Nile Basin Initiative
Nile Trans boundary Environmental Action Project

REPORT ON TRAININ MODULES AND MATERIALS AND QUALITY ASSURANCE PROGRAM FOR KENYA

March, 2007

NILE BASIN INITIATI

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NILE TRANSBOUNDARY ENVIRONMENTAL ACTION PROJECT (NTEAP)

Report on

DESIGN AND DEVELOP SPECIFIC TRAINING MODULES FOR WATER QUALITY AND DESIGN A QUALITY ASSURANCE PROGRAMME FOR KENYA

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Acronyms

AAS: Atomic Absorption Spectroscopy
APHA: American Public Health Association
ASAL: Arid and Semi-Arid Lands
BCM: Billion Cubic Meters
BOD: Biological Oxygen Demand
B.Sc.: Bachelor of Science
B.Tech: Bachelor of Technology
CAAC: Catchment Areas Advisory Committee
CBO: Community Based Organization
COD: Chemical Oxygen Demand
CDMHA Centre for Disaster Management and Humanitarian Assistance
DO: Dissolved Oxygen
EC: Electric Conductivity
EIA: Environmental Impact Assessment
EMCA 1999: Environment Management and Coordination Act of 1999
FCA: Full Chemical Analysis
GC: Gas Chromatography
GC-MS: Gas Chromatography-Mass Spectrometry
GDP: Gross Domestic Product
GIS: Geographical Information System
GLC: Gas Liquid Chromatography
HPLC: High Performance Liquid Chromatography
HYDATA: Hydrological Data
IMTR: Institute for Meteorological Training and Research
ITCZ: Inter-Tropical Convergence Zone
IWRM: Integrated Water Resources Management
JICA: Japan International Cooperation Agency
JKUAT: Jomo Kenyatta University of Agriculture and Technology;
KARI: Kenya Agricultural Research Institute
KEBS: Kenya Bureau of Standards
KEWI: Kenya Water Institute
KIE: Kenya Institute of Education
KPIS: Kenya Plant Inspectorate Services
KSh: Kenya Shilling
KU: Kenyatta University
LBDA: Lake Basin Development Authority
LVEMP: Lake Victoria Environment Programme
MENR & W: Ministry of Environment, Natural Resources and Wildlife
MMUST Masinde Muliro University of Science and Technology
MoWI: Ministry of Water and Irrigation
M.Sc.: Master of Science

M.Tech: Master of Technology
MU: Moi University
N: Nitrogen
NARL: National Agricultural Research Laboratory
NBI: Nile Basin Initiative
NEMA: The National Environment Management Authority
NETWAS: Network for Water and Sanitation
NGO: Non-Governmental Organization
NH_3: Ammonia
NIB: National Irrigation Board
NO_2: Nitrate
NO_3: Nitrite
NTEAP: Nile Trans-boundary Environmental Action Programme
NU: Nairobi University
NWC & PC: The National Water Conservation and Pipeline Cooperation
P: Phosphorus
PES: Payment for Environmental Service
pH: Hydrogen ion Concentration
Ph.D.: Doctor of Philosophy
PRA: Participatory Rural Appraisals
PVC: Poly-Vinyl Chloride
TN: Total nitrogen
TP: Total phosphates
TV: Television
USD: United States Dollar
UV: Ultra-Violet
WAB: Water Appeal Board
WB: World Bank
WRM: Water Resources Management
WRMA: Water Resource Management Authority
WSB: Water Services Boards
WSRB: Water Services Regulatory Board
WSTF: Water Services Trust Fund
WUCST: Western University College of Science and Technology

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Executive Summary

The Nile Trans boundary Environmental Action Project (NTEAP) is one of the eight projects under the Nile Basin Initiative (NBI) Shared Vision Program and it is of five years duration. The main objective of the project is to provide a strategic environmental framework for the management of the transboundary waters and environmental challenges in the Nile River Basin.

In order to meet the broader objective of the Project a study was commissioned in Kenya to determine the technical and human capacity in water quality training modules, parameter testing and quality assurance programme. This report presents the findings of the study in Kenya.

The study, which lasted for one month, from 15th August to 15th September 2006, had three-fold objectives: to design and develop specific training modules targeted at the different cadre of staff and depending on the Kenyan needs; to characterize, identify and recommend key water quality parameters of cross-border and trans boundary and basin wide importance; and to design a quality assurance program both at the national and transboundary level.

The objectives of the study were achieved through various means. Questionnaires were designed and sent to over twenty organizations, both governmental and non-governmental, that deal in water issues. Both training and practicing organizations, within and outside the Nile basin (Lake Victoria Basin) were covered by the questionnaire. Special visits to major Governmental and Non-Governmental organizations such as the Ministry of Water and Irrigation (MoWI), Nairobi; Kenya Bureau of Standards (KEBS); National Environment Management Authority (NEMA), Network for Water and Sanitation (NETWAS) Limited; Lake Victoria Environment Management Programme (LVEMP) were done. Invaluable information was also obtained from the internet.

Training on water quality monitoring in Kenya is well developed. Therefore there is sufficient human capacity to train the upcoming young professionals and the practicing professionals who wish to upgrade their skills in modern methods of water management.

The technical personnel and facilities in water quality laboratories in learning institutions are capable performing a wide range of water quality tests, analysis and presentation. However, not all the water quality parameters can be tested by majority of the laboratories due to lack modern or complete lack of equipment and/or reagents.

This study has therefore highlighted the main issues to be addressed in the water quality management, training, analysis and pointed out the parameters of national, international and those of trans boundary importance.

NATIONAL OVERVIEW

Physiography

The Republic of Kenya lies on the eastern side of the African continent, between Latitude 5^{O} 40' N and 4^{O} 4' S and Longitudes 33^{O} 50' and 41^{O} 45' E. The country has a territorial area of territorial area of 582,640km ^{2} which includes a water surface area of 11,230 km^{2}. Kenya is characterized by tremendous topographical diversity, in which nearly every landform type ranging from the glaciated mountain to a true desert landscape is represented. The land elevation varies greatly from sea level at the Indian Ocean to over 5,000m at the peak of Mt. Kenya. The entire landscape is dominated by a flight of plateaus, which conveys the impression of extensive upland plains rather than mountainous environment.

The Kenyan climate is primarily controlled by the Inter-Tropical Convergence Zone (ITCZ) and the wide range topographic relief. As a result of the ITCZ, most parts of the country are characterized by two rainy seasons, March to May (long rains) and October to December (short rains). Air temperatures vary from 40^{O} C in the low latitude arid areas to below freezing on Mt. Kenya.

The average rainfall over the country is approximately 620mm and this ranges from less than 250mm in the Arid and Semi-Arid Lands (ASAL) to over 1800mm in the Lake Victoria Basin.

Socio-Economic Aspects

The economy of Kenya, with a population of 32.2 million people (2003 population estimates), is largely dependent on agriculture and tourism which are the largest contributors of the GDP. The finance and manufacturing sector constitute the second largest contributors in terms of GDP.

Water plays a very important role in the economy as a resource for urban and rural consumption, energy generation, agricultural development, industrial growth and livestock development. Kenya is however classified as a chronically water scarce country with a limited endowment of less than 6503 per capita per year of fresh water.

Kenya Water Resources

Kenya receives an average annual rainfall of 567 millimeters, conversing to 322.7 Billion Cubic Meters (BCM) of water. The availability of this amount of water depends on the rate of run-off, the aridity of watersheds, and the methods of interception in various processes of the hydrological cycle. The surface water forms 96% of the total available water resources while the rest is the groundwater component. The major rivers through which the surface water flows are Tana and Athi Rivers flowing into the Indian Ocean, The Sio, Nzoia, Yala, Nyando, Sondu-Miriu, Gucha-Migori and Mara rivers flowing into Lake Victoria, the Turkwel and Kerio Rivers flowing into Lake Turkana, the Ewaso Ng'iro North flowing into the Lorian Swamp and Ewaso Ng'iro South flowing into Lake

Natron in Tanzania. The fresh water lakes include Victoria, Naivasha, Baringo, Jipe and Chala. The Lake Turkana is slightly saline while the Lakes, Nakuru, Bogoria, Elementeita and Magadi are saline.

Drainage Systems

The drainage system in Kenya is determined by the Great Rift Valley, which runs approximately from North to South. From the flanks of the Rift Valley, water flows westwards to Lakes Victoria and Kyoga and Eastwards to Indian Ocean. The Rift Valley itself has an internal drainage system. The drainage system in Kenya is subdivided into five drainage basins as shown in Figure 1 below: -

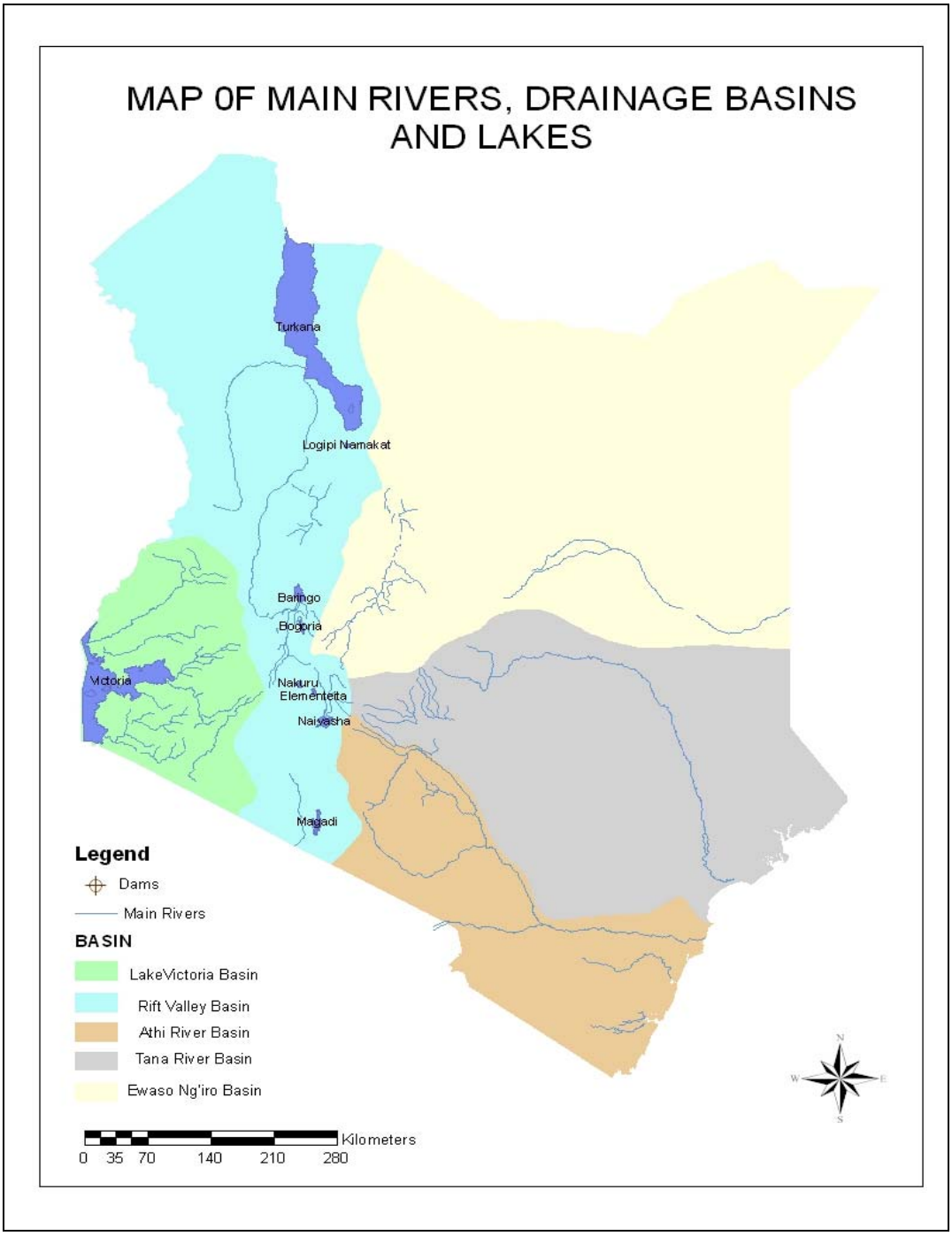

Figure 1: Drainage Basins in Kenya

i. The Lake Victoria drainage basin comprises the area west of the Rift Valley that drains into Lakes Victoria and Kyoga through numerous rivers. This basin comprises 8% of the territorial area of Kenya contains more than 50% of the country's water resources. This sub-basin also happens to be part of the Nile Basin.

ii. The Rift Valley internal drainage basin constitutes 22% of the total land area

iii. The Athi River drainage basin constitutes 12% of the total land area and drains into Indian Ocean
iv. The Tana River drainage basin constitutes 22% of the total land area and drains into the Indian Ocean.
v. The Ewaso Ng'iro North drainage basin constitutes 36% of the land area and drains into Lorian Swamp and the Republic of Somalia.

The surface water yield potentials of the five drainage basins are as indicated in table 1 below: -

Table 1: Kenya Drainage Basins and their Surface Water Potentials

Basin	**Area (km^2)**	**Mean Annual Rainfall (mm)**	**Annual Basin Runoff X 10^9m^3**
Lake Victoria	49,000	1,370	13.80
Rift Valley	130,452	560	3.26
Athi River	66, 837	740	1.31
Tana River	126, 026	700	3.70
Ewaso Ng'iro North	210,226	410	0.34

Shared Water Resources

Kenya has a fair portion of shared water resources with Tanzania, Uganda, Somalia and Ethiopia. Besides the rivers flowing into Lake Victoria and hence forming the headwaters of the River Nile, the Omo river flows into lake Turkana from Ethiopia the Daua River from Ethiopian highlands and along the Kenya-Ethiopia border before entering into Somalia, while the Umba River flows from Tanzania through Kenya to the Indian Ocean, and the Mara River flows from Kenya to Tanzania and enters into Lake Victoria at Mwanza. So far no conflict has emerged within the riparian countries concerning the shared water resources. However as more projects are proposed and developed in future, conflicts may arise between riparian countries as a result of over utilization of waters from rivers with low flows.

In recent years, the water quality for the rivers discharging into Lake Victoria and the Lake itself has deteriorated. The discharge of raw or partially treated municipal and industrial pollutants as well as the high levels of silt-laden run-off from the agricultural land and urban areas into the water have posed serious environmental and health problems. The management of the Lake Victoria basin therefore demands an intergraded approach in order to achieve an effective reduction of pollutants levels and conserve natural resources to achieve this objective, Kenya is participating is participating in the Lake Victoria Environment Programme (LVEMP) which was initiated in 1994 through a tripartite agreement among Kenya, Uganda and Tanzania. It is expected that through the implementation of the programme the environmental degradation of the basin will greatly be reduced and sustainable utilization and development will continue.

There is one principle aquifer at the Kenya/Somalia boundary, the Merti aquifer. Abstraction from this aquifer has so far been low. Although no significant problems are foreseen, detailed studies on shared aquifers will be required to regulate their usage in the future.

Water Resources in the Lake Victoria Basin

Water resources in the Lake Victoria basin form an integral part of the total water resources in Kenya. From Table 1, we note that even though the Lake Victoria basin forms the smallest fraction of the basin-wide area in Kenya, it contributes the highest annual runoff. Lake Victoria also hosts the country's major industries, such as the sugar factories and the Pan Paper Factory at Webuye in addition to being an intensively farmed area. These activities of land use put enormous pressure on the water quality since they provide large levels of point and non-point sources of pollution.

Challenges in Water Management

The management of Kenya water resources has faced serious challenges as a result of factors both within and outside the water sector. These challenges include; -

- Resources scarcity leading to intense competition and water use conflicts amongst and between various users. Current water apportionment and enforcement are weak and are fundamentally responsible for the conflicts.
- Climate variability leading to frequent floods and droughts and consequently causing massive economic damages;
- Growing population with increasing demand on water for domestic use, food security, hydropower generation leading to large unmet demand;
- Catchment degradation resulting in increased runoff, flash floods, reduced infiltration, erosion and siltation;
- Water pollution from urban and rural sewerage and sanitation facilities, industry, agriculture and mines are undermining the country's water resources, escalating public health risks, retarding economic development and intensifying poverty;
- Uncontrolled groundwater development, encroachment on recharge areas and poor management of the resource is causing salt-water intrusion, contamination as well as depletion of the resources;
- Proliferation of invasive pant and animals species is imposing a huge cost on the use and operations of water supply and energy facilities, navigation, fishery and public health;
- Low investment in water storage facilities;
- Inadequate capacity for resource assessment and development;
- Inadequate water supply and sanitation services in the country;
- Lack of comprehensive policy, legal and institutional framework to guide and manage water resources development initiatives;
- Lack of effective implementation and coordination mechanisms in the management and development of water resources;
- Lack of strong financial base in the water sector;
- Lack of coordination between the different water actors;
- Lack of sustainability of water management activities.

Policy Framework

The water policy in application prior to 2003 was not documented but based on government directives and as articulated in various sessional papers and government gazette. In most cases, the policy directives were sectors specific, while in a few incidences they would touch on national issues and therefore fall squarely on the Ministry of Water which, was and is the custodian of the country's water resources.

The ownership of the country's water resources is vested in the government. The government has in turn government has in turn placed this responsibility on the Ministry of Water Resources which executes this mandate based on the Water Act Cap 372.

The government policy as articulated before the year 2003 laid emphasis on sector specific management.

In order to address the weakness and challenges facing the water sector and to achieve sustainable management and development of the water resources, the Kenya Government, through various policy documents, had in the past introduced various initiatives aimed at improving the management of water resources and provision of water and sanitation services. These initiatives did not achieve the expected goals. Consequently, the government prepared the Sessional Paper No. 1 of 1999 on National Policy on Water Resources Management and Development, a paper that set-out the framework intended to bring out and about a culture that would promote comprehensive water resources management and development, bring in decentralization of operational activities from the Central Government to other actors as well as introducing the Private Sector involvement and increased participation of communities in order to improve efficiency in service delivery.

The water policy addressed the following four aspects: -

1. Water resources management
   To preserve, conserve, and protect available water resources and to allocate it in a suitable, rationale and economical way
2. Water supply and sewerage development
   To supply water of good quality and insufficient quantities to meet the various water needs, including poverty alleviation, while ensuring safe disposal of waste water and environmental production,
3. Institutional framework
   To establish an efficient and effective institutional framework able to achieve systematic management and development of the water sector,
4. Financing of the water and sanitation sector
   To develop sustainable financing mechanism for effective water resource management, water supply, and sanitation development.

The policy adopted and integrated water resource management approach as a framework for addressing water requirement in the domestic, agricultural, industrial, livestock sector, etc. the policy also clarifies the rules of the different actors along the following lines:

- The government to provide regulatory and policy guidelines to the sector
- The private and public sector to provide water supply and sanitation services,
- The communities to play a role in water resource management.

The policy further adopts the river basin as the management and planning unit and proposes that catchment bodies become responsible for advising on water allocation decisions.

The policy also proposes application/introduction of volumetric fees of water abstraction in order to meet costs on assessment, monitoring, conservation and the general management of water resources and adopts a polluter-pays principle as a mechanism towards effective control of water pollution.

Legal Framework

Until the year 2002, the Water Act Cap. 372 of the laws of Kenya constituted the legal document for the management of water resources in Kenya. Its objective was to make better the provision for the conservation, control, apportionment and use of the water resources of Kenya and for purposes incidental to and connected with the management of the same.

The Water Act was first enacted in 1962 and revised in 1972. The custodian of the Water Act was the Water Apportionment Board which ensured the implementation of the water management requirements as stipulated within the Act. The Board was under the technical advice of the water development department and its powers stemmed form those of the Minister in-charge of water development matters. The minister appointed the Board as stipulated in the Act. The ownership of water in Kenya is vested in the Government and the minister is empowered to discharge those powers arising out of the Act or to delegate such powers to the Board.

Under the technical advice of the director of water development, the Board was mandated to make further regulations for the better management of the country's water resource. It was also empowered to issue permits or licenses pertaining to water usage and to cancel or withdraw any water rights issued to the user subject to such action being in line with the requirements of the Water Act. The Water Apportionment Board was also empowered to protect the better protection and conservation of the country's water resources and catchment areas.

The Water Act Cap 372 was found to fall short of closely facilitating the management of the country's water resources particularly from water pollution. In this regard, the Act has been revised and it is envisaged that the revised edition which has now been enacted and released for implementation will allow the management of water resources to be in conformity with day-to-day technological and legal requirements.

The Water Act 2002 became operational on 18th March, 2003 and provides an enabling institutional and legal framework for the implementation and realization of the objectives stated in the National Policy on Water Resources Management and Development in the country.

The Act provides the basis for the commencement of comprehensive reforms in the water sector which include: -

i. Defeining the roles of the various actors in the water sector and thereby minimizing or eliminating conflicts in institutional responsibilities;
ii. Establishment of effective, efficient and autonomous institutions to manage water resources and provide water and sanitation services
iii. Attract investment through partnership with water and sewerage companies formed by local authorities and lending from the International and Local financial institutions. To realize this objective, a Water Services Trust Fund (WSTF) has been established to provide financial resource for development of water and sewerage infrastructure. Mainly in the areas without adequate water services.
iv. Refocuses the roles of the minister in charge of water affairs policy formulation, guidance and sourcing for investment funds.

Towards this end, the following institutions have been established to operate as state corporations: -
The Water Resource Management Authority (WRMA) has the overall responsibility of ensuring the good management of the country's water resources;

The Water Services Regulatory Board (WSRB) is responsible for regulation of water and sewerage services in partnership with Kenyans.
The Water Services Boards (WSBs) of which there are seven in the country are responsible for the efficient and economical provision of water and sewerage services in their areas of jurisdiction.
The Water Appeal Board (WAB) will provide a mechanism for dispute resolution.

The WRMA is responsible for the following: -

- To develop principles, guidelines and procedures for the allocation of water resources;
- To monitor, and from time to time to re-assess, the national water resources management strategy;
- To receive and determine application for water use permits.
- To monitor and enforce conditions attached to permits for water use;
- To regulate and protect water resources quality from adverse impact;
- To manage and protect water catchment areas;
- To determine changes to be imposed for the use of water from any water resource;
- To appoint water Catchment Areas Advisory Committee (CAACs) who will advise offices of the authority at the appropriate regional offices on: -
  - Water resource conservation, use and apportionment;
  - The grant, adjustment, cancellation, variation of any permit;
  - To deal with any other matters pertinent to the proper management of water resource in the country.

The Water Act 2002 further provides for the formulation of water resource management strategy and national water services strategy to operationalise the National Policy on water resources management and development. In this regard, the government through the Ministry of water and irrigation has drafted a country's strategy paper on intergraded water resources management addressing the problems facing water resources management. These problems are centred around

- ✓ Inadequate and unsustainable water resources management practices.

- ✓ Weak water allocation procedures;
- ✓ Lack of clear roles of different actors;
- ✓ Weak enforcement capacity and inadequate financing.

Water sector reforms

The on-going water sector reforms in Kenya are expected to positively affect the management of water resources and water quality in that the Government, through the water resource management authority, has identified the weaknesses in the current water resources management processes and is establishing the necessary institutions to efficiently and effectively manage the water resources.

It will strengthen the national water quality monitoring programme to achieve effective water quality monitoring.

Institutional Framework

Prior to 2003, the institutional framework for water resource management in Kenya was complex entailing many actors mandated by the Water Act Cap. 372 of the laws of Kenya as well as sub-sectoral legislation. The ultimate responsibilities for water resources management however, resorted with the ministry of water resources which operated a large number of rural water supply schemes and was responsible for monitoring its quantity and its quality. At the same time, there were other agencies who were engaged in separate, augmenting or parallel water management activities.

The institutions involved in the water management are as follows: -

Ministry of Water and Irrigation

The ministry of Water and Irrigation is the main custodian of water resources in Kenya and has the responsibility for policy formulation and regulation of water sector activities. The functions of the ministry include planning, implementing and operating gazzetted water supplies in rural and urban areas with some exceptions, which are under respective local authorities. The Ministry is also responsible for water resources management, which encompasses the following: -

1. Regular review of the water act;
2. Assessment of water resources;
3. Development of strategies and methods of preservation, conservation, utilization and apportionment of water resources;
4. Enforcement of water pollution control regulations in accordance with the provisions of the Water Act;
5. Review of National Water drinking standards;
6. Coordination, collection, analysis and maintenance of water resources data.

a. The National Water Conservation and Pipeline Cooperation (NWCPC)

The NWCPC was established in 1988 as a parastatal body in the ministry of water resources with a long-term objective of managing water supplies in a self-sustaining manner and to supply water to users at an affordable level. In pursuit of stated objectives, several water schemes which were under

the Ministry of water both operational and at the planning, design and construction stages were transferred to the cooperation shortly after its formation including operation and maintenance personnel attached to the schemes.

Currently, the corporation operates and maintains many water supplies in rural and urban areas throughout the country.

b. The Kenya Water Institute (KEWI)

The KEWI was started in the 1960s as a staff training school in the Ministry of Water. Its role was in the training of paraprofessionals in the water sector who were absorbed by the Ministry. The institute has since expanded its role from training of paraprofessionals for the ministry's exclusive use to offering training of more diversified personnel on water management and development for the entire water sector.

Ministry of Local Authority

The ministry of local authorities through powers delegated by the ministry for water resources undertakes to manage and develop water resources within the urban area which have been identified and agreed on between the two parties. The ministry has been responsible through the respective local authorities for water and sewerage services in towns and municipalities encompassing various stages of projects development.

Ministry of Health

There are two major departments under the ministry of health, which are closely associated with water management issues. These include the public health and the government chemist departments.

a. <u>Public Health Department</u>

The Ministry of Health through the public health division is involved in the provision of preventive health care through: -

- Mobilizing and sensitizing of communities on water and sanitation matters through identification, planning and selecting appropriate technologies.
- Water qualities surveillances
- Water supply improvement at household and small groups levels.
- Water quality monitoring and prosecution of offenders
- Environmental sanitation and hygiene promotion.

In the execution of these roles, the public health department collaborates with other actors notably the ministry in charge of water affairs, the ministry of culture and social services, NGOs, and donors. The ministry of health lays emphasis on promotion of preventive health and hygiene and in this regard, management of water quality and adequate sanitation are given prominent consideration.

b. <u>Government Chemist Department</u>

The Government chemist functions were recently put under the ministry of health. Its roles in the water sector include: -

- Testing and analysis of water for drinking, industrial, agricultural, fisheries;
- Undertakes the analysis of water and effluents samples to acquire evidence presentable in courts as evidence for enforcement of various regulations relating to water pollution.

Ministry of Agriculture

The ministry of agriculture involvement in the water resources sector is currently limited to soil and water conservation.

The soil and water conservation operations are directed towards catchment protection for improved water resources management.

The ministry of agriculture through the soil and water conservation operations comes at the following: -

i. Training on identification, planning, implementation, and operation and maintenance of various necessary structures.
ii. Water spreading banks
iii. Soil erosion control banks;
iv. Rock water catchment
v. Water collection pans;
vi. Sub-surface bunks;
vii. Rehabilitation of rangelands
viii. Tree nurseries

Ministry of Regional Development

The regional development authorities include the Lake Basin Development Authority, the Tana and Athi Rivers Development Authority, the Ewaso Ng'iro North Development Authority, the Ewaso Ng'iro South Development Authority, Kerio Valley Development Authority and the Coastal Development Authority. These authorities are catchement-based and their roles in water management involve coordinating the abstraction and use of water resources, water-based developments, water conservation measures, promotion and participation in catchment protection and data collection.

Ministry of Environment, Natural Resources and Wildlife

The ministry of Environment, Natural Resources and Wildlife (MENR & W) is responsible for the national environmental protection and plays a significant role in catchment, water quality and quantity protection.

The National Environment Management Authority (NEMA)

The Environment Management and Coordination Act of 1999 (EMCA) which operates under the MENR & W has elaborate provisions for the protection and conservation of the environment with specific reverences to rivers, lakes and wetlands. In this regard the Act enables NEMA in consultation with relevant agencies to issue guidelines for the management of the rivers' and lakes' environment.

The Act ensures the preparation of Environmental Impact Assessment Reports and Audit(s) for all projects as one way of ensuring that development and on-going projects have minimal impact on the environment and in particular on the state of the water resources in the country.

KEBS and NEMA

Kenya Bureau of Standards (KEBS) is the statutory body for preparation of standards in Kenya.

The National Environment Management Authority is responsible for establishing a Standards and Enforcement Review Committee (EMCA, 1999). The committee is required to recommend standards to NEMA in respect to: -Drinking water; water for industrial use; water for agricultural use; water for recreational use; water for fisheries and wildlife; and any other prescribed water use.

KEBS plays a role of determining the quality of water for various uses. KEBS provides the following services; -

1. Development of standards for the water sector;
2. Laboratory testing services
3. Protecting the water consumers or users from being exploited by commercial water providers
4. Implementing water standards
5. Metrology and calibration
6. Training programmes and technical advise through seminars, standardization and quality assurance
7. Documentation and service provision

Other institutions

Other institutions playing minor roles in the water sector include: -

- Ministry of livestock and fisheries development;
- Ministry of home affairs, national heritage and social services;
- Ministry of transport and communication (Kenya Meteorological Department);
- Ministry of Energy.

Technical Training and Water Quality Testing in Kenya

There are over 100 institutions that specialize in water and sanitation issues (NETWAS, 1997). Training in water and sanitation issues in Kenya is done at various levels; short-courses, certificate, ordinary diploma (OD), higher national diploma (HND), Bachelors level, Masters Level, and at Doctorial level. All the water and sanitation training matters are required to be approved by the Ministries of Water, Environment and Education.

Bachelors, Masters and Doctorial level trainings are mostly carried out in Public Universities; Nairobi University, Moi University, Kenyatta University, Egerton University, Jomo Kenyatta University of Agriculture and Technology; Maseno University and Masinde Muliro University

of Science and Technology. Certificate, Diploma and Higher National Diploma trainings, though are offered by various Universities and other institutions, they are mainly done at National Polytechnics: Kenya Polytechnic, Mombasa Polytechnic, Eldoret Polytechnic and Kisumu Polytechnic.

Some of the training institutions have the capacity to carry out the water quality testing and analysis and they also have the modern technologies and computer facilities to carry out the data analysis and interpretation. The Ministry of Water has well equipped laboratories, though most of them are outdated, to carry out the water quality tests. The laboratories at the various branches of the Ministry of water, however, lack modern facilities and have insufficient technical staff and to carry out water quality tests and analyses. For instance only 3 and 1 technical staffs in all the national water laboratories have masters degree and certificate in water technology, respectively. Most of the staff have OD and HND qualifications.

TRAINING

Training Modules

Various training institutions in Kenya are engaged in producing qualified and competent human capacity in Kenya. Training in water quality is done at most public universities at Ph. D level,

Masters level and Bachelors level as shown in Tables 2, 3, 4 and 5 below. Training at lower levels is also carried out at government research centres and specialized institutions as indicated inn Tables 6 and 7. The information in the tables is based on returns from questionnaires filled by the respective institutions. Information was also obtained from published data and advertisements in the papers. The other training institutions such as University of Nairobi, Egerton University, Maseno Uniuversity and other tertiary institutions also offer these programmes.

Table 2: Nature and Level of Water Quality Training at Kenyatta University

Nature and type of training	Level of training
Environmental science	Undergraduate and Masters
Hydrology and water resources	Undergraduate and Masters
Integrated watershed management	Masters
Chemistry: Environmental chemistry, advanced instrumental analysis.	Masters
Biochemistry; environment and health,	Masters
Ecology: problems in water pollution,	Masters

Table 3: Nature and Level of Water Quality Training at JKUAT

Nature and type of training	Level of training
Water pollution and its analysis. Practically oriented short course for technical staff	Certificate
Analysis of water and waste water. Practically oriented short course for technical staff	Certificate
Global Environment and ASAL engineering. For highly specialized people	Masters

Table 4: Nature and Level of Water Quality Training at MU

Nature and type of training	Level of training
Bachelor of technology in civil and structural engineering	Masters
Master of technology in water and environmental engineering	Undergraduate

Table 5: Nature and Level of Water Quality Training at MMUST

Nature and type of training	Level of training
Emergency water supply	Masters
Sewerage and wastewater treatment; Public health engineering	Undergraduate
Drinking water supply and systems; Hydrology; Water resources engineering;	Undergraduate
Hydraulics; irrigation and drainage engineering	Undergraduate
Environmental modeling; environmental hydrology; environmental pollution and control; GIS and remote sensing;	Undergraduate

Environmental Impact Assessment (EIA), Audit and Planning Logistics	Certificate

Table 6: Nature and Level of Water Quality Training at KARI

Nature and type of training	Level of training
Irrigation water quality analysis and interpretations. The training involves water sampling, handling, analysis and reporting.	Undergraduate Masters

Table 7: Nature and Level of Water Quality Training at IMTR

Nature and type of training	Level of training
Hydrology Climate Risk Management	Postgraduate Short Courses

Some courses, especially, at the University level have a component of water quality. For example M.Sc courses offered by universities, Tables8, 9, and 10, have a substantial components of water quality. Some universities such as WUCST, Table 10, offer modules which one can register for as an isolated course and be awarded a certificate. other types of courses, modules, units, duration and level (national, regional or international), being offered by Kenyan institutions are as shown in Tables 11 and 12.

Table 8: Scope and Duration of Modules in Water Quality at KU

Type of course	Modules and units taught	Duration and cost of the course	National/regional/ international
Msc. Chemistry	10 units and a masters thesis	2 years 320, 000 Ksh.	National
Msc. Hydrology and water resources	10 units and a masters thesis	2 years 320, 000 Ksh	National
Msc. Integrated Watershed management	15 units and a masters thesis	4 semesters, 320,000 ksh. tuition	Regional
Msc. Ecology	10 units and a masters thesis	2 years 320, 000 Ksh	National
Msc. Environmental Science	10 units and a masters thesis	2 years 320, 000 Ksh	National
Msc.Biochemistry	10 units and a masters thesis	2 years 320, 000 Ksh	National

Table 9: Scope and Duration of Modules in Water Quality at MU

Type of course	Modules and units taught	Duration and cost of the course	National/regional/ international
Undergraduate course in Civil and Structural Engineering	239 units in 5 years	5 years 150, 000 Ksh. Per year	National, regional and /international
Graduate course in Water and Environmental	2 years	2 years 250, 000 Ksh. per	National, regional and /international

Engineering		year	

Table 10: Scope and Duration of Modules in Water Quality at MMUST

Type of course	Modules and units taught	Duration and cost of the course	National/regional/ international
Msc. Disaster Preparedness and Engineering Management	11 modules and a masters thesis	2 years 320, 000 Ksh.	National, regional and /international
M.Sc, Disaster Management and Sustainable Development	11 modules and a masters thesis	2 years 320, 000 Ksh.	National, regional and /international
Graduate Diploma in Disaster Preparedness and Engineering Management	10 units and a project report	2 years 260, 000 Ksh	National, regional and international
Graduate Diploma in Disaster Management and Sustainable Development	10 units and a project report	2 years 260, 000 Ksh	National, regional and international

Table 11: Scope and Duration of Modules in Water Quality at JKUAT

Type of course	Modules and units taught	Duration and cost of the course	National/regional/ International
Water Pollution and its Analysis	35 Modules of 105 hours in total	6 Weeks	Regional – East, Central and Southern Africa

Table 12: Scope and Duration of Modules in Water Quality at IMTR

Type of course	Modules and units taught	Duration and cost of the course	National/regional/ international
Postgraduate diploma course in Operational Hydrology	10 Modules	9 Months USD 2,000	International
Hydrological data base management (HYDATA)	1 Module	1 Week, USD 150	International
Application of remote sensing in WRM	1 Module	1 Week, USD 150	International
GIS applications in water management	1 Module	1 Week, USD 150	International
Rainfall-Runoff modeling	1 Module	1 Week, USD 150	International
Surface water flow and quality modeling, groundwater flow and transport modeling	2 Modules	2 Weeks, USD 300	International
Integrated water resources management (IWRM) – demands and losses, economics of water resources planning	3 Modules	1 Week, USD 150	International

National Training Facilities and their Capacities

The status and type of technical training facilities, especially in the water and environmental sectors in some of the institutions in Kenya is as shown in Table 13. We point out that ths is only a representative sample that we believe represents the overall picture in Kenya. Not all institutions returned questionnaires such as University of Nairobi, Egerton University and Maseno University. In addition even in the institutions that returned questionnaires not all departments were included. However for purposes of this analysis, we belief that the information analyzed below is a fairly true representation of the status in the other institutions.

Most of the technical facilities for testing water quality parameters are available and in good conditions. However, facilities in some laboratories in the country are outdated and in poor conditions.

Table 13: Technical Facilities Available in some of Kenyan Institutions

Type of technical facility	**Institution**				
	KARI	KU	MMUST	JKUAT	MoWI
Flow analyzer	A, O				A,O
AAS	A, O	A, O			A,OP
Spectrophotometer	A, O	A, O		A, O	A,OP
pH meter	A, O	A, O	A, O	A, O	A,OP
EC meter	A, O				
Flame photometer	A, O			A, O	A,OP
Polarography		A, O			
UV/Visible spectrometer for phosphates and nitrates)		A, O			A,OP
Conductivity meter		A, O			
GPS current meter		A, O			
GIS facility		A, O			
Sediment sampler		A, O			
Weather instruments		A, O			
Digital camera, stopwatches		A, O	A, O	A, O	
Filter photometer				A, O	
Erlenmeyer flask, pipette, BOD bottles			A, O	A, O	
Autoclave				A, O	
Turbidity meter				A, O	
DO meter, thermometer			A, O	A, O	
Settling column				A, O	
Vacuum flask				A, O	
Floatation funnel				A, O	
TFE coating Imhoff cone			A, O	A, O	
Sibata photo calorimeter				A, O	
Oven and furnace			A, O	A, O	A,OP

Analytical balance				A, O	
Curettes				A, O	
Vacuum pump				A, O	
Fleming purifying jar				A, O	
Magnetic stirrer				A, O	
Incubator				A, O	
HPLC					A,OP
Water distiller					A,OP

Key: A – Available, O – Operational, P – Poor condition

The existing technical capacity for overall water quality monitoring and assessment in the Kenyan institutions is as summarized below.

(1) Kenyatta University

i. Sampling
There are academic and technical staffs competent to do sampling and the equipment used is available. The continuity of the sampling on regular basis is however not established for sites. In the rural areas, very little has been done on the water quality.

ii. Testing
Laboratory testing methods are generally well understood, only that they are carried out in the various laboratories; Environmental Science lab, Ecology laboratory, Chemistry lab and the Biochemistry laboratory in isolation.

iii. Data Generation
The data generated is not on systematic sites where trends can be observed, but on project basis for undergraduate of masters studies, basically on physical, chemical and microbial examinations/tests. There are data on heavy metals, organic matter, nutrients in Nairobi river basin and a section of Gucha / Migori River.

iv. Data Analysis
Data has been analysed in the existing laboratories of Biological Sciences, Biochemistry, and Chemistry. The use of GPS and other geo-referencing techniques have been affected. Standard apparatus and methods have been used e.g. AAS (Atomic Adsorption Spectroscopy), UV/Visible for nutrients and CG for pesticides

v. Data Interpretation
Documented interpretation of data is on thesis projects done in the Biological Sciences, Chemistry, Environmental Science, Biochemistry and Geography. The Departmental supervision is really on isolated individual cases.

(2) Kenya Agricultural Research Institute

i. Sampling
Personnel and equipment available including water sampling bottles, soil solution samplers, fridge, cool box, transport (pool)

ii. Testing
Experienced personnel and adequate laboratory equipment including flow analyzer, AAS, spectrophotometer, PH meters, EC meters, Flame photometer

iii. Data Generation
Automated and manual generation

iv. Data Analysis
Adequate capacity

(3) Jomo Kenyatta University of Agriculture and Technology

i. Sampling
Qualified and competent technical staff both in sampling protocol as well as suitable sampling equipment

ii. Testing
Well equipped laboratory for analyses.

iii. Data Generation
Automated data generation facilities not available but the institution is well equipped to be able to generate sufficient data through frequent sampling at appropriate selected sites.

iv. Data Analysis
Available qualified personnel for data analysis and interpretation

v. Data Interpretation

(2) Masinde Muliro University of Science and Technology (MMUST)

i. Sampling
The following are available for sampling: -
- Technical staff
- Water and waste water sampling equipment
- Preservatives and related chemical reagents
- Storage and cooling chambers

ii. Testing
Available for testing of physical, chemical parameters and inadequate capacity for biological testing

iii. Data Generation
Available for data generation for physical, chemical parameters and inadequate capacity for biological data generation

iv. Data Analysis
Sufficient capacity to analyze data in terms of: -
- Technical and professional personnel;
- Softwares and computer capacity;

v. Data interpretation
Sufficient capacity for data interpretation in terms of: -
- Professionals in the water environment field;
- Related professionals in physics, chemistry, biological sciences

(3) Moi University (MU)

i. Sampling
The department of civil and structural engineering has the laboratory capacity for sampling that includes cool boxes, glassware (bottles) and the necessary transport vehicles (1 4-wheel drive Toyota Landcruiser and 1 Toyota Hiace), and tadequate technical personnel.

ii. Testing
The department of civil and structural engineering has Kenya of Bureau of Standards (KEBS) recognized Public Health Engineering laboratory for testing water and wastewater.

iii. Data Generation
The teaching and technical staffs at the department of civil and structural engineering are capable of carrying out field and laboratory work, and have computer facility to generate and store all the data as necessary.

iv. Data Analysis
The teaching staff at the department of civil and structural engineering has the knowledge and capacity to analyze data both manually and by computer as necessary. All teaching staff is currently allocated a computer each.

v. Data interpretation
The teaching staff at The department of civil and structural engineering have the knowledge and capacity to interpret all the laboratory test results and give reports as necessary

Based on the need to monitor the Kenyan Rivers and their tributaries as one system, and based on the existing technical capacity shortfall within the country; the appropriate training modules/courses are designed to be offered, on water quality monitoring and assessment for different levels of manpower and are as shown in Table 14 below

Table 14: Designed Courses on Water Quality Monitoring and Assessment

Name of the Course	Modules and units taught	Duration of the course	National/regional/ international
Diploma course in Water and Wastewater analysis and management	Covers aspects on water source development, operation and maintenance.	2 years	National, regional and international
Certificate in Water and Wastewater Analysis and Management	Covers aspects on laboratory testing, water sampling and reporting.	3 Months	National, Regional
Short certificate course in Water and	Focuses on the update in modern water analysis	3 Weeks	National/regional

Wastewater Analysis and Management	techniques.		
Irrigation water quality assessment	Interpretation of water quality data for the purpose of irrigation, Irrigation water management techniques, monitoring irrigated soils for the water quality related problems	1 Week	National/regional/international
Water pollution and its analysis	Water quality monitoring Sources of pollution; Catchment management and water pollution; Sampling methods and sample preservation; Solid waste disposal and effects on water pollution; Data quality; Quality control; Physico-chemical techniques. Bi-monitoring of water quality.	1 1/2	Regional
Analysis of water and wastewater	Water quality; laboratory organization and safety; bio-indicators of water quality; Physico-chemical indicators of water quality; physico-chemical techniques; biological techniques sampling methods and preservation samples; data analysis; atmospheric pollution.	1 month	National
Instrumentation	Covers aspects related to instrumentation and control. Problem shooting and handling. Simple repair and servicing of analytical instruments.	1 mnoth	Natinal
Masters in IWM	Principles of integrated water resources management, watershed degradation and rehabilitation, demand and supply of watershed resources, environmental impact assessment.	2 Years	Regional
MSc. Hydrology and Water Resources	Hydrometry and surface water hydrology, assessment and management of water resources, environmental aspects of hydrology, Ecohydrology, urban hydrology.	2 Years	National
Msc, Environmental Chemistry	Environmental chemistry, industrial waste water collection and treatment, pollution and	2 Years	National

	pollution control, Environmental ecology, Solid waste management.		
Msc. Environmental Science	Ecology of fresh water algae and macrophites, Ecology and conservation, Principles of pollution control, Water resources.	2 years	National

The capacity of Kenyan institutions in offering water quality monitoring training on a full time or part time basis at both national and regional levels is as shown in Table 15

Table 15: Capacity of Resource Persons in Water Quality at KU

Name	**Qualifications**	**Experience**
Prof. Mwakio Tole	PhD in Environmental Geology	Extensive supervision and field work
Dr. Jane Murungi	PhD Environmental analytical Chemistry	Extensive supervision and field work
Prof. Steven Njuguna	PhD in aquatic ecology	Extensive supervision and field work
Prof. Chhabra	PhD in Environmental chemistry	Extensive supervision and field work
Prof. P. Okemo	PhD Microbiology	Extensive supervision, Laboratory and field work
Dr. Kotut	PhD Aquatic Ecology	Extensive supervision and field work
Dr. Christopher Ondieki	PhD Hydrology	Extensive supervision and field work
Dr. Joy Apiyo Obando	PhD Geomorphology	Extensive supervision and field work

Table 16: Capacity of Resource Persons in Water Quality at KARI

Name	Qualifications	Experience
Gachini, G.N.	Soil Scientist (MSc)	More than 20 years experience in soil and water, dealing laboratory analysis and recommendations. Currently the officer in charge of the soil and water analytical laboratories at NARL. Has been involved in training of laboratory technicians, extension workers and farmers.
Muchukuri K.I.	Laboratory technologist, HND in analytical chemistry	Has 17 years experience in analysis and interpretation of soil and water samples. Has been involved in training laboratory technicians.
Gichamba C.K.	Laboratory technician (Laboratory technician	More than 10 years in handling and analysis of soil and water samples

	certificate)	
Check A.L.	Analytical Chemist (M.Sc. degree)	Has over 15 years in experience in soil and water analysis, reporting and quality assurance
Sijali I.V.	Irrigation Scientist with BSc degree in (Chemistry and Maths) and MSc (Irrigation Engineering)	More 20 years dealing with irrigation and drainage, including interpretation of suitability of water for irrigation. Currently the Head of Irrigation and Drainage Research Programme. Has been involved in training of Scientists, technicians and farmers.

Table 17: Capacity of Resource Persons in Water Quality at JKUAT

Name	Qualifications	Experience
Dr. A.O. Mayabi	PhD in Environmental Engineering	Water quality and wastewater analysis and training over 10 years
Dr. G.M. Thumbi	PhD, Sanitary Engineering	Water quality and wastewater analysis and training over 10 years
Dr. M.O. Nyadawa	PhD, Water resources Engineering	Catchement management and pollution control over 10 years
H.M. Mutua	M.Sc, Water Engineering	Water pollution control
P.K. Kibetu	M.Sc, Public Health Engineering	Water pollution and control
K. Matoke	M.Sc, Water resources and irrigation engineering	Catchment management and water quality

Table 18: Capacity of Resource Persons in Water Quality at MU

Name	**Qualifications**	**Experience**
Dr. J. Kibiiy	PhD. Hydrology, M.Sc. Civil Engineering	Extensive supervision and field work of over 5 years
Mr. J.K. Ngetich	M.Sc. Water and Waste Water Engineering	Extensive supervision and field work of over 22 years
Mr. H.J. Ehagi	M.Sc. Civil Engineering (Hydraulics Engineering)	Extensive supervision and field work of over 18 years
Mr. W. Ndirangu	M.Tech. Water and environmental Engineering	Extensive supervision and field work of over 6 years
Mrs. C. Odinga	Technician (Public health engineering)	22 years experience as water and wastewater analyst
Mr. O. Magachi	Technician (Public health engineering)	22 years experience as water and wastewater analyst

Table 19: Capacity of Resource Persons in Water Quality at MMUST

Name	**Qualifications**	**Experience**
Prof S.K. Makhanu	PhD in Hydraulics	Extensive supervision and field work of over 15 years
Prof. S.B.B. Oteng'i	PhD Meteorology	Extensive supervision and field work of over 20 years

Dr. S.S. China	PhD Environmental hydrology	Extensive supervision and field work of over 15 years
Dr. Rop	PhD Hydrogeology	Extensive supervision and field work of over 15 years
Dr. E.M. Neyole	PhD in Environmental health	Extensive supervision and field work of over 5 years
Dr. J.B. Miima	PhD Surveying	Extensive supervision and field work of over 5 years
Dr. B.T. Ongor'	PhD, Hydrology	Extensive supervision and field work of over 5 years
Mr. S.O. Omuterma	M.Sc, Environmental Science	Extensive supervision and field work of over 10 years
Mr. G.W. Waswa	M.Sc, Civil Engineering (Global Environment and ASAL Eng,)	Extensive supervision and field work of over 5 years
Mr. N. Mburu	M.Sc, Civil Engineering (Global Environment and ASAL Eng,)	Extensive supervision and field work of over 5 years: Ministry of water and irrigation, University
Mr. K.J. Kolongei	M.Sc, Water Resources Engineering	Extensive supervision and field work of over 5 years: National Irrigation Board (NIB), University
Mr. G. Mwasame	B.Sc, Civil Engineering	Laboratory work for over 5 years
Mr. K. Luvai	Diploma, Civil Engineering	Laboratory work of over 5 years

Recommended Training Materials to be Used for Training

Other recommended training materials that can be used to train communities and other stakeholders at the catchments level in order to enhance their perception of water quality issues and create awareness about water quality management

a. Involvement of communities in participatory watershed management plans, through workshops with participation of universities, water authorities, and non governmental organization and water resource users associations, for selected catchments.
b. The importance of vegetation or biodiversity on water quality, Soil erosion and its effect on water quality and aspects of integrated water resources management.
c. During rains, the nutrients and other wash materials from agricultural farms are deposited in the rivers and the trends of the contaminants can be established through monitoring during the dry season (Sept/October and Feb) and the wet season (March/ April and Oct/ November). The concentrations are expected to be high in dry season and in some instances in the start of rain season, the fertilizer applications can be washed off and high flows may yield greater loss of agro-chemicals.
d. Technical staff can be trained on biological and other indicators of water quality and ways of improving the water quality, maintenance and usage of equipment.
e. Participatory Rural Appraisals (PRAs) on water quality. This technique can be used to train communities in identifying water quality problems, cause of the problems, and cost implication of the problem and how to deal with the problem. The community can produce an

action plans to deal with the water quality problem. The plan will also include stakeholders who would benefit from the outcome of the community action plan, especially in the case of where Payment for Environmental Service (PES) is possible.

f. Use of brochures, fliers, demonstration
g. Small scale treatment systems for excreta disposal in rural areas (pit-latrines, compost latrines), Solid waste disposal; Water related/borne diseases
h. Use of posters in community barazas (meetings)
i. Use of video tapes in open-days exhibitions in public institutions;
j. Environmental and ecological parks in public parks in towns and cities
k. Television (TV) sponsored broadcasts;
l. Exhibitions during public shows such as agricultural shows;
m. Student attachments to community based projects and services;
n. Special presentations to primary, secondary and tertiary learning institutions;
o. Extra-curricula activities in schools
p. Community needs training in water quality assessment issues such as simple indicators like water colour, smell and proliferation of aquatic weeds.

WATER QUALITY PARAMETERS

Routinely Analyzed Water Quality Parameters

Based on the local situation and from the available secondary data sets, the following water quality parameters that are regularly tested for in Kenya

i. Physical parameters(pH, Turbidity, Total suspended solids and silt content, Salinity, taste, electrical conductivity, transparency/ colour, temperature)
ii. Chemical parameters (Total nitrogen, total phosphates, nitrate levels, pesticides, Fluoride, BOD, Chemical Oxygen Demand (COD), hardness, alkalinity, total dissolved solids, manganese, iron, heavy metals, cations - sodium, calcium, magnesium; anions – carbonates, hydrocarbonates, sulphates, chlorides, ammonia, and nitrites)
iii. Biological quality parameters (total coliform, E-coli, Feacal coliform and bacterial density, bacteriology)
iv. AA S is crucial. The gas /liquid chromatography is needed to analyze pesticides and organic contaminants (e.g. petrol, oil etc). An HPLC can be used.

Table 20 shows the adequacy of laboratory facilities, technical personnel, and parameters tested in Kenya

Table 20: Laboratory Facilities and Technical Personnel in Water Quality Parameters Testing in Kenya

Water Quality Parameter	Adequacy in Technicians	Adequacy in Facilities	Reasons/Comments
Total nitrogen (TN)	Adequate	Adequate	Routinely done

Total phosphates (TP)	Adequate	Adequate	Routinely done
Heavy metals	Adequate	Fair	Using AAS and outdated technology. Need for modern equipments
pH	Adequate	Adequate	Enough staff and PH meters in the labs
Conductivity/ suspended solids	Adequate	Adequate	Available in chemistry lab
BOD /COD	Adequate	Adequate	Routinely done
Bacteriological quality	Adequate	Adequate	
Phosphate and Nitrate levels	Adequate	inadequate	
Trace elements/ toxic metals	Adequate	Adequate	
Turbidity	Adequate	Adequate	
Calcium, Sodium and Potassium	Adequate	inadequate	Auto-analyzer is needed
Sediment load, flow rates, water quality models	inadequate	inadequate	Sediment load samplers needed, Water quality models needed
Cations	Sufficient	Sufficient	Well equipped laboratory/ Qualified personnel/ Centrally placed in Nairobi
Anions	Sufficient	Sufficient	Well equipped laboratory/ Qualified personnel/ Centrally placed in Nairobi
EC	Sufficient	Sufficient	Well equipped laboratory/ Qualified personnel/ Centrally placed in Nairobi
Pesticides and other hydrocarbons	Adequate	Adequate	Using GC
% Silt content	Sufficient	Sufficient	Well equipped laboratory/ Qualified personnel/ Centrally placed in Nairobi

It was noted that in the institutions surveyed, the staffing of technicians is adequate and laboratory facilities for basic tests are adequate. However, there is need to adequately equip laboratories with consumables and reagents.

Methods for biological and microbiological tests of the following parameters are documented in KEBS, 1985, Part 3. These include Coliform test, Escherichia Coli (Faecal Coliform), Faecal Streptococci, Clostridium Welchii, Iron Bacteria, Sulphate reducing bacteria, Sulphur Bacteria, Gelatin Liquefying Bacteria, and Slime forming bacteria.

Commends on the status of water quality in the river basin:

> It showed that the rivers were polluted and the sources were identified as farming activities and industries. The parameters cover a wide indicator spectrum from bacteriological, physico-chemicals as well as nutrient load. On the other hand, tested parameters do not adequately describe the status of water quality for the purpose of irrigation of food and fodder crops because heavy metals are not analyzed.

Water Quality Parameters that Should be Tested

Other additional parameters recommended for testing and analysis:

- Sediment loads to include bottom rolling sediment loads, Bromides and fluorides, heavy metals, such as lead, mercury, arsenic, chromium and zinc.
- Determination of water animal life, their abundance and possible migration as a result of pollution.

Other parameters that should be considered for regular testing as part of the wider critical monitoring of the Nile basin environment:

- Pesticides, BOD, COD, pH, Temperature, Phosphates, nitrates and nitrites, % Silt content
- Heavy metals, biological life in all waters of the Nile basin to monitor tye animal and plant life.
- Any pollution or other changes would be indicated by the change in animal and plant life behavior.
- Oil contents at various points in the rivers especially those passing through major towns where oil based industries are common.

Parameters of Cross-Border, Trans-Boundary and Basin Wide Significance

Parameters that could be regarded to be of national, cross-border, trans-boundary and basin-wide importance are shown in Table 21. This is based on the duration of the parameter in the water body, its transfer mechanisms, and persistence of toxicity levels.

Table 21: Water Quality Parameters of Trans-boundary Significance

Parameter	National	Cross-Border	Trans Boundary	Basin-Wide
Nitrates	√	√	√	√
Turbidity	√	√	√	√
Sulphates	√	√	√	√
Nitrites	√	√	√	√
Fluoride	√	√	√	√
Organic solvents	√	√	√	√
Microbial Organisms	√	√	√	√
Cations (Na, K, CA, Mg)	√	√	√	√
Anions (CO_3^{-2}, HCO_3^-, SO_4^{-2}, Cl^-, NH_4^-, NO_3^-	√	√	√	√
pH	√	√	√	√
Electrical Conductivity	√	√	√	√
Total nitrogen	√	√	√	√
Total phosphates	√	√	√	√
Biomass	√			
Metals	√	√	√	√

Pesticides	√	√	√	√
% Silt content	√	√	√	√

The existing water quality monitoring stations, which should be considered to be part of the proposed regional regular River Nile water quality monitoring network of stations: -

i. Nyando river basin (sugar belt and fertilizer input from tea and maize farms). Some selected gauging stations/sites could be used e.g. 1E03.
ii. Nzoia river basin (Paper mill and other agricultural activities): use some selected hydrological stations along the river Nzoia, especially the station at Rwamba
iii. Gucha/Migori river basin (slaughter houses and agrochemicals from agricultural activities). Use the major river gauging sites, especially the station at Wathonger
iv. Yala River: the station at Daraja is suitable
v. Sondu /Miriu Rivers: the preferred station is at Nyakwere
vi. Malaba river: The preferred station is at Malaba
vii. Mara river: the preferred station is at Keekorok
viii. Lake Victoria: the preferred stations are: north of Rusinga and offshore Muhuru Bay near Tanzania Border at KP3. (Omwenga, 2006)

Suggestions on how the deficit between the parameters being analyzed, and those that should be analyzed can be bridged.

- Harmonised data base and concurrent updated monitoring. This could be accomplished by documenting the data already used in various works and establishing specific sites where continuous data could be obtained. There should be close collaboration with the agencies such as Ministry of water, the Lake Basin Development Authority (LBDA) to ensure accuracy and continuity of data acquisition.

- By selecting wide spectrum indicator parameters, such as, biological indicators if possible

- Heavy metals can be analysed at National Agricultural Research Laboratory (NARL) with provision of necessary equipment

- More technical experts should be trained in water analyses at the middle level, such as diploma and certificate levels
- More monitoring centres or stations should be set up to adequately cover the Nile Basin from the catchment tributaries to the lakes to the River Nile itself and all the way to the Nile delta
- Strengthen the capacity of the monitoring stations; both the existing and the new ones to be set up or accredited to adequately test for all the relevant parameters.
- Hold workshops and seminars countrywide and region-wide to discuss the overall importance of the monitoring exercise of the whole Nile Basin.

Pollutants and Their Sources

An inventory of the major pollution sources, possibly with their geo-references, the type of pollutants emanating from them, and statement on monitoring that is being carried out for these pollutants. Apart from the industrial establishments that are point pollution, others sources of pollution listed in Table 22 are non-point pollution and would not be geo-referenced.

Table 22: Types and Sources of pollutants in Kenya

Pollutant	**Source**	**Monitoring Level Or Status**	**If Trans Boundary (Indicate Regions)**
Industrial effluents	Industrial establishments such as, Webuye, Chemelil and Muhoroni	Not regular	Affects the entire Nile basin
Mineral phosphates	Industries and agricultural activities	Only few rivers monitored	Affects the entire Nile basin
Soil erosion sediments	Deforestation and intensive agriculture in the upper basins	Few sites monitored	Affects the entire Nile basin
Domestic sewage	Urban wastes and rural latrines	No regular measurements	Affects the entire Nile basin
Herbicides	Non point sources	Rare measurements	Affects the entire Nile basin
Burning of agricultural waste introducing phosphorus and sulphur into the atmosphere	Maize and sugarcane belts in Nyando, Nzoia and other LVB rivrers.	Not usually monitored	Affects the entire Nile basin
Fertilizers	Agricultural activities		Affects the entire Nile basin
Fungicides			Affects the entire Nile basin
Heavy metals	Industries and vehicles	Only few rivers monitored	Affects whole basin
Fertilizers	various	N/A	Transboundary/National (Lake Victoria, Lake Turkana, Lake Nakuru)
Soil erosion	Erosions	N/A	Transboundary/National (Lake Victoria, Lake Baringo, Lake Turkana)
Factory effluents (Liquids and solids)	various	N/A	Transboundary/National (Lake Victoria, Athi River, Lake Nakuru)
Factory emissions (gases)	various	N/A	Transboundary/National (Lake Victoria, Lake Nakuru)
Oxygen demanding matter	Various	Unsatisfactory	Transboundary for some rivers in East Africa such as

			tributaries of Nzoia river, Mara river
Bacteriological	Wastewater from various sources	Unsatisfactory	National

Recommendations for the testing of all key parameters of trans-boundary importance

There is need to monitor all the major rivers draining the Lake Victoria basin especially for levels of nutrients in the form of nitrates and phosphates which enhance growth of algae and water hyacinth affecting aquatic and riverine biodiversity. Water samples could be collected from key stations selected on basis of anthropogenic activities. The pollution sources such as agricultural runoff, industries, effluents from slaughter houses and human settlements along the rivers could be captured. All the key parameters should be monitored; DO, BOD, PH, Nutrients (nitrates, sulphates, Nitrites), temperature and turbidity. These should be carried out on periodic basis so that the trends could be established for both wet and dry periods. The flow rates should also be established as well as sediment load transport. The low flows are known to yield high concentrations and sediments are expected to carry the pollutants so they should also be known. Current meter gauging at both low and high flows are essential as they are related to pollution levels.

All in-coming and out-going transboundary rivers and other transboundary water bodies should be monitored more frequently for those parameters of transboundary importance in order to avoid possible conflicts and to be able to give prompt early warnings in case of any possible serious pollution episodes.

Key parameters for irrigation water quality: Cations (Na, K, CA, and Mg), Anions (CO_3^{-2}, HCO_3^{-}, SO_4^{-2}, Cl^{-}, NH_4^{-}, and NO3-, pH, Electrical Conductivity and % Silt content

Parameters That can be Tested by Communities, Institutions and Schools

Parameters that can be conveniently tested for in the field by NGOs, CBOs, institutions and schools by use of portable equipment that are easily available in the market:

- PH
- Turbidity
- Temperature
- Fluorides
- Bacteriological
- Turbidity
- Color
- Electrical Conductivity
- Sediments

Where applicable, bio-monitoring of parameters including fish/bentus macro-invertebrates for bacteriological analysis should be encouraged as these need no specialized equipment but only training of personnel in the techniques.

QUALITY ASSURANCE

Water Quality Assurance Program

Methods being used for water quality sampling and testing both in the laboratory and in the field are as shown in Table 23.

Table 23: Water Quality Field Sampling and Laboratory Testing Methods

Water Quality Parameter	Field Sampling Method	Field Testing Method	Laboratory Testing Method
pH	Meter measurements	Portable pH meter	pH meter
Turbidity(NTU)	Meter measurements and based on APHA methods	Portable turbidity meter	Turbidity meter
Temperature	APHA methods	Thermometer/conductivity meter	Thermometer/conductivity meter
Suspended solids	APHA methods	N/A	Membrane filtration-APHA methods
Fluoride Concentrations	N/A	N/A	SPADNS Method
Pathogenic bacteria	Use of sampling bottles	Microbial tests	Standard Total Coliform fermentation techniques
Dissolved Oxygen (DO)	250 ml. Glass bottles; APHA methods	Oxygen analyzer	APHA reflux methods; Modified Winkler's titration method
Biological Oxygen Demand (BOD)	250 ml. Glass bottles; APHA methods	Electronic BOD meter	Modified Winkler's titration method
Total Sulphates, Total Phosphorus	Gravimetric method	N/A	Barium-precipitation test
Alkalinity	APHA methods	Portable kits	Titration method
Nitrate levels	500 ml PVC bottles	N/A	Phenol disulphonic acid method
Total coliforms	APHA methods	N/A	APHA membrane filtration methods

Faecal coliforms	APHA methods	N/A	APHA membrane filtration methods
pH	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	pH-meter measurement
EC	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	EC Meter measurement
K, Na	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	Flame Photometer measurement
Ca, Mg	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	AAS measurement
Cl^-	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	Titration
SO_4^{-2}	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	Turbidimetric method
CO_3^{-2}	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	Titration
NH_4^-, NO_3^-	Chek 2003 and Sijal et.al., 1997; APHA methods	Chek 2003 and Sijal et.al., 1997	Spectrophotometer

Methods of field sampling and presentation of the following parameters are contained in KEBS, 1999, Water Quality Sampling, Part 3.

Acidity and alkalinity, dissolved aluminum, free and ionized ammonia, arsenic, barium, BOD, Boron and borates, bromides and bromine compounds, calcium, carbon dioxide, carbon organic, chlorides, chlorophyll, chromium (VI), total chromium, cobalt, COD, Colour, Conductivity, copper, cyanides, total cyanides, detergents, dry residue, fluorides, greases, hydrocarbons, heavy metals, hydrazine, hydrocarbons, hydrogen-carbonates, iodides, iron (II), total iron, lead, lithium, magnesium, manganese, total mercury, nickel, nitrate, nitrite, odor, organic chlorine, total orthophosphates, dissolved orthophosphates, oxygen, ozone, permanganate index, organo-chlorine pesticides, organo-phosphorus pesticides, petroleum and derivatives, pH, dissolved silicates, total silicates, silver, sodium, sulfates, sulfides, sulfides, phenol index, phenols, dissolved phosphorus, total phosphorus, potassium, selenium, cationic surfactants, anionic surfactants, suspended and sedimentary matter, tin, total hardness, total residue, turbidity, uranium and zinc, total coliforms, thermo tolerant coliforms, faecal streptococci, salmonella, shigella, benthic macro-invertebrates, periphytons, phytoplankton, zooplankton, alpha activity, beta activity, radio-iodine, gamma activity, radon isotopes, radium, radio-strontium, titium gas or water, uranium, plutonium

Laboratories, nationally, regionally or internationally with water quality assurance programs
The laboratories under the Ministry of Water and other parastatals such as KEBS, Table 21 below, are adequately equipped to carry out Full Chemical Analysis (FCA), Bacteriological and Physical analysis of both water and wastewater in Kenya. However, most of the Laboratories under the Ministry of Water branches across the country have outdated equipments and shortages of technical staff.

Inter-laboratory collaboration exists among private and government laboratories. Most government (Ministry of Water) branch laboratories and private laboratories collaborate with Centrla testing Laboratory in Nairobi (Government Laboratory in Nairobi) to carry out major water quality tests.

Table 24: Laboratories in Kenya with Water Quality Assurance Programmes

Water Quality Assurance Program	**National Laboratory**	**Regional Laboratory**	**International Laboratory**
Periodic regular monitoring: surface water, groundwater,	Ministry of Water Laboratory for water quality		
Samples done as per request	Government Chemist		
	Nuclear Institute Laboratory for trace elements		
	Kabete water works		
	Geology and Mines for AAS		
	Kenya Plant Inspectorate Services – KPIS for pesticide analyses (Chromatographic equipment)		
	Kenya Industrial Research Development Institute (KIRDI)		
	Nairobi City Water and sewerage Company, Kabete Laboratory		
Surface water, groundwater and Lake Victoria water quality monitoring programme		Lake Victoria Environment Management Programme Laboratories (LVEMP)	
Testing as per request			Kenya Bureau of Standards
			KEMPHIS
			SGS

The efficacy and accuracy of the reported water quality analytical results:

Random and uncoordinated samples are taken from various sites on rivers and other water systems according to specific study objectives. Reagents are bought by students. Monitoring should be carried out on regular basis so that a data base for the trends of the water quality can be determined.

Table 25 shows the parameters featured in the water quality assurance program and performance of the corresponding laboratories

Table 25: Parameters Featured in Water Quality Assurance Programmes in Kenya

Name Of Laboratory	Parameters Featured	Performance of The Laboratories
KU – Chemistry Laboratory	Nitrates, Phosphates, Nitrites and heavy metals.	Good but there is need for modern equipment, e.g. UV/Visible instrument.
KU – Ecological Laboratory	Microbiological contamination: Total coliform, feacal coliform, E-coli	Good.
KU – Biochemistry Laboratory	Microbiological contamination: Total coliform, feacal coliform, E-coli	Good.
KU – Environmental Science Laboratory	Microbiological contamination: Total coliform, feacal coliform, E-coli	Good.
JKUAT – Chemistry, Civil Laboratotories	Most parameters	Good
University of Nairobi: various laboratories	Most parameters	Good
Egerton University: Water laboratory, Environmental Lab.	Most Parameters	Good
Maseno Universiy: Enviromental Lab.	Most paprameters	Good
Moi Univ.: Civil, Environmnetal labs.	Most parameters	Good
Kenya Water Institute	Mots parameters	Good
MoW- Kakamega	FCA, Bacteriological, Wastewater	Poor: Equipment maintenance and supply of reagents are required
MoW- Kisumu	FCA, Bacteriological, Wastewater	Fair
MoW- Nakuru	FCA, Bacteriological, Wastewater	Poor: Needs equipments, such as AAS, flame photometer, oven, large hot plate, descator,

		autoclave, GLC
MoW- Nairobi	FCA, Bacteriological, Wastewater	Fair: Need equipments; GC-MS, HPLC, CO_2 incubator, Spectrophotometers, incubators for anaerobic incubation
LVEMP Kisumu Laboratories	Most parameters	Good
LBDA Kisumu Laboratories	Most parameters	Good

Note: Good represents a functioning laboratory.

Based on the above, and in order to enhance the integrity of the results produced by the laboratories, the following appropriate water quality assurance program is proposed together with the parameters of trans boundary significance that should be featured in the program

First we need to ensure refresher course training for technicians and avail adequate facilities. Shorter courses could be designed for technicians. Harmonize parameters for monitoring and establish regular monitoring at specific sites in the watersheds. Document analysed results and synthesize a periodic reporting for environmental impact assessment. Provide feedback mechanisms for stakeholders to have input to the issues. Expand on the monitoring for water quality from wells and springs as well to cater for wash load from agricultural areas. Data loggers that could capture flow rates sediments and turbidity and PH values automatically at selected sites are desirable.

Atmospheric pollutants delivered by dust should also be monitored. Some wells in the Lake Victoria basin have been found to be contaminated with E-coli and the surface water has had to be contaminated from the ground water systems.

Indeed, heavy metals, pesticides, phosphates, nitrates, nitrites, dissolved organic matter need to be monitored on regular basis as they affect water quality and aquatic organisms.

There is a need to sensitize and educate the communities on proper ways of waste disposal and prevent any further degradation of the natural resources of the Nile basin. Water borne diseases and pollution sources could be minimized and the Millennium Development Goals enhanced. There should legislation to prevent pollution of water resources by ensuring that factories and industries and slaughter houses do not discharge untreated wastes to the rivers.

(i) We can conduct inter laboratory water sample exchange and analysis at National, Regional and international levels for quality assurance programme.
(ii) We can a standard reference water sample in each laboratory
(iii) Calibration of equipment and quality control charts
(iv) Inter laboratory staff exchange programmes
(v) Sampling protocol and preservation to be followed
(vi) Inter-laboratory testing of methods used
(vii) Within laboratory: -
- Instrument calibration with standards
- Analysis of externally supplied standards
- Use of laboratory control charts

Table 26 shows the parameters and the respective proposed frequency of testing. It is worthy noting that biological monitoring indicators can be employed to detect the presence and levels of some pollutants such as heavy metals and micro-pollutants.

Table 26: Parameters and proposed sampling frequency for water quality monitoring

River/Lake	Parameters	Frequency	Comments
Rivers 1. Nzoia 2. Yala 3. Nyando 4. Sondu Miriu 5. Migori 6. Mara Lakes 1. Victoria Other Rivers 1. Nairobi River 2. Turkwel River 3. Tana River 4. Athi River Other Lakes 1. Nakuru 2. Naivasha 3. Bogoria 4. Baringo 5. Turkana	Colour	Weekly	These parameters should also be measured whenever there are sudden changes such as heavy rainfall, severe droughts etc
	Turbidity	Weekly	
	pH	Weekly	
	Suspended solids	Weekly	
	Dissolved solids	Monthly	At least one of these parameters should be measured
	Conductivity	Monthly	
	Nitrates	Monthly	
	Phosphates	Monthly	
	Biochemical Oxygen Demand (BOD)	Monthly	Important at points of discharge of municipal wastewaters and industrial effluents
	Chemical Oxygen Demand (COD)	Monthly	
	Total coliforms	Monthly	Important at points of discharge of municipal wastewaters, polluted rivers and lakes.
	Faecal coliforms	Monthly	
	Sediments	Monthly	Should be measured whenever there is heavy rains
	Heavy metals	Every 3 months	Should be measured whenever suspicion arises of possible pollution
	Micro-pollutants (pesticides and herbicides)	Every 3 months	

A successful water quality assurance programme consists of nine main phases which form a cycle. These are; -

Phase 1: Data collection

Relevant data is collected from the field through monitoring and observation stations set up at various points along the rivers and lakes. Data is also collected through interview, questionnaires, seminars, workshops, and observations in the field.

Phase 2: Data handling and storage

Proper standards and procedure are designed and implemented on handling and storage of the data. This includes the format of recording, and storage. Considerations are given to order, manner and organization of recording of data; use of computers and files to store data etc.

Phase 3: Data analysis

The procedures and standards of analysis of data are designed and documented. This will depend on the probable users and objectives of a given water quality assurance programme. Data should be analyzed and synthesized in a format that suits the intended user and objectives of the water quality programme.

Phase 4: Water quality assessment and reporting

Phase 5: Dissemination and utilization of information by individuals and organizations
Phase 6: Water quality management
Phase 7: Information needs
Phase 8: Assessment strategies
Phase 9: Monitoring programmes

CONCLUSIONS

Kenya has adequate human resource capacity to carry out training, both short and long courses in water quality issue. This is depicted from the number of professionals with advanced degrees – masters and doctorial - in water related courses. However, there seems to be shortage and indeed an acute shortage of middle and lower level human capacity in water quality in Kenya. This is also shown from the few personnel in the Ministry of Water and Irrigation Laboratories.

Most private organizations and a few public institutions of learning have well equipped laboratories to carry out water quality parameter tests. However, some of the laboratories need modern equipments, which will enhance efficiency and accuracy of the tests.

A wide range of water quality parameters are tested and monitored by various organizations in the laboratory and in the field.

RECOMMENDATIONS

Short courses in water quality are required in Kenya. This will enable the already practicing professionals to take refresher courses and acquire modern skills such as EIA techniques, computer applications in water quality, use of GIS and remote sensing in water quality monitoring and assessment.

Lack of necessary equipments to tests some water quality parameters such as heavy metals have resulted into lack of sufficient data on such parameters. Most of the national laboratories are still using outdated techniques and equipments in their water quality works. There is need for modernization of existing laboratories and building of new ones in addition to the ones already existing.

Training of communities on matters of water quality can be done through various ways. The Government, through the provincial administration and its relevant ministry officials can encourage local Barazas through which people can be trained on the management of their local river catchments.

Institutions of higher learning in Kenya offering high level training on water quality should design their courses such that practicing personnel and other persons who may not afford to start and finish such courses in a single block can take them in piecemeal. Modular approach is highly recommended for such courses. This will motivate more people to enroll for such courses.

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8 APPENDICES

A. UPPER LEVEL: WATER QUALITY PRACTIONERS

TITLE TRAINING PROGRAMME

WATER QUALITY MANAGEMENT IN THE LAKE VICTORIA BASIN FOR UPPER LEVEL

WATER PRACTITIONERS

TARGET GROUP PARTICIPANTS
This course targets higher level managers in the water sector. Policy and decision makers in water sector and water administrators from English Speaking countries in the Nile Basin Countries.

OBJECTIVES
To upgrade and enhance the use of modern skills in water quality management in order to utilize the scarce regional water resources.

COURSE STRUCTURE
A. Use of modern software in water quality management;
B. Management of the scarce water resources
C. Use of modern equipment in water quality monitoring and analysis
D. Development of skills in water quality management

MINIMUM ENTRY REQUIREMENTS OF PARTICIPANTS
- Holder of M.Sc. or equivalent in areas related to water quality management with experience of at least 3 years in management position organizations dealing in water;
- Holders of B.Sc. or its equivalent in areas related to water quality management with experience of at least 5 years in management position in organizations dealing in water;
- Holders of Diploma or its equivalent in areas related to water quality management with at least 10 years experience in management position in organizations dealing in water.

COURSE DURATION
The course is to last about 40 days per year and is residential.
The number of participants shall; be a maximum of fifteen (15) per session. Several parallel sessions or series sessions may be held in the same year depending on demand; and the availability of funds, resources persons and facilities.

PARTICIPATING COUNTRIES
Participants will be drawn from the following countries of the Nile Basin: Burundi, DRC Congo, Egypt, Ethiopia, Rwanda, Sudan, Tanzania, Uganda and Kenya.

RESOURCE PERSONS

Resource persons will be drawn from the relevant training institutions in Kenya. This will be out of the technical cooperation between the relevant Training Institutions and the Nile Basin Initiative (NBI). Where there is shortage of specialized professionals sourcing will be done from institutions which are outside Kenya. The external sourcing will be done through the NBI.

FACILITIES AND EQUIPMENT

Most institutions in Kenya are equipped with necessary facilities and equipment to mount and run the proposed course. These include components which are fully loaded with necessary software such as GIS and other necessary packages in water quality management. Laboratories in most of the public and private institutions are equipped with modern analytical equipment such as Gas Chromatography (GC) and Atomic Absorption Spectrophotometer (AAS).

TIME ALLOCATION

The following information is based on the assumption that the course will last forty (40) days. Course units are designed to last 2 or 1.5 hours.

Period	**Session**	**Time**	**Duration**
Morning	1	08.00 – 10.00 hrs	2.0 hrs
	Break	10.00 – 10.30 hrs	0.5 hrs
	2	10.30 – 12.30 hrs	2.0 hrs
	Lunch	12.30 – 14.00 hrs	1.5 hrs
Afternoon	3	14.00 – 15.30 hrs	1.5 hrs
	Break	15.30 – 16.00 hrs	0.5 hrs
	4	16.00 – 17.30 hrs	1.5 hrs
TOTAL HOURS			**7.0 hours**

Time Budget

Time available : 40 days
Less arrival and departure 3 days
Less opening ceremony 1 day
Less closing ceremony 1 day
Total non-learning days 5 days
Time available 35 days
Less Sundays and Saturdays 8 days
Learning days 27 days or 27 x 7 hours = 189 hours

The 189 hours are budgeted as follows: -

Activity	**Duration (Hrs)**	**Proportion (%)**
Lectures	40	21
Discussion	40	21
Seminars	30	16
Practice	24	13

Project	25	13
Educational tours	20	11
Demonstration	10	5
TOTAL	**189**	**100**

COURSES

WQM 301: Integrated watershed management
The course covers aspects of water hydrology, water balance and use of modern packages in watershed management.

WQM 302: Integrated Water Resources Management (IWRM)
This course will focus on water demand, losses and economics of water hydrology and water resources.

WQM 303: Hydrological database management (HYDATA)
The course covers aspects of water data gathering, synthesis, analysis and organization of data bases as secondary data.

WQM 304: Application of remote sensing (RS) in WQM
In this course techniques of remote sensing are used in the management of water resources.

WQM 305: GIS applications in WQM
GIS techniques are applied to analysis aspects of water resources. Theory and practices of GIS are covered to enable the participant apply and interpret GIS information. Use of GIS in information presentation will be emphasized.

WQM 306: Dissemination of water quality information
Techniques in data analysis, reporting and documentation will be covered.

WQM 307: Policy formulation and decision making using water and wastewater data
This course will cover the recent developments in water policy formulations to manage the water resources and catchment level. The Water Act 2002 will be analyzed to strengthen the water quality monitoring programme.

WQM 308: Integrated water resources planning
Emphasis will be placed on the planning as the precursor for effective management and implementation of water schemes and projects. The basic elements of water master plan will be discussed.

WQM 309: Computer packages in Water Quality Management;
In this course computer packages in water quality management will be covered. Such packages will include the WaterCad and AutoWater.

WQM 310: Project cycle management;

In this course emphasis will be made on the project cycle management from planning, project formulation, implementation, pilot projects, extension and withdrawal of donor funds. Evaluation at each stage of project implementation will be covered.

WQM 311: Water resources development;
The course discusses source development under different water scarcity scenarios versus the demand for domestic, industrial, drinking water and irrigation. Different water siurces will be covered including rain water, spring, river and lake waters.

WQM 312: Watershed and river basin management;
Holistic approach in river basin management will be discussed. Emphasis will be out on participatory community water management.

WQM 313: Financial management and utilities;
Financial aspects in water undertaking will be discussed to make water supply a self sustaing and efficient organization. Revenue collection and accounting will e discussed.

WQM 314: Operations in WQM;
Operations of water schemes will be discussed for efficient delivery of the water service schemes.

WQM 315: Water and environmental Law and institutions;
Environmental issues will be discussed in conformity with the EMCA Act 1999.

WQM 316: Public-Private partnerships in WQM;
Water undertaking as a private enterprise will be discussed. Merits and e-merits of water privatization versus efficiency of water sector delivery will be discussed.

WQM 317: Wetland and river plain ecology;
This module will discuss the fragile ecosystems in the wetlands and riverine systems. Issues of conservation will be discussed.

WQM 318: Environmental planning
The course looks as the water issues as part of the wider environment. Planning and conservation of the water environments will be discussed.

B. MIDDLE LEVEL WATER QUALITY PRACTIONEERS

TITLE TRAINING PROGRAMME

WATER QUALITY MANAGEMENT IN THE LAKE VICTORIA BASIN FOR MIDDLE LEVEL WATER QUALITY PRACTIONEERS

TARGET GROUP PARTICIPANTS
Practicing engineers, researchers, water undertaker, in water sector and middle level managers in water sectors from English Speaking countries in the Nile Basin Countries.

OBJECTIVES
To upgrade and enhance the use of modern skills in water quality management in order to utilize the scarce regional water resources.

COURSE STRUCTURE
A. Use of modern software in water quality management;
B. Management of the scarce water resources
C. Use of modern equipment in water quality monitoring and analysis
D. Development of skills in water

MINIMUM ENTRY REQUIREMENTS OF PARTICIPANTS
- Holder of M.Sc. or equivalent in areas related to water quality management or;
- Holders of B.Sc. or its equivalent in areas related to water quality management with experience of at least 3 years in relevant areas or;
- Holders of Diploma or its equivalent in areas related to water quality management with at least 5 years experience in related areas.

COURSE DURATION
The course is to last about 40 days per year and is residential. The number of participants shall; be a maximum of fifteen (15) per session. Several parallel sessions or series sessions may be held in the same year depending on the availability of resources persons and facilities.

PARTICIPATING COUNTRIES
Participants will be drawn from the following countries of the Nile Basin: Burundi, DRC Congo, Egypt, Ethiopia, Rwanda, Sudan, Tanzania, Uganda and Kenya.

RESOURCE PERSONS
Resource persons will be drawn from the relevant training institutions in Kenya. This will be out of the technical cooperation between the relevant Training Institutions and the Nile Basin Initiative (NBI). Where there is shortage of specialized professionals sourcing will be done from institutions which are outside Kenya. The external sourcing will be done through the NBI.

FACILITIES AND EQUIPMENT
Most institutions in Kenya are equipped with necessary facilities and equipment to mount and run the proposed course. These include components which are fully loaded with necessary software such as GIS and other necessary packages in water quality management. Laboratories in most of the public and private institutions are equipped with modern analytical equipment such as Gas Chromatography (GC) and Atomic Absorption Spectrophotometer (AAS).

TIME ALLOCATION
The following information is based on the assumption that the course will last forty (40) days. Course units are designed to last 2 or 1.5 hours.

Period	Session	Time	Duration

Morning	1	08.00 – 10.00 hrs	2.0 hrs
	Break	10.00 – 10.30 hrs	0.5 hrs
	2	10.30 – 12.30 hrs	2.0 hrs
	Lunch	12.30 – 14.00 hrs	1.5 hrs
Afternoon	3	14.00 – 15.30 hrs	1.5 hrs
	Break	15.30 – 16.00 hrs	0.5 hrs
	4	16.00 – 17.30 hrs	1.5 hrs
TOTAL HOURS			**7.0 hours**

Time Budget

Time available : 40 days
Less arrival and departure 3 days
Less opening ceremony 1 day
Less closing ceremony 1 day
Total non-learning days 5 days
Time available 35 days
Less Sundays and Saturdays 8 days
Learning days 27 days or 27 x 7 hours = 189 hours

The 189 hours are budgeted as follows: -

Activity	**Duration (Hrs)**	**Proportion (%)**
Lectures	46	24
Discussion	40	21
Practice	40	21
Project	24	13
Educational tours	15	8
Demonstration	14	8
Seminars	10	5
TOTAL	**189**	**100**

COURSES

WQM 201: Water and Health

The course discusses water as a vehicle for direct transmission of microorganisms that affect human health. Water for use in general sanitation.

WQM 202: Water Quality Standards

The course discusses the importance of water quality standards in order to safeguard human health. Drinking water standards for various organizations are discussed.

WQM 203: Data Quality

The main parameters of data quality, namely, precision and bias are discussed. Interpretation in data quality management programme is discussed and participants taken through the pratical aspects of the data quality.

WQM 204: Water Treatment
Water treatment process is discussed for conventional treatment of river water. Specific tretamnet processes are discussed for rain, well and lake water.

WQM 205: Computer packages in Water Quality Management;
The course exposes participants to various computer packages in water quality management.

WQM 206: Sources of Water Pollution
The course discusses the main sources of pollution: point and non-point sources. Examples of such sources in the Lake Victoria Basin are discussed and visited for the field practice.

WQM 207: Water Microbiology
Water microbiology will cover the role of bacteria as the main cause of sanitary problems. The distribution, metabolism and chemical composition of these microorganisms will be discussed.

WQM 208: Large Community Water Disposal
Water disposal for large communities will be discussed. This covers oxidation or stabilization ponds and conventional or trickling filters in sewerage treatment works.

WQM 209: Measures to Prevent Water Pollution
Measures to prevent water pollution will be discussed in the following broad areas: legislative measures, waste minimization techniques and waste disposal control measures.

WQM 210: Water Quality Monotoring
Water quality monitoring will be discussed focusing on data quality, sampling, testing, reporting and basin-wide monitoring networks. Examples on the monitoring programme in the LVB will be discussed and appreciated through field visits.

WQM 211: Method Development and Evaluation
Techniques of developing methods under conditions of information scarcity will be discussed for purpose of simple analysis.

WQM 212: Modern equipment in water and wastewater analysis;
Participants will be exposed to the use of modern equipment in water quality analysis. Modern laboratories in the Nile basin countries will be visited.

WQM 213: Environmental Impact Assessment;
Environmental Impacts analysis will be discussed for water quality monitoring. Impacts covering short term and long term periods will be discussed.

C. LOWER LEVEL: WATER QUALITY PRACTIONEERS

TITLE TRAINING PROGRAMME

WATER QUALITY MANAGEMENT IN THE LAKE VICTORIA BASIN FOR LOWER LEVEL WATER PRATICIONERS

TARGET GROUP PARTICIPANTS

Practicing water quality technicians, laboratory technicians, field staff from English Speaking countries in the Nile Basin Countries.

OBJECTIVES

To upgrade and enhance the use of modern skills in water quality management in order to utilize the scarce regional water resources, improve efficiency and effectiveness among water practitioners in the shortest time possible.

COURSE STRUCTURE

The course structure will involve discussions, desk-top exercises, practice , field skills and hands-on training n the use of modern equipment to cover the following scope:

A. Use of modern equipment in water quality monitoring and analysis;
B. Data collection and storage;
C. Development of skills in water quality monitoring and reporting.

MINIMUM ENTRY REQUIREMENTS OF PARTICIPANTS

- Holders of B.Sc. or its equivalent in areas related to water quality management with experience of at least 1 year in relevant areas or;
- Holders of Diploma or its equivalent in areas related to water quality management with at least 3 years experience in related areas.
- Holders of Certificate or its equivalent in areas related to water quality management with at least 5 years experience in related areas.

COURSE DURATION

The course is to last about 40 days per year and is residential. The number of participants shall; be a maximum of fifteen (15) per session. Several parallel sessions or series sessions may be held in the same year depending on the availability of resources persons and facilities.

PARTICIPATING COUNTRIES

Participants will be drawn from the following countries of the Nile Basin: Burundi, DRC Congo, Egypt, Ethiopia, Rwanda, Sudan, Tanzania, Uganda and Kenya.

RESOURCE PERSONS

Resource persons will be drawn from the relevant training institutions in Kenya. This will be out of the technical cooperation between the relevant Training Institutions and the Nile Basin Initiative (NBI). Where there is shortage of specialized professionals sourcing will be done from institutions which are outside Kenya. The external sourcing will be done through the NBI.

FACILITIES AND EQUIPMENT

Most institutions in Kenya are equipped with necessary facilities and equipment to mount and run the proposed course. These include components which are fully loaded with necessary software such as GIS and other necessary packages in water quality management. Laboratories in most of the public and private institutions are equipped with modern analytical equipment such as Gas Chromatography (GC) and Atomic Absorption Spectrophotometer (AAS).

TIME ALLOCATION

The following information is based on the assumption that the course will last forty (40) days. Course units are designed to last 2 or 1.5 hours.

Period	**Session**	**Time**	**Duration**
Morning	1	08.00 – 10.00 hrs	2.0 hrs
	Break	10.00 – 10.30 hrs	0.5 hrs
	2	10.30 – 12.30 hrs	2.0 hrs
	Lunch	12.30 – 14.00 hrs	1.5 hrs
Afternoon	3	14.00 – 15.30 hrs	1.5 hrs
	Break	15.30 – 16.00 hrs	0.5 hrs
	4	16.00 – 17.30 hrs	1.5 hrs
TOTAL HOURS			**7.0 hours**

Time Budget

Time available : 40 days
Less arrival and departure 3 days
Less opening ceremony 1 day
Less closing ceremony 1 day
Total non-learning days 5 days
Time available 35 days
Less Sundays and Saturdays 8 days
Learning days 27 days or 27 x 7 hours = 189 hours

The 189 hours are budgeted as follows: -

Activity	**Duration (Hrs)**	**Proportion (%)**
Practice	50	26
Lectures	40	21
Discussion	40	21

Project	20	11
Demonstration	20	11
Educational tours	13	7
Seminars	6	3
TOTAL	**189**	**100**

COURSES

WQM 101: Laboratory Occupational Health and Safety

The course discusses the safe laboratory practices. General laboratory rules are discussed: accidents, vigilance. Work practices including protective gear, waste disposals and laboratory hazards are discussed.

WQM 102: Elements of Water Laboratory

The course discusses the various equipment in different levels of laboratories. Room layout and controls are discussed.

WQM 103: Water Purification Plants

Participants will be taken through the various elements of water purification plants and follow this with field visits to various water purification plants.

WQM 104: Sampling methods and Sample Preservation

The course discusses techniques in sampling from various sources: water faucet, shallow reservoir, deep reservoir, well and sewage.

WQM 105: Physico-chemical Techniques

Participants will be taken through the physico-chemical techniques in water analysis. The course will be expose each participant to laboratory practice.

WQM 106: Reagent Grade Water

Participants will be taken through the preparation of reagent grade water that is used for dilution of reagents and the blank analysis.

WQM 107: Quality Control

Participants will be taken through the quality control measures including: operator competence, calibration with standards, analysis with externally supplied standards and use f control charts.

WQM 108: Laboratory Techniques

This is a pratical session where participants will be expected to carry out selected testes and report on the results for various water samples. Any significant discrepancies will be discussed to identify the sources of any errors and how to correct them.

WQM 109: Reporting of Laboratory Results

Standards reporting procedures will be used in the reporting of results from various tests.

SHORT COURSE ON WATER QUALITY MANAGEMENT

QUESTIONNAIRE FOR COURSE EVALUATION

1. **Details of the course participant**
2. **Objectives**
3. **Curriculum Design**
4. **Course Conduct**
5. **Administration And Management**
6. **Overall Comments**
7. **Contact Address**

NILE BASIN INITIATIVE (NBI)

WITH

[NAME OF HOST INSTITUTION]

1. DETAILS OF THE COURSE PARTICIPANT

Name: _____

Country: _____

Institution: _____

Position: _____

Year: _____

2. OBJECTIVES

1. To what extent were you aware of the objectives of this training programme before you came to Kenya? Please circle the appropriate rating percentage.

0%	25%	50%	75%	100%
I----------	----------I----------	----------I----------	----------I----------	----------I
Not aware at all				Fully aware

2. Please indicate the extent to which the main objectives of the course were met

0%	25%	50%	75%	100%
I----------	----------I----------	----------I----------	----------I----------	----------I
Not met				Fully met

3. In your own to what extent were your expectations of this course fulfilled?

0%	25%	50%	75%	100%
I----------	----------I----------	----------I----------	----------I----------	----------I
Not fulfilled				Completely fulfilled

For the participants who did not mark 100% on any of the above objectives, please, give comments

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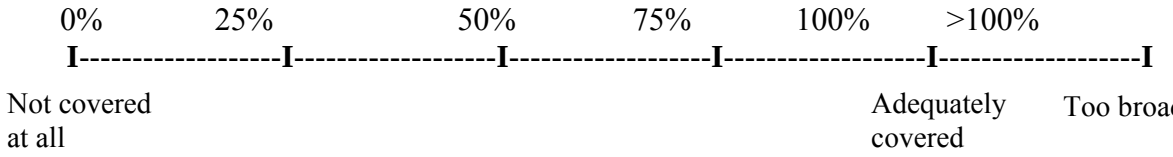
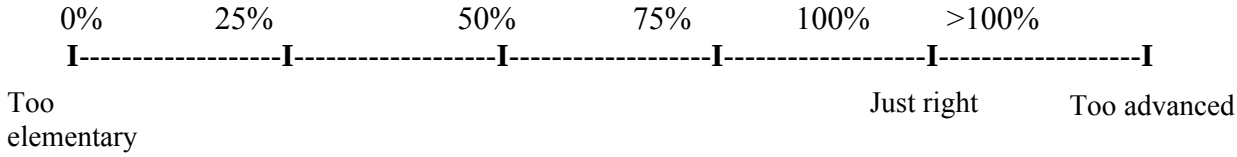
3. CURRICULUM DESIGN

Coverage, Level, Time Allocation, Intensity and Duration:

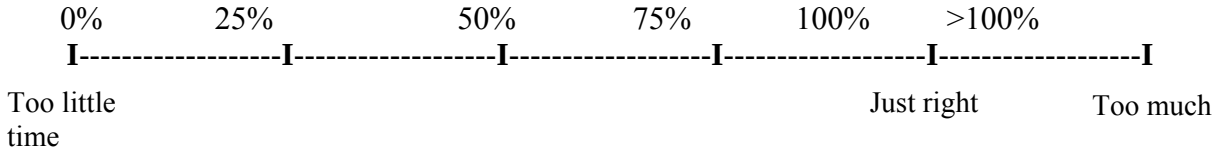
Coverage of the curriculum



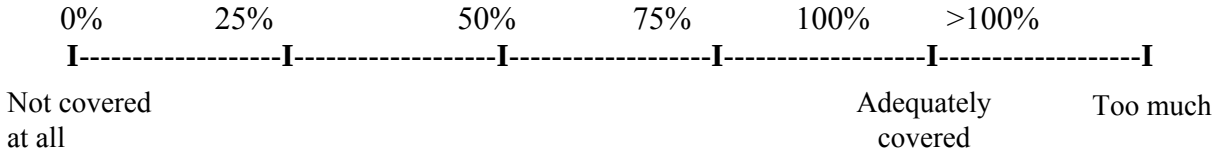
Level



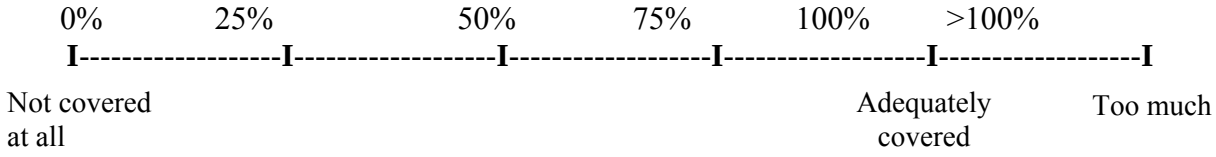
Time allocation



Lab practice



Computer practice



Study tours

Too little Just right Too much

Intensity

0% 25% 50% 75% 100% >100%

I----------I----------I----------I----------I----------I

Too leisurely Just right Too long

Please, write your comments, if any of your score is not 100% in any of the above items on curriculum design

Programming of the topics

Do you think the topics were programmed systematically? If not, please give us your suggestion to improve the training.

_____

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The most or the least valuable topics:

What do you think are the two (20 most interesting and beneficial topics in the training programme?

1.

2.

What do you think are the two (2) least interesting and beneficial topics in the training programme?

1.

2.

Please comment, if you have any:

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4. COURSE CONDUCT

1 Teaching Method

To evaluate the teaching method and application to your works of each topic or subject matter by the scale below. Please fill the checklist on the next page with the number that approximate your opinion.

0% 25% 50% 75% 100%

I----------I----------I----------I----------I

Very poor Outstanding

2. Application of techniques and knowledge
3. Do you think that you will have to make good use of techniques and knowledge you have attained in this course in your country?

0% 25% 50% 75% 100%

I----------I----------I----------I----------I

Very few Quite many

For the participants who marked below 75% above items on COURSE CONDUCT, please give us your comments.

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5. ADMINISTRATION AND MANAGEMENT

How do you rate the general administration and management of the course?

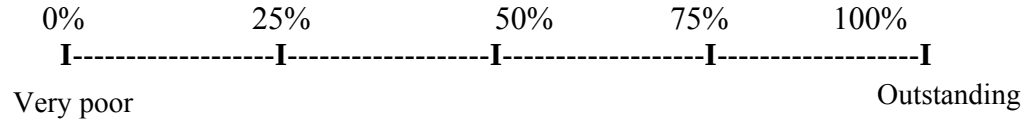
Coordination of the course conduct;

0% 25% 50% 75% 100%

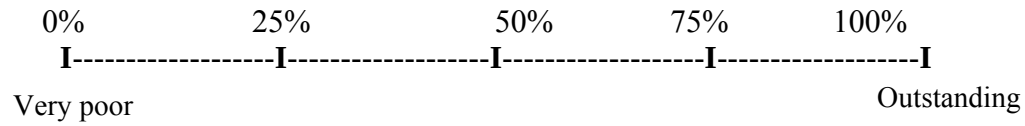
I----------I----------I----------I----------I

Very poor Outstanding

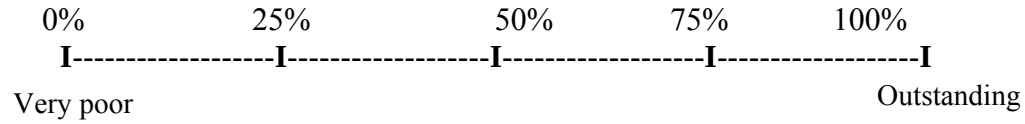
Pre-course information (General Information and Orientation);



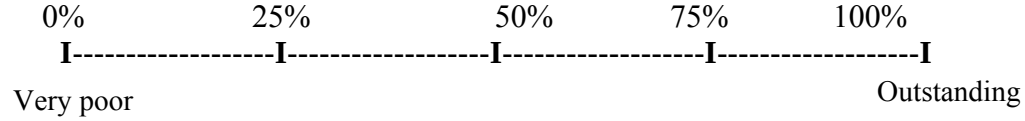
Arrangement for study tours;



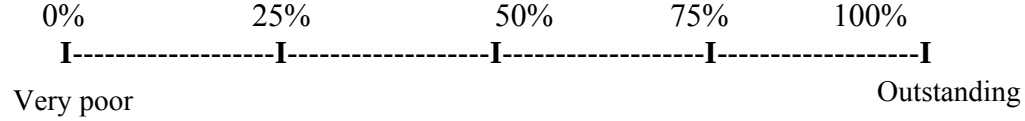
Housing



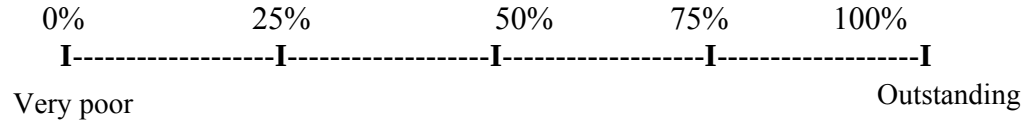
Food



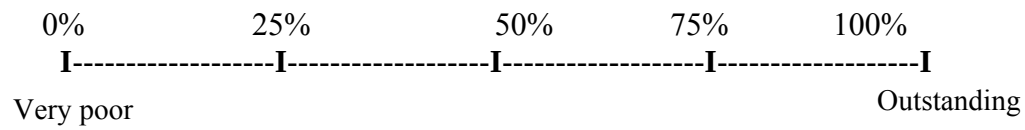
Allowance



Transportation



Social programme (Welcome party, V.C,s Dinner, ect);



Communication among the participants;

0% 25% 50% 75% 100%

I----------I----------I----------I----------I

Very poor Outstanding

Please comment, if you have any

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6. CONTACT ADDRESSES

Please give us relevant addresses where we should send General Information (G.I.) for the next programme in your country.

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Thank you.