestation will increase the supply of surface and ground water, decrease sediment loads and add organic matter to the soils. As Hosier (1988) pointed out, deforestation of the Ethiopian highland, cultivation of steep slopes and erosion from them have made possible the fertile cultivation along the Nile for centuries. Due to extreme pressure on land (which led to the loss of protective vegetation skin) and erodible tropical soil characteristics, soil disappears, "the surface run-off increases and the ground water is not totally refilled since the rain water does not infiltrate in the same degree as before" (Tvedt, 1992; Olsson, 1987). As a result, abnormal floods and unexpected droughts have increased in Ethiopia, which have caused considerable loses in agriculture, dams and water reservoirs damaging the human settlements in the lower Nile riparian countries (Darkoh, 1992).

CONFLICTS ON WATER RESOURCES

Conflicts between and among nations, rich and poor people, pastoralists, nomads and farmers on water resources is a phenomenon in all parts of the world. Conflicts between and among the upper and lower Nile riparians are ancient and any type of water development project in the upper Nile source regions has been a threat to the lower riparian states. Although several agreements for the utilisation of the Nile waters were signed in 1902, 1929, 1959, 1967, 1981 and 1993 (Hurst, 1952; Godana, 1985; Collins, 1990; Pearce, 1991; Ethiopian Herald, 1993; Vesilind, 1993), none of these have ever included the Ethiopian side nor promoted Ethiopian interest or protected its natural resources.

Unless Ethiopia is supported to build its own dams and irrigation canals, assisted to rehabilitate its river basins and as long as water is not utilised on equal bases between the upper and the lower Nile riparian countries, maintaining peace and stability in the region becomes questionable. One of the five Upreti's (1994) principles for environmental conservation is equity and social justice. Without this principle it is neither possible to protect Ethiopian's natural resources nor satisfy human needs for the present and coming generations.

THE NEED FOR ENVIRONMENTAL CONSERVATION

Unfortunately, there are no well established international laws on river basins that could create understanding between the water contributors and users. Interestingly enough, Egypt and the Sudan, which do not contribute to the Blue Nile water resources, are the users, while Ethiopia's right has been denied. How much and for how long Ethiopia can afford not to harness its water resources to alleviate its own problems, which are aggravating the environment? It is estimated that Ethiopia has 0.9 mill. ha of irrigable land in the Blue Nile river basin and 1.5 mill. ha in the Baro-Akobo basin (a White Nile tributary) that could be developed under irrigation schemes (Zewdie Abate, 1992). Although Ethiopia contributes enormous amounts of water to the Nile flow, currently the country has no water allocation (Whittington *et al.*, 1994).

In contrast, Egypt utilises 3.2 x 10^9 ha. Due to shortage of farm land, Egypt is said to reclaim more than 0.58 mill. ha of desert land in the coming years (Kishk, 1993). In order to irrigate the reclaimed land, more than $10x10^9$ m^3 of additional water is needed by the year 2000 (Abdu-Zeid, 1991; Kishk, 1993). Since 97% of the land in Egypt is desert each drop of water and each kilogram of silt are important. However, due to environmental deterioration and poor water management, salinization is increasing and the ground water rises up and dissolves salts up to the root zones of the plants which kills them (Olsson, 1987). The Sudan has developed 1.8 mill. ha of land. Irrigated agriculture uses 18.3 x 10^9 m^3 of water each year and it is projected to expand by 1.5 mill. ha. The annual demand of water will reach to more than 31 x 10^9 m^3 in the coming years (Zewdie Abate, 1990).

All these point out that restructuring a new agreement on the use of water resource in the three countries is a strongly felt need. Such an agreement should allow Ethiopia to use her water resource and to obtain international support to finance irrigation schemes and to rehabilitate its deteriorated environment. Ethiopia has lost regional and natural rights to divert its water resources for development purposes. The country does not have sufficient hydrometeorlogical data, capital, modern technology, trained manpower for environmental management and support from international organisations and donor countries. In contrast, Egypt has appropriate technology and information about the river basin. The country is backed by the developed countries and international organisations and the state have given top priority for the development of hydraulic technology and water control. Nevertheless, unless the water resources are redistributed (on the basis of trans-boundary water resources policy, population and resource sizes and wealth) among the Nile riparian countries, sustainable development cannot be maintained.

What is happening today in the region is that the lower Nile riparian states are demanding more water without contributing to the rehabilitation of the deteriorated environment in the Blue Nile basin. The basic problem facing Egypt is that there is not enough water available to meet the growing demands for irrigation and electricity. Currently, the Aswan High Dam supplies about 20% of the Egyptian's total power needs, which are growing by about 6% yr^{-1}. The dam may not supply more that 10% by the year 2000 (Whittington *et al.*,

1994). The main reasons are the rapid population growth and the environmental degradation in the Blue Nile source region, which need collective rehabilitation measures.

Rehabilitation measures require regional and international support and Ethiopia alone and by itself can not mitigate the deteriorated environment. In order to introduce sustainable (conservation-based) water utilisation programmes, well discussed and integrated river basin planned policies are indispensable. To begin with, the state and quality of the existing environment of the basins must be understood and the Blue Nile basin should be rehabilitated by all countries in the region before things turn to worse. As argued by Upreti (1994), "the policy-makers .... must agree in principle that the solutions for the environmental and human problems, namely of conservation of biodiversity and habitat restoration with ecosystem development, must be sought within the context of well-connected landscape ecosystem processes on a regional basis".

Based on detailed studies on the physical and human environments, well thought-out principles as guide-lines, laws and regulations must be developed in order to utilise the water resources on sustainable development basis by all riparian countries. Unfortunately, such indispensable issues are not discussed. With demand on water increasing, neither international laws and regulations nor real understanding between the Nile riparian states have been established. However, for the benefit of the lower Nile riparian countries the Blue Nile river basin must be considered as an ecological region, be utilised in an integrated, unified and co-operative manner; and Ethiopia must be allowed and be supported to utilise her water resources through conservation based sustainability measures.

THE PROPOSED PROJECT TYPES AND SITES

In order to feed its rapidly growing population, Ethiopia, sooner or later, will introduce reservoir, dam and irrigation projects along the Blue Nile river basin. Before the introduction of such projects, a) the lower Nile riparian countries must recognise Ethiopian's rights to water resources, b) the Blue Nile environmental management must be understood and c) Ethiopia must offer

specific and concrete proposals. Here some environmentally sound and economically viable project types (reservoirs, dams and irrigations) and project sites (on the tributaries, Lake Tana and Blue Nile river) are proposed as follows:

The first proposed project is the development of small and medium-scale dams and irrigation systems on village or household level along the various Lake Tana and Blue Nile tributaries. These types of projects are less expensive, manageable or maintainable, efficient in saving water and energy and can increase agricultural production. Small-scale hydro-electric power stations can also be generated in most of the tributaries on community and village levels; and these in turn can save thousands of trees that are now cut every day for fuel-wood and for other purposes. These projects will not affect the water flow, rather they reduce sediment loads, which is a serious problem for the lower Nile riparian countries.

The second proposed project is the development and use of Lake Tana and its surrounding as a water reservoir. The United States Bureau of Reclamation argued as early as in 1964 that one of the numerous advantages of the construction of the Blue Nile reservoirs in Ethiopia can be the saving of huge amounts of waters that presently evaporate (through evaporation and evapotranspiration) from the lower riparian countries, specifically from the Aswan High Dam reservoirs on the White Nile. Such reservoirs can provide over-year storage and can also control the unexpected floods that also affect the Sudan and reduce large sediment loads, which presently affect agricultural output and water quality in Egypt (Whittington *et al.*, 1994). Through the construction of water reservoirs in and around Lake Tana, the alluvial plains of Fogera and Dembya in the north, Takusa in the west and Achefer in the south of Lake Tana, can be irrigated and crops can be cultivated two or three times a year, which will lead to food self-sufficiency in the Blue Nile river basin.

The third proposed project sites and types are divided into two: a) Small-scale dams and irrigation projects to be introduced on the outlet of the Blue Nile, along the Dura depression and the Sudan border (Fig. 1), b) Large, medium and small-scale hydro-electric power stations to be introduced on the various water falls sites along the Blue Nile river. Through these measures, the rural

population in the region can be provided with alternative energy and Ethiopia can sell electricity to the lower Nile riparian countries. The regional water marketing system can finance Ethiopia to implement her afforestation and soil conservation programmes in the region, which is also useful to the lower Nile riparian countries.

For the establishment and implementation of such development projects: a) the willingness of the local people, b) a stable and widely supported national government, c) carefully designed plans and strategies, d) restructuring of human and agricultural settlements, e) adequate capital and experts, f) scientific understanding of the physical environment such as geological, agronomical and hydrometeorlogical environments, g) financial and moral support from the international communities are prerequisites. The implementation of the above mentioned proposals can lead to co-operation and regional-based conservation of the natural resources, and alleviate human misery and environmentally hostile conflicts among the Nile riparian countries.

If the upper and lower Nile riparian states continue arguing on the so called "national and regional rights" on waters, further environmental deterioration is imminent as nature has its own limitation to serve its users. As Rees rightly argues "true sustainability requires that we recognise the reality of ecological limits to material growth and the need to live in the interest of our remaining ecological capital. This is not an option but an absolute necessity if we are to have a sustainable future" (Rees, 1990).

CONCLUSION

Water is an indispensable resource and it has also been a source of conflicts in many parts of the world. Through the building of gigantic dams and canals, Egypt and the Sudan exploit water resources from the Blue Nile basin. Ethiopia neither utilises effectively its waters and silts nor protects these resources through effective afforestation programmes. Some of the main constraints to environmental rehabilitation are lack of: a) understanding between the upper and lower Nile riparian states; b) knowledge about the physical and human environ-

ments in the river basin; c) resources and administrative capacity; and d) short and long-term conservation-based environmental rehabilitation measures.

How can realistic and long-lasting conservation-based sustainable development programmes be introduced and implemented? National governments in the Nile riparian countries will have to have strong political determination to introduce correct land-use and environmental planning, provide people with basic education, especially ecological economics and environmental awareness. To do these, a joint committee (as a common body) for co-ordination of investigation of the Blue Nile river basin has to be established in the region. As Upreti (1994) argues, environmentally sound and socio-economically responsible planning require scientific knowledge and understanding not only of the biophysical and hydrological environments, but also of the socio-economic, ethical and moral aspects of human environment. The root causes of today's environmental degradation, ecosystem destruction, human misery and social instability result from highly egocentric attitudes and approaches of human beings towards the natural system and lack of understanding of the human institutions.

If such environmental rehabilitation and conservation measures are not introduced and implemented urgently, the upper and lower Nile riparian countries may not be able to alleviate poverty and avoid conflicts and to produce food from their farms in the future. These situations will eventually force people to change the existing agricultural and human settlement sites, increase mass migrations, diseases and deaths. For a healthy environment, increased life supporting system, secured politics and for a sustainable future in the Nile riparian countries long-lasting conservation based sustainable development programs are indispensable.

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