RATIONALE FOR THE ESTABLISHMENT OF INTEGRATED DRAINAGE BASIN MANAGEMENT

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Introduction

The development of water resources is an essential prerequisite for the alleviation of food shortage and energy crisis in Africa. The drainage basin is the best conceptual unit for assessing water resources potential in any given region. We may define a drainage basin as an area of land on which the rain that falls is collected into rills, rivulets, streams and finally into a single river outlet that joins a larger tributary or flows into a reservoir. The major drainage basins are, however by their nature, international because they transcend national boundaries. The size of a drainage basin may vary from a few square kilometers to several thousands of square kilometers as the Nile, Congo and Amazon basins.

It is obvious that the unity of a drainage basin simply is the collection of water over the catchment and its flow through one mouth into a reservoir. In other words, the waters within the geographical area of a particular basin constitute a critical and, therefore, a most useful conceptual unit for establishing a legal regime and for

organising co-operation and collaboration for land and water resources development, utilisation and conservation (cf. Sauto - Maior, 1975).

The United Nation's General Assembly observed in 1970 that the biophysical characteristics of a river basin tend to form a relatively cohesive ecological system and therefore, is one of the units suitable for planning. Such a planning typology is basically and essentially integrated. It requires alot of environmental as well as socio-economic data.

The drainage basin is a suitable conceptual unit because it constitutes a dynamic system in which all environmental parameters may be measured and evaluated. The environmental inputs into a drainage basin include the sun's insolation which is the primary driving force for all terrestrial systems. The insolation causes wind movement, evaporation and rainfall. These combine to create a biophysical environment which plants and animals live in, as well as interact with and transform. The outputs from the drainage basin, on the other hand, include water in the form of runoff into the rivers, vapour from transpiration of plants, and sediment from the earth's surface. Such an analysis of inputs and outputs makes it possible to produce an inventory of the water resources of a river basin as well as analyze the environmental impacts of any form of development within the basin.

River basin planning and development can be rather complex. An integrated river basin development, besides being an evaluation of

both surface and ground water resources, is a survey of all the natural resources of the basin. These natural resources include land, human resources, animal resources, economic, social and environmental conditions. Because these resources are interrelated, a multi-disciplinary approach is essential to achieve integrated river development. The planning process and policy formulations become even more complex if the river basin is an international one. Inspite of some of the difficulties that may come as a result of lack of coordination and political goodwill amongst the riparian states, the resulting benefits tend to outweight the problems. Many river basins in Africa transcend more than one state and this warrants a regional approach to the development of water resources. It is imperative therefore to evaluate the characteristics of water resources in Africa in order to assess the benefits that will accrue from harmonious and integrated water development planning.

Africa is known to have vast resources for social and economic development. Presently economic development strategies need to be tied with environmental policy because as states develop, the through-puts of development, including industrial, agricultural and municipal wastes, begin to accumulate in the environment. The problem becomes complex in a situation where no pollution standards exist. This is the case with many developing countries. The problem may be aggrevated by the fact that many states discharge their effluents into the rivers with minimal treatment. Moreover, the administration of pollution control

measures becomes very difficult for international rivers (see for example C.E.Q., 1980). Integrated basin planning becomes a very important tool for coordinating and solving grievances that may arise from effluents discharged by upstream riparian states.

It is important to mention from the outset that the use of a drainage basin as a tool for planning may be limiting in some cases and strenuous in others. The concept of a drainage basin as a region for planning may be limiting if the basin is small and hence the development of resources may suffer from diseconomies of scale. On the extreme end of the stick there have been some river basins, for example, the Mekong River Basin, where planning and implementation strategies have led away from optimum utilisation of water to an emphasis on regional economic development. The Lake Basin Development Authority in Kenya, unfortunately, may be approaching the stage of becoming a mega-basin in which economies of scale, in terms of both administration and production, may begin to have diminishing returns.

I. Some Observations on the Water Resources of Africa.

Africa lies about 40^{o} north and south of the equator. The annual average rainfall is about 686 mm which is the lowest of all the continents in the world. The evaporation rate is also higher in Africa than in all other continents except South America. After the rain falls, some rainwater infiltrates into the ground, some evaporates back to the atmosphere and the rest runs off in the form of floods and

flows in rivers. The percent runoff of rainfall is a measure of the surface water available for use and it is the lowest. About 77% of rainfall is either evaporated or runs off as flash floods which not only kill many people,at times, but often destroy property in many parts of Africa.

It is this geographical as well as seasonal variation in rainfall that is responsible for drought and food shortage and lack of development. But it is not sufficient to bemoan lack of water because Africa has, besides other natural resources, more land than surface water resources. It is, therefore, imperative that irrigation and appropriate water management methods be applied for the benefit of the inhabitants of the drainage basins.

Table 1. Water Resources of Africa Compared to the World.

Continent	Area (Million Sq km)	Precipitation (mm.)	Total runoff (mm.)	Evaporation (mm.)	Coefficient of runoff
Africa	30.3	686	139	547	0.23
Asia	45.0	726	293	433	0.40
Australia	8.7	736	226	510	0.31
Europe	9.8	734	319	415	0.43
North America	20.7	670	287	283	0.31
South America	17.8	1648	583	1068	0.35
The World	132.3	834	294	540	0.36

Source: United Nations, E/CN.14/NRD/WR/1, 1976.

In the past, water was thought to be a gift of nature. In Kenya for example, severe droughts that last nine or more months in a

year cover nearly two-thirds of the total area of the country every five years. In these drought-prone areas, surface water resources are limited because of loss by rapid runoff from flash floods and evaporation. The development of both natural and human resources in the drought-prone areas depends on whether conjunctive water use planning can be adopted. Conjunctive water use is a planning concept in which both surface and ground water resources are evaluated, planned and developed. Since the use of surface water will likely cause a deterioration of ground water or vice versa, planning of total water resources in a drainage basin is imperative.

An evaluation of total water resources requires knowledge of the hydrological cycle of which some of the processes are little known. Moreover, in an integrated development planning, social-economic parameters must be known because the purpose of development is to improve the standard of living of the people. In any case, socio-economic factors, which are complex to study, should not distract us from proceeding with development, assuming technological and engineering capabilities are available.

II. Social Interests in Water Resources

Water is valued by man in many ways. There are nearly twenty principal uses of water of which some extract water from its source, some use it in-stream while others use water on-site. The main on-site water use is in forestry and also in swampland areas. However, there is a need to find a functional link between water uses and water availability. Presently water uses are given in social and economic terms and also by territorial structures of public administration. On the other hand water availability is quantified in hydrological terms and can only be related to river basins or ground-water basins.

These difficulties in accounting for water use are overcome by introducing a third variable - the population factor. The population

factor represents the interests of the society. The major social interests in water resources may be categorised according to the dominance of ecologically or technologically oriented development. The utilization of hydrological potentials include economic utilization of water for agriculture, forestry, hydropower, industry and others as well as the use of water for social welfare. The ecological uses of water include recreation, settlement as well as cultural and landscape aesthetic values.

The demands of technology-oriented development includes drainage and flood control for the needs of the population and settlements. The demands also relate to how the needs, such as water for domestic use, drainage and protection against floods as well as water quality, affect the population and settlements. The needs connected with production are related to water for industry, irrigation, transportation, disposal of used waters and wastes.

Africa is not in short supply of such needs because of its historical background and as a result of its geographical location. The discussion that follows identifies in a broad manner, some principles and practices of drainage basin management and the problems that Africa faces in planning and developing river drainage basins.

II. Integrated Drainage Basin Management.

The main issues facing Africa are many and crucial but surmountable. As a result of the recent drought food security ranks very high on the agenda of many nations. It is known that Africa is the only continent which is unable to feed its people. But the problem of food security is made complex because of the interrelationships between environmental and socio-economic factors that have hampered development and resulted in environmental degradation in general.

Closely related to food security is the energy crisis that started in 1973 after the oil embargo by the Arab oil producting countries. Although the embargo was not aimed at affecting African states, they were the worst hit by escalating oil prices and decreasing foreign exchange earnings because of their economic structures and technological dependence on the western nations.

Other resource development issues relate to lack of environmental data. This hinders proper assessment of resources and evaluation of alternative resource uses. Before integrated development planning is undertaken an enormous amount of data is required. As a matter of fact, making decisions using appropriate data is the only item that separates planned development from economic growth. Such planned developments are based on sound environmental data and appropriate technology. It is important to note that there are two types of technical information required for sound planning. One is the technical information that is available but is not adaptive to development needs or able to solve the problems facing African states. The second type pertains to social and economic problems that have to be researched in order to understand the social dynamics that hinder development in some communities and not others. Both types of information are presently not available and more research is needed in order to improve the situation.

The need for integrated watershed management, therefore, must address the questions related to food production and environmental management. One of the main questions is to find out what combinations of management and conservation practices need to be applied to increase crop production and at the same time gain greater control over the drainage basin. Because any type of land use will, in the short-run, undergo some form of degradation, it may be necessary to establish the tolerable level of management-induced land degradation in any drainage basin. Such questions are important in an integrated development because the use of one kind of resource within the basin will affect or influence the rate of use in another.

In an attempt to answer some of these questions, we shall discuss some comparisons of technical information on principles of integrated drainage basin management that are available for practice and the problems of adjusting such principles for use in tropical Africa.

Integrated Drainage Basin Management

Drainage basin management is concerned with establishing management control over rainfall water - and particularly control over water during impact with the earth's surface - infiltration into soil, and drainage from upslope soils to downslope stream and river channels. The key word is control. However, both the rainfall volume and intensity cannot be controlled by any form of management techniques.

As discussed earlier, any form of landuse will destabilize the ecological dynamics of the drainage basin. If one decides that the basin should not be destabilized, then the catchment must be preserved. The impact of human activities on the drainage causes, invariably and at different levels of use, flooding and sediment discharge into the streams and affects dry season flow in lower parts of the watershed. Under such circumstances when land use intensity must increase in order to raise agricultural production, the solution to environmental degradation revolves around how to practically and acceptably reduce soil erosion and runoff within the drainage basin.

In many cases we are tempted to use technical information on principles and practices of drainage basin management from research done in temperate latitudes. Such information is not appropriate because of the differences in physiography, the tropical location of the continent and the socio-economic status of the farmers in temperate latitudes.

The technical information on drainage basin management in temperate countries is inappropriate because the practices have been

developed for gentle slopes (less than 20% and in areas of low rainfall intensity. The rainfall intensity in tropical Africa can be 10 to 20 times greater than in temperate latitudes and such intensities cause soil erosion and flooding. For these reasons the rate of soil erosion and soil development cannot be the same when the temperate and tropical weather conditions are compared.

The other difference between temperate and tropical landuse relates to farm systems. The farmers in temperate latitudes are relatively well-informed, generally have large individual landholdings and low population pressures on the available land. The converse is true in Africa where, as a result of population pressure and inavailability of employment in urban areas, the small-holdings have been re-divided into uneconomically smallher holdings.

The socio-economic conditions of farmers in temperate latitudes are different from those of farmers in Africa. The farmers in temperate latitutdes have relatively higher returns on their farm investment. The high returns coupled with the readily available credit and financial support as well as effective extension services make it possible to invest in detailed conservation techniques.

Principal Areas of Research in Drainage Basin Management

In the foregoing it has been discussed that technical information that is based on research done in temperate latitudes is inappropriate for application in tropical Africa. Besides the problem of appropriateness, there is the fundamental question of lack of data for integrated and comprehensive development planning of drainage basins. We may tackle these issues under five sub-headings, namely collection of long-term hydrometeorological data, study of biophysical processes, design management based on adaptive research, management of steep lands and the need for information dissemination and public education.

There is a compelling need to carry out hydrometeorological surveys both at national and regional levels. Such data types should be on soils, water, landuse and the geomorphology of the drainage basin. It is known that landuse plans and conservation strategies must be included at an early stage in any comprehensive and integrated development planning. In cases where such data are unavailable, planners will not be able to provide sensible and defensible project priorities.

The collection of data may be accompanied by an evaluation of biophysical processes and technological, social and economic considerations. The main purpose of development is to improve the standard of living of the people within the basin. It is commendable to solicit their participation on the development of the basin at an early stage.

In many African countries data are insufficient for integrated and comprehensive development planning. However, the development process cannot be retarded while data are being gathered. Instead, development may proceed but the management thereafter will need to be based on adaptive research. Adaptive research takes advantage of information that is already available, be it from the local people or from previous preliminary studies. Such information may be used to adapt management techniques to local conditions. For the success of such programmes, multi-disciplinary and multi-sectoral approaches may be adopted. However even if the results from adaptive research fails to solve the problem at hand, the advantage is that it points out that basic research must be carried out.

Research pertaining to the management of steep lands needs to be a priority in many countries. A recent workshop on the geo-ecology of African mountains indicated that steep lands of Africa have not only been preferred for settlement purposes because of their cool and humid climates but also for their strategic location during wars and limited diseases vectors (Krhoda, 1986a). Unlike the temperate

latitudes, steep lands support a large farming population. Moreover, there has been continuous interaction between the mountains and the lowlands (see for example Krhoda, 1986(a)).

Many development projects in developing countries are started usually with little information. In the preceeding discussion, it was suggested that inadequate data need not hinder the progress of development planning. However, in all cases of such development strategies, a mechanism for monitoring the functioning of the development programme need to be built within the drainage basin. Research which will form the basis of land use change such as that done by Pereira (1973) and his colleagues at the East African Agricultural and Forest Organization in Kericho and Aberdare forest are very important. This particular study dealt with the impact of clearing forests for agricultural production on the hydrological cycle and sediment production.

The final area of research is the need for information dissemination and education to accompany drainage basin development planning. Information and education needs may be directed to five groups of persons. First, information needs to be given to land users, for they are the ones who determine the success or failure of a management system. Extension workers, senior managers and policy makers and the scientific community also need to be informed and educated on the intentions of the development project. But when all these have been completed the predictability of the management practices still depends on the continuous collection of data, updating programmes of action and improving the model parameters.

IV. Conclusion.

The drainage basin is an important concept and region for organizing, planning and developing natural resources. Although the unity of any drainage basin is based on water, the centrality of the

role of water resource development on the overall general development of any region may not be underscored. For this reason the exploitation of natural resources of a region may be organized around the development and management of water resources. This new perspective of resource development has been reinforced by the need to consider all environmental inputs in every development project. It has been argued that the drainage basin is one of the concepts that may be used in collecting environmental data and modelling impacts of development.

The major drainage basins in Africa are international. Because of this, such drainage basins may be used for setting legal and scientific regimes for cooperation and collaboration in development activities. It is evident that African states have similar problems of development, and these problems centre on food security and energy and environmental degradation. Some of these problems are associated with the need to design and operationalise an integrated development strategy. It is to this end that the international drainage basin organizations will benefit from economies of scale and comparative advantages amongst member states.

The international drainage basin organization need to consider the impact of rapid population growth on both the standard of living of the people and on the environment. Because of the rapid increase of population, the extent of forest zones has decreased, and farming has extended into steep slopes and to fragile semi-arid and arid ecological zones. While this is taking place, there is little quantitative data on the impact of landuse on the tropical environment. Although conservation practices on steep slopes and specific farm and forestry practices have been undertaken, there appears to be no quantitative assessment of their effectiveness. Much data, however, exists from the temperate latitutdes which needs to be adapted for use in tropical lands.

There is a need for adaptive research to improve on technologies and test findings of research from temperate latitutdes for our use in tropical areas. The collection of hydrometeorological data may be justified by the need to design an integrated and comprehensive development strategy. From such data it will be possible to understand the biophysical processes and their comparison with the rates in temperate latitudes. The impact of high tropical insolation, evaporation and temperatures on the biophysical processes need to be identified and harnessed for the development of the region. When all this has been done such information needs to be disseminated to land users and managers for implementation.

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