Integrated Water Resources Management with Reference to Developing Countries

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Key words: Water scarcity, increasing needs, planning; international cooperation

SUMMARY

Water is vital for human survival and for economic development of a region. The need to maintain available water resources for water resources development, provision of good quality water for utilization by the increasing population and for the optimum benefit in development of the region should therefore be a priority for any country hoping to improve and sustain adequate standard of life for its populace. However conflicting demands for this resource often make decisions very critical: a case in point is the utilization of the water resource for hydropower generation against the downstream development for irrigation. There is a need therefore to have clear, long-term management policies to ensure optimum benefit to the region. The Integrated Water Resources Management facilitates appropriate planning, feasibility and implementation of water resources projects and management through development of policies, legal framework, appropriate manpower development and consideration of important driving factors including economics, social aspects, environment and political climate. International organizations and donor agencies also have a critical role in this process by providing necessary support through sharing of knowledge and best practices and ensuring that lessons learnt from the past are fully incorporated into new ventures. . This paper looks at the problems of water management, various aspects of *Integrated Water Resources Management*, implementation of such management policies in general, with special reference to specific cases undertaken in the past. The paper concludes by highlighting why integrated water resource management is so crucial in developing countries and the important role that international organizations will be required to play in ensuring the success of such projects through facilitation of development of multi-disciplinary professional teams and organization of international and collective funding for such projects.

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1. GENERAL

Vast quantities of water exist on the earth. Research shows that oceans cover an area of about 360 million sq. km, which is equivalent to almost 71% of the earth's surface; in addition water is present in lakes, rivers and streams, underground and in the atmosphere. However of the total quantity available, which amounts to over 1,300 million cubic km, only 35 to 40 million cubic km. is freshwaters. Refer to Table 1 (page 2) for details.

TABLE 1 - DISTRIBUTION OF WATER ON THE EARTH

NO.	WATER OCCURANCE	ACKERMAN & LOF (X MILLION CUM)	R.L.NACE
1	Oceans	1,307.51	1,300.00
2	Salt Water Lakes & Inland Seas	-	0.01
A	**SALT WATER**	**1,307.51**	**1,300.10**
3	Glaciers, Polar Ice Caps and Ice sheets	30.43	28.50
4	Atmospheric Moisture	0.01	0.01
5	Hydrated Earth Minerals	0.00	-
6	Water in Plant & Animals	0.00	-
B	**Non Utilizable Fresh Water**	**30.44**	**28.51**
7	Fresh Water Lakes	0.12	0.12
8	Rivers	0.00	0.00
	Surface Resources overland	**0.13**	**0.12**
9	Soil Moisture	0.04	0.07
10	G/water upto 800m	4.50	4.00
11	G/water below 800m	5.63	4.00
C	**Available Fresh Water**	**10.29**	**8.19**
D	**Total Fresh Water Resources**	**40.74**	**35.70**
E	**Total Water Resources of Earth**	**1,348.25**	**1,336.80**

Available waters are dynamic and circulate over the earth's surface as explained by the Hydrology Cycle, with the quantities over a specific area or a region varying because of natural factors.

2. IMPORTANCE OF WATER

"Water is Life" is a notion which is accepted without exception. It is one commodity without which life cannot exist on this earth – not only because it is essential for the actual living process but also because it is necessary for supporting man's material activities, which lead to his material development. With increasing human population and consequent increasing human activities, coupled with decreasing natural resources, the need for water for survival

has taken on added dimensions in the recent years. Progressive pollution of freshwater supplies by accelerated human activity has made an already critical problem, even more acute! To combat this problem, techniques are being developed to ensure economic and optimum usage in order to reduce the extent of depletion of water quality thus ensuring that adequate resources are available for future generations. Integrated Water Resource Management is one way of addressing this problem.

3. STATISTICS OF HUMAN POPULATION AND MAN'S ACTIVITIES FOR WATER DEVELOPMENT

World's population increased at an average rate of 1.88% from 1950 to 1980, 2.004% from 1980 to 1990 and was expected to increase by 1.5% from 1990 to 2025 . The rate of growth has always been higher in developing countries. The world's population was 5 to 10 million during the New Stone Age, 250 to 300 million at the beginning of the Christian Era, 500 million in 1650, 2,486 million in 1950, 4,415 million in 1980 and 5,300 million in 1990. It had been estimated that this will be increased to 8,206 million by 2025. The details are given in Table 2 below.

TABLE 2 - HUMAN POPULATION AND POPULATION GROWTH ON THE GLOBE

REGION	POPULATION IN MILLIONS (% OF WORLDS POPULATION)			AVERAGE ANNUAL GROWH RATE	
	1990	2000	2025	1990- 2000	2000-2025
Africa	645 (12.30)	872 (14.2)	1,617 (19.7)	3.02	2.47
Asia					
E.Asia	1,324 (25.2)	1,475 (24.1)	1,721 (20.9)	1.08	0.62
S.Asia	1,734 (33.1)	2,074 (33.9)	2,814 (34.3)	1.79	1.22
Latin America	451 (8.6)	546 (8.9)	779 (9.5)	1.91	1.42
North America	275 (5.2)	297 (4.9)	345 (4.2)	0.77	0.66
Europe	491 (9.5)	512 (8.4)	524 (6.4)	0.26	0.09
USSR	292 (5.6)	315 (5.3)	368 (4.5)	0.76	0.62
Ocenia	26 (0.5)	30 (0.5)	38 (0.5)	1.43	0.95
World	5,246 (100)	6,122 (100)	8,206 (100)		

4. WATER RESOURCES

Water resources of varying sizes, quantities and quality are distributed on the earth, the uneven distribution being the result of climatic, hydrological, and meteorological factors. Table 3 below lists some of the major rivers of Africa, together with their basin surface area

TABLE 3 - MAJOR RIVERS OF AFRICA.
(BASIN AREA OVER 50,000 SQ.KM.)

NAME OF RIVER	COUNTRIES	BASIN SURAFCE AREA(sq.km)
Senegal	Guinea, Mali, Mauritania, Senegal	338,000
Gambia	Gabia, Guinea, Senegal	77,000
Volta	Ivory Coast, Ghana, Mali, Upper Volta, Dahomey	390,000
Oueme	Dahomey, Nigeria	50,000
Niger	Cameroon, Chad, Dahomey, Guinea, Ivory Coast,Niger, Nigeria, Mali, Upper Volta	1,100,000
Ogooue	Cameroon, Gabon, Congo, Gabon	205,000
Congo	Angola, Burundi, Cameroon, Congo, Zambia,Tanzania, Rwanda, Central African Republic	3,820,000
Cunene	Angola, S.W.Africa	1,000,000
Orange	Basutoland, S.Africa, Bechuanaland, S.W.Africa	640,000
Limpopo	Bechuanaland, Mozambique, Zambia, S.Africa	358,000
Sabe (Save)	Mozambique, Zambia	101,000
Zambezi	Angola, Baceuanaland, Malawi, Mozambique, Zambia	1,250,000
Ruvuma	Mozambique, Tanzania	140,000
Juba	Ethiopia, Kenya, Somalia	200,000
Shebelli	Ethiopia, Somalia	260,000
Nile	Kenya, Uganda, Tanzania, Rwanda, Burundi, Sudan, Egypt,Congo UAR.	2,800,000

Some of the large resources, as in Table 3 cannot be controlled, developed and used for the maximum benefit of the population as many of them are shared by different riparian countries or regions or zones. These require long records of accurate data and a highly coordinated development satisfactory to areas of interest to avoid conflicts and disagreements as a result of conflict of interest, and varying individual government strategies. The resources include large lakes for utilization and management and coastal regions for management of coastal waters. There is therefore a need for coordination by a global agency.

It is vital to know the quality and quantities of available waters in an area, the flow and storage characteristics and the status and other details of the watersheds. In the past years, some organized work has been done for data collection, data processing and analysis and data banks created using available facilities. However there is insufficient information available for planning purposes, particularly in developing countries, where lack of funding and trained manpower and other priorities has hampered the process of data collection.

5. NEED FOR EFFECTIVE WATER RESOURCES MANAGEMENT

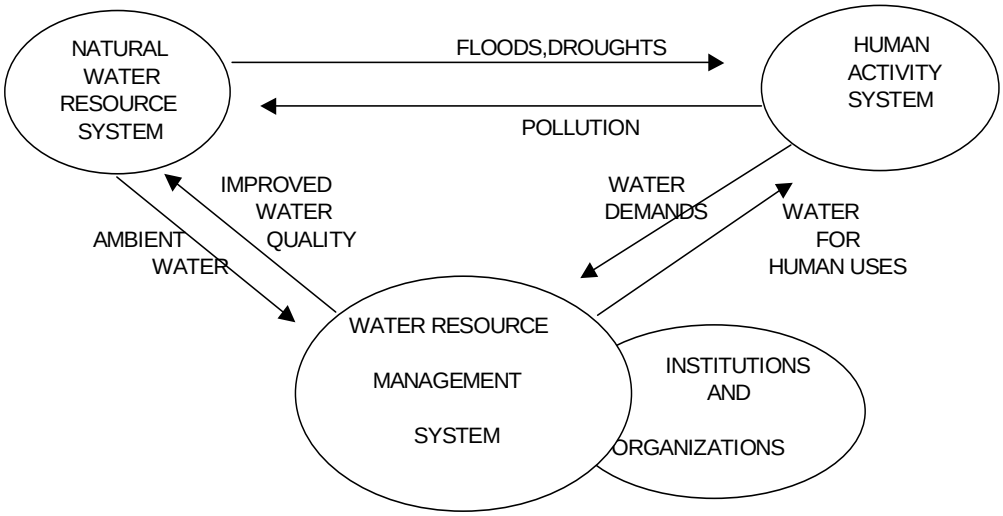
The low priority given to water management in the mid 1900s was understandable as the water resources available then were more than adequate to meet the demands of the population. However the unprecedented increase in the population growth rates, urbanization and the resultant activities have led to not only massive depletion of the water resources but also deterioration of the existing supplies. There is therefore an urgent need now to manage

water resources more effectively if we are to avert a crisis situation. This is why the concept of Integrated Water resources Management for sustainable water resources development was conceived.

6. CONCEPT OF INTEGRATED WATER RESOURCES MANAGEMENT

The concept of sustainable Water Resource development can be applied to a single element of water resources in a region. This would be inadequate as in this case only the single element e.g the adequacy of water would be recognized. The other elements of the development of the river catchments, and the aspects of human activity, which are equally important, would be neglected. A better concept would be the consideration of adequacy of water, development of a river catchments and aspects of human activity within an individual system. Even this would be inadequate and unsatisfactory. It would be best to look at the global picture i.e. water adequacy, river catchments and aspects of human activity of all systems within complete catchments. This would basically include water adequacy for domestic supply, agriculture, industry development and recreation activity, watershed development and socio economic development of the society within all systems. This management is termed as The Integrated Water Resources Management. It is a blend of three sub-systems which are inter-related to achieve specific objectives as illustrated in figure 1 below.

Figure 1- System view, integrated water resource management



6.1 The Natural Water System

The Natural Water System Consists of the water and the water related natural resource endowment or supply available for human uses including recreation in its natural state.

6.2 The Human Activity System

The Human Activity System Is composed of activities of people that affect and are affected by the natural water resource system. It covers the demand side for water uses such as irrigation, domestic water supply, waste disposal, navigation, hydro-electric power, fisheries and recreation and reduction of damages from flooding, water pollution and drought.

6.3 The Water Resource Management System

The Water Resource Management System consists of activities and relationships in the public and private sectors concerned with harmonizing the supply and demand sides so as to achieve the objectives of the society.

7. OBJECTIVE OF THE INTEGRATED WATER RESOURCES MANAGEMENT SYSTEM

The main objectives of the system are to maintain a sustainable source of water supply that provides optimum benefit to the population in the complete catchments by satisfying their personal needs while allowing them to undertake socio economic activities without unnecessarily damaging the environment and also to control the resource in a way that minimizes the impact of natural disasters

8. REQUIREMENTS OF THE HUMAN ACTIVITY SYSTEM OF MANAGEMENT

8.1 Actions Affecting the Population and its Movement

It is necessary to enforce birth controls among the population. The movement from Urban to Rural centers must be controlled to prevent excessively high demands and low standard of living in urban areas. The movement of the population to flood prone areas may be useful but should be handled seriously due to significant losses including loss of lives and pollution of the water resources as a result of floods.

8.2 Actions Affecting the Demands for Water System

The necessity to control the quality of the waste disposals into water resources; if purified sufficiently, the waters resource could be re-used for activities downstream, prevent loss of aquatic life and in some cases marine life. It would also be useful to adopt the idea of use of storm waters for aspects where such waters can be useful and start the rainfall harvesting and utilize solar energy for individual houses.

8.3 Actions Affecting Human Activities

When planning activities for water utilization, it would be useful to do a feasibility of the area for an appropriate decision on the activities to be undertaken. It is also important to introduce

activities with multi purpose benefits in line with acceptable strategy. Table 3 (page 6) provides the aspects of water utilization and the purposes of the activities undertaken.

Table 3: Aspects of Utilization (Human Activities) and the Purposes of each Activity.

NO	ACTIVITY	PURPOSE OF ACTIVITY
1	Flood Control	Flood damage prevention and reduction,protection of economic development,conservation storage, river regulation, recharging ground /water,water supply, hydro-power development,protection of life.
2	Irrigation	Agriculture production
3	Hydroelectric Power	Provision of power for economic development and Improved living standards
4	Navigation	Transportation of goods and passengers
5	Domestic & Industrial w/supply	Provision of water for domestic, industrial, commercial, municipal and other uses
6	Watershed Management, Soil Conservation & Erosion Control	Conservation and improvement of the soil, sediment batement, runoff retardation, forests & grassland improvement, protection of water supply
7	Recreation use of Water	Increased well-being and health of the people Enhancement of sports opportunities
8	Aquatic ecosystem maintenance	Improvement of habitat for fish & wild-life, reduction or prevention of fish or wild life losses associated with development, ,provision & expansion of commercial fishing
9	Pollution Abatement	Protection and improvement of water supplies for municipal, domestic, industrial and agriculture use,and for aquatic life and recreation.
10	Insect Control	Public Health, protection of recreational values, protection of forests and crops.
11	Drainage	Agriculture production, urban development, protection of public health
12	Sediment Control	Reduction of silt loading streams & protection of reservoirs.
13	Salinity Control	Abatement or prevention of salt water contamination of agricultural, industrial,and Municipal supplies.

9. REQUIREMENTS OF THE MANAGEMENT RESOURCE SYSTEM

The requirements are concerned with Institutions and their organization.

9.1 Data Collection and Assessment

The scientific basis of the supplies are well understood. However the quality and quantities of water availability, the effects on water due to natural forces (floods and Droughts) and the effects of changes within the individual watersheds must be understood. This requires:

- The scientific data collection of all elements of the Hydrology cycle including precipitation, Evapo-Transpiration, Stream-flow, Soil moisture, Ground water flow and the characteristics of storages.
- Appropriate storage of the available data and the data processing and analysis for appropriate use.
- Organization and Management of data banks especially in case of collective zones, regions or countries.

9.2 Planning of the Development Project

The projects are always planned in accordance with the government strategy and to provide the optimum benefit to the population concerned. The two vital issues that must be kept in mind in case of project development are

- It is clear that the Water resources do not follow political boundaries set for the zones, regions or countries. The river basins, lakes and the seas generally have shared resources for different areas eg Nile basin covering Kenya , Uganda, Tanzania, Rwanda, Burundi, Sudan and Egypt.
- There are likely to be conflicts of priority in the decision for development eg The Tana river basin of Kenya where the decision was required on either to build dams for hydro-power upstream or to initiate irrigation project down-stream
- The general need for multi-purpose development
- The need for a management plan especially for sustainability of water supply, and feasibility of project for decision making for development.
- The problems of Management within a river basin, Lakes and reservoir development, Ground water development and coastal area are each different and require individual consideration and specialties.

9.3 Important Elements Required as Part of Integrated Water Resources Management Projects

The following are important for Integrated Water resources Management undertaking.

- Understanding of the government strategies or the National objectives and priorities for Water Resources development. In case of shared waters it would be necessary even to understand the priorities of riparian states for the preparation of a mutual agreement between the partners.
- Availability of skilled manpower, infra-structure and equipment for implementation of the project and the follow up for continuity ie operation and maintenance of the project in a professional manner. This would include the setting up of the data bank and models of assessment for the available data.
- Legal framework with possibilities of law enforcement to avoid destruction or damage to the resource by the population both at national and international levels.

- Availability of effective institutions to monitor the state of the resources and where necessary enforce the general guidelines set up for appropriate utilization of the available resources and to prevent any activity of destructive nature.
- Co-operation of the organizations concerned especially the governments of all riparian states for necessary actions to prevent national catastrophes.

10. SPECIAL REQUIREMENTS FOR DEVELOPING COUNTRIES

It is noted that the developing countries have lagged behind due to financial constraints, lack of skilled man-power, unavailability of appropriate equipment and very often due to unavoidable circumstances preventing lack of co-operation between the riparian states. It is therefore necessary for them to have the support of international organizations such as The United Nations Agencies and the European Union for implementation of large scale projects. UNESCO initiated the International Hydrological Programmed in 1945 at an international level. In the initial stages they provided the financial support for the development of the infrastructure, training of manpower, logistics for collection and processing of hydrological data and setting up of data banks. The World Meteorological Organization also provided similar support to developing countries. It has a subsystem for Transfer of Technology through organization of multi-national funding and technical support.

11. KENYA AS A DEVELOPING NATION

A National Master Plan was initiated with the support of the donor agencies in 1992. The status of water resources development was determined, the potential for further development was assessed in all areas of water use and strategies developed for various uses. It is noted that

- The country experiences droughts and floods leading to associated problems, such as problems of soil erosion from agriculture land leading to deterioration of water quality (Pollution and Sedimentation) and reduction of storage capacity of reservoirs and lakes, problems due to existence of fluoride and salt in ground waters, and salt water intrusion on the coastal belt.
- The country has a relatively good data in the Data Bank but there is a potential for improvement.
- The existing utilization is low in relation to the available water resources. There is a potential for development in all aspects of water utilization.
- The country's population has been increasing at the rate of 3.4 to 4%. The urban areas increase at a higher rate.

12. GENERAL

The Republic of Kenya with an area of 592,000 sq.km of which 11,230 sq.km are covered by lakes. It is at sea level on the Eastern Coast and rises to 6000m around the lower Rift Valley. The average rainfall is 621 mm varying from 411mm to 1368mm with 83% of the country experiencing semi-arid to arid climate.

12.1 Water Resources

The country is dissected by the Rift Valley and has five major drainage basins. The Lake Victoria basin extends from the Western edge of the Rift Valley on the southern side to the western border of the country, The Athi River basin extends from the eastern edge of the valley to the south east border of the country, the Tana and Ewaso - Ngiro basins extend from the eastern edge of the Rift Valley to the eastern border of the country which experience semi arid/ arid climates. Most of the lakes are associated with the Rift Valley. Lake Victoria lies on the western boundary; it is the second largest lake in the world. The freshwater lakes hold 315 million cum of water that is under-utilized.

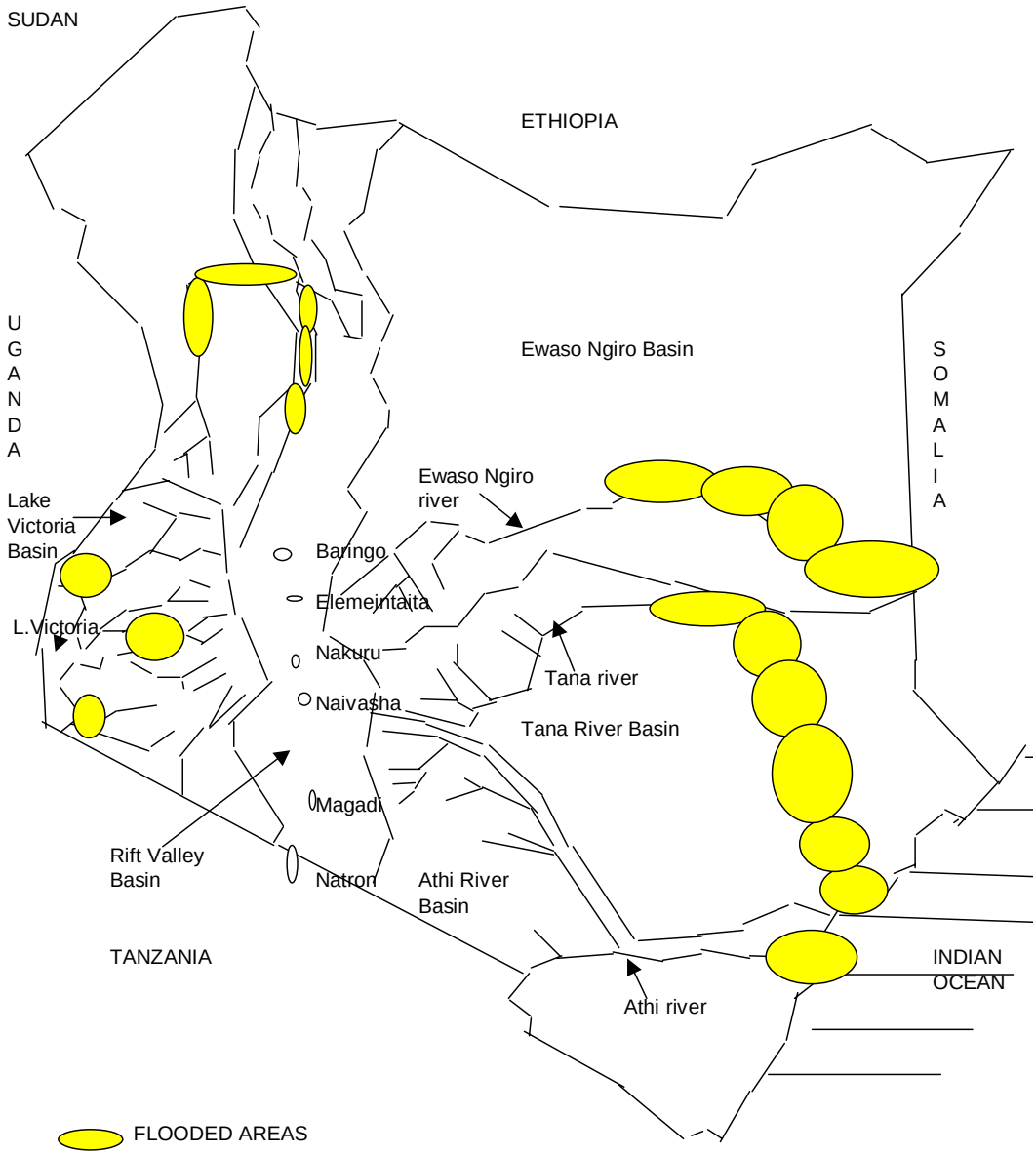
TABLE 4 - DRAINAGE BASINS OF KENYA

DRAINAGE AREA	CATCHMENT AREA (SQ.KM)	ANNUAL RAINFAL (MM)
L.Victoria	46,229	1,368
Rift Valley	130,452	562
Athi River	66,837	739
Tana River	126,026	697
Ewaso Ngiro	210,226	411
Kenya	579,770	621

TABLE 5 - DETAILS OF MAOR LAKES OF KENYA

LAKE	ALTITUDE (m)	AREA (sq.km)	MAX DEPTH (m)	WATER QUALITY
Victoria	1,133	69,500	79	FRESH
RIFT VALLEY				
Turkana	375	6,405	120	fresh
Baringo	975	130	10	fresh
Bogoia	991	34	10	saline
Nakuru	1,758	26-52	1.3	saline
Elemeintaita	1,776	18	1.1	saline
Naivasha	1,884	180	6.5	fresh

Figure 2 - The Republic of Kenya with drainage basins, rivers, lakes and the major flood areas.



12.2 Floods and Droughts

Major floods in L.Victoria basin and the Tana River basin occurred in 1937,1947, 1951, 1957-1958,1961 and 1977-1978. The 1961 floods in Tana basin with peak discharges of 3,000 cum/sec were estimated to be 50 year floods. The area inundated was estimated to be over 500sq.km. These floods also affected L.Victoria basin in the Kano Plains and other low lying areas. L.Victoria levels rose by 1.25meters in 1962. The worst Droughts occurred in 1931 – 1935 in Central Kenya, the second worst in 1941-1945. Other severe droughts occurred in 1971-1975 and 1981-1985; the occurrence of drought is quite erratic area by area.

Major droughts with serious effects on man, livestock and wild life occurred during 1928, 1933-34, 1942-44, 1952-55, 1960-61,1965 and 1970's .

12.3 Sedimentation

The rivers carry a lot of sediment which in most cases is increasing. The Turkwell Dam and Tana River Dam both face major problems of storage depletion affecting their capacity for hydro-power. The Lake Victoria basin rivers carry the sediment into L.Victoria and the Athi river with high loads of sediment during the rainy season carries the sediment into the Indian Ocean along the Kenyan Coast.

12.4 Ground Water

The country has 10,000 boreholes drilled for various purposes. These are in Volcanic, Sediments and Basements. The waters are used mainly for agriculture, public water supply, domestic supply, irrigation and livestock. The water qualities depend on the area but there is a problem of excess fluoride particularly in the Central Kenya and the Rift Valley area, Iron content in Western and S. Eastern parts of the country, and salinity in the N. Eastern region and Coastal areas.

12.5 Population

The population of the country today is 32 million and is expected to rise to 40 million by 2010. The details of 1989, 1990 and 2000 on rural and urban populations with indications of shifts from rural to urban areas are given in Table 6 (page 10).

TABLE 6 - POPULATION DETAILS OF KENYA

AREA	1989		1990		2000		2010	
	No.	%	No	%	No.	%	No.	%
URBAN	3,736	17	3,965	17	7,933	26	12,698	32
RURAL	17,661	83	18,784	83	22,779	74	27,607	68
TOTAL	21,397	100	22,749	100	30,712	100	40,305	100

12.6 Present Status and Potential for Development of Water Resources in the Country

The present status of water availability and use were thoroughly studied and documented. The requirements based on the strategy for development were noted and utilized to prepare a Water Resources Development Plan for 2010. The projections made and the water resources development projects planned in the country are summarized below.

12.6.1 Water Supply (to Cater for the Total Population)

The development in urban areas is expected by direct supply from surface sources or from storage reservoirs on surface sources and/or through intra-basin or inter-basin transfers. The

development in rural areas by direct supply from surface sources or from ground water or by roof catchments or by building of small dams or sub-surface dam or from an extension from Urban supply pipeline.

12.6.2 Livestock and Wild-life

By development of watering points, shallow wells or from the ground using wind mills.

12.6.3 Agriculture

Use of available free land with agricultural potential. This must exclude the forest area, the National reserves, the National Parks, Game reserves and Township areas.

12.6.4 Irrigation

Development of small scale and large scale Irrigation schemes covering the potential area of 75,000 ha.

12.6.5 Hydro-Power

Development of Single-purpose and Multi-purpose dams for water supply, Irrigation and Hydro-power.

12.6.6 Ground Water

Development of Shallow wells and Bore-holes.
Flood Mitigation Plans - A number of major schemes for Urban drainage and minor river improvement.

12.6.7 Large Scale Water Transfers

A number of projects with long distance surface water transfers**.**

12.6.8 Lake Management

Lake Victoria and the Rift valley lakes.

12.6.9 Coastal Region

Study of the Coastal region for Strategy and Development of the coastal waters.

12.7 INTEGRATED WATER RESOURCES DEVELOPMENT IN KENYA

It is noted that the country has a vast potential for development. However it will require trained man-power, large funding programmes, infra-structure and well thought through

logistics and most importantly, co-operation of the Riperian States to ensure optimum benefits to all concerned. The example of shared basins are Lake Victoria and the contributing rivers as part of the Nile Basin Project, Lake Turkana and River Turkwell Development as part of L. Turkana Catchment development and the Coastal belt of Kenya.

It is noted that Kenya has already had significant contributions from the United nations Agencies and the Donor countries.

13 SPECIFIC EXAMPLE OF INTEGRATED WATER RESOURCES DEVELOPMENT PROJECT - NESTOS/MESTA RIVER BASIN IN BULGARIA

A case in point is the shared water resource between Bulgaria and Greece which was supported by The European Union and by the National government.

13.1 Objectives

The objectives of the study were to promote co-operation between EU and Phare countries, to prevent conflicts between States and to establish co-operation networks among counterpart organizations and entities in both countries, to assist the countries to overcome problems of development without affecting the environment and in the interest of the local population (alleviation of poverty), to ensure the protection of the environment.

13.2 Purpose of the Project

Preparation of study for Integrated Management of the waters of Nestos/Mesta river basin with the purpose of

- Developing a Draft Master Plan for both the riparian states. - The proposed plans should involve multi-purpose and multi-objective planning and management principles in consideration of structural and non-structural alternatives. The plan should include an action programme setting the guidelines for the Integrated Water resources Management of Nestos/Mesta river basins.
- Assisting the riparian countries (Bulgaria and Greece) in the development
- Conservation and using the Nestos/Mesta basin water resources in an integrated manner through basin wide co-operation for benefit of all.
- Using use the study in the preparation of National Management Plan of the waters of Mesta River Basin

13.3 Impact

Mesta River starts in Bulgaria and continues into Greece. It is necessary for Greece to ensure good quality water enters Greece. The project will contribute to good quality water in both countries. This will avoid cross border friction and pollution of Water resources.

13.4 Background and Justification

This is provided for the study.

13.5 Table of Log-Frame Matrix Conditions

This gives the following

- Overall Objective, Indicators of Achievement, Sources of Information and assumptions.
- The Project Purpose, indicators of Achievement, Sources of Information and assumptions.
- Detailed Implementation Chart with Components, Period allocated to completion of jobs.

14. RECOMMENDATIONS

It is clear that The Integrated Water Resources Management is the best way to ensure availability of sustainable supplies of water for the future generation. The developing countries need to embark on this and wherever there is already some progress follow up using the National Resources in conjunction with the support of the International Agencies. The cooperation between the riparian is of course absolutely necessary if necessary with the support of the donor countries and International organizations.

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Membership

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– Institution of Engineers of Australia - M.I.E. Aust.
– Institute of Engineers of Kenya - R. Eng., M. I. E. K.

Experience

– Engineering & Water Resources - Private consultants.
– Engineering & water Resources - Irrigation Commission of Australia
– Engineering - Private consultants
– Engineering and Water Resources - Ministry of Water development of Kenya
– Research in Engineering & Water resources- Ministry of Water Development of Kenya.
– Training of Engineers, Hydrologists - University of Nairobi.
– Training of Professionals & technicians - WMO & FAO, Kenya.
– Property Management & Investment - Jubilee Insurance Co., Nairobi
– Management of Business - Nairobi.

Publications

– Charania S.H. - Extension of runoff records in small catchments in semi-arid regions.
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– Charania S.H. - Description of Flood Prediction methods in Kenya.
– Charania S.H. - Effects of Agricultural methods on drainage from Irrigated areas.
– Charania S.H. - Determination of Surface water yields for an area in Kenya.
– Charania S.H. - Strategy for organizing a sediment data collection network based on the available hydrological records in Kenya.
– CharaniaS.H–Adequacy of Rainfall and Runoff networks (coast province).
– CharaniaS.H -Expecting to complete papers on Lakes study and Flood and Flood Mitigation.

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