In addition:-

i. physical access corridors to key production areas must be open to both migrant livestock and wildlife.
ii access to wet season dispersal areas must also be kept open and these areas not adjudicated.

10.2 Establishment of Environmental Guidelines

(1) Environmental assessment and management guidelines

There are no established comprehensive environmental guidelines in Kenya, other than a guideline included in the Environmental Management Report (NES, 1978). Since environmental conservation is an increasingly important issue in the future, the preparation of comprehensive guidelines will be a prerequisite requirement. The guidelines shall cover both the principle rules of environmental impact assessment and environmental management plans. The guidelines may be legislated as standard or law in the long run.

In preparing the guidelines, the following will be usable as reference literatures;

(a) Guidelines for Integrated Regional Economic cum Environmental Development Planning, Asian Development Bank, 1988

(b) The World Bank Operational Manual, Operational Directive 4.00, Environmental Policy, World Bank, 1989

(c) Environmental Planning and Management and the Project Cycle, Asian Development Bank, 1988

(d) Environmental Guidelines for Selected Infrastructure Projects, Asian Development Bank, 1988, covering water supply, irrigation, hydropower, industrial development, forestry development, sewerage and excreta disposal, etc.

The guidelines should of course suit the conditions prevailing in Kenya and cover the items particular to Kenya. Hence, the preparation of the guidelines will be a great task possibly needing several years or more. National Environmental Secretariat (NES) is the agency capable of handling this issue.

Towards the preparation of the guidelines, it is suggested that NES would commence to prepare the concept of guidelines and accumulate necessary baseline information:

(a) Identification of general environmental issues prevailing in Kenya (NB: Earlier studies and this report could provide such information)

(b) Listing of areas and sectors to be covered by the guidelines

(c) Collection of baseline data and information with regard to environmental issues identified in (a) above, for each specific issue

(d) Preparation of the terms of reference for aquiring donor's assistance

(2) Water quality standards

Water quality standards (or guidelines) may be regarded as one of components to be covered by the environmental guidelines. The standards will comprise (i) effluent quality standards and (ii) receiving water (or stream) quality standards. The necessity of establishing the standards is emphasized in Subsection 7.3.3. In this subsection, approach to the preparation of receiving water quality standards is discussed to respond to a special request from MOWD.

(a) Classification of water use/quality requirement

(i) Determination of desired water quality level for each type of water bodies and water uses

- Water body: classified broadly into surface water (including coastal water) and groundwater

- Water use: domestic/industrial water supply, agriculture, fishery, hydropower, recreation, etc.

(ii) Review of existing water quality data

- Analyse the gap between the desired water quality and actual water quality

- Check whether the desired water quality is not impractically excessive

(iii) Classification of quality level groups by type of water uses (see Table N7.29 for an example)

- Surface waters : 3 ~ 5 categories
- Coastal waters : 3 ~ 4 categories

(b) Determination of water quality items for which the standards are to be established:

(i) Standards relating to protection of public health: e.g. cyanide, alkyl mercury, organic phosphorus, cadminium, lead, hexavalent chromium, arsenic and total mercury.

(NB: Relatively severe values are usually set forth in view of importance of human health. Accordingly, there is no much difference between the standards of various countries)

(ii) Standards relating to preservation of the environment: pH, biochemical oxygen, suspended solid, dissolved oxygen and coliform bacteria

(c) Determination of water quality values

(i) Prepare a matrix table consisting of the factors of (a) and (b) above (see Table 7.29 for an example of the matrix table) and determine water quality value for each matrix element

(ii) Evaluate whether the determined values are practical compared with present water qualities in various water bodies. In case present water quality already exceeds the determined value, due review of the latter value may be necessary.

(d) Monitoring

(i) Monitoring of water qualities

- formulation of water quality monitoring programme
- analysis of data
- planning and implementation of various water quality conservation measures

(ii) Review of adequacy of the determined values

- based on monitoring of the actual water qualities, evaluate the adequacy of the determined values including "safety factor" set out in determining the values

- modify the standards as may be required to arrive at the establishment of practical/realistic standards.

(e) Legal and institutional set-up

(i) Legislation of water quality conservation rules or regulations

(ii) Assignment of an implementation agency and enactment of the power for the implementation

(iii) Budgetary and manpower supports for the implementation

REFERENCE

N.01 The Water Chemistry of the Upper Athi River 1975
N.02 Groundwater Quality of Kenya
N.03 National State of the Environment Report
N.04 The Disposal of Effluents from Coffee Producing Factories and River Pollution
N.05 Water Pollution Control in Kenya 1973
N.06 Narok District Environment Assessment
N.07 Kilifi District Environmental Assessment Report
N.08 Nakuru District Environmental Assessment Report
N.09 Kitui District Environmental Assessment Report
N.10 Lower Tana River
N.12 District Environmental Assessment Report (Kajiado)
N.13 Bungoma District Environmental Assessment Report (Kajiado)
N.14 Kwale District Environmental Assessment Report
N.15 Kisii District Environmental Assessment Report
N.16 Kirinyaga District Environmental Assessment Report
N.17 Lamu District Environmental Assessment Report
N.18 Desertification Control in Africa Actions and Directory of Institutions (Volume 11)
N.19 Annotated Directory of Organization dealing with Desertification Control and Dryland Development
N.20 Desertification Control in Africa
N.21 Desertification Control Bulletin
N.22 Research and Training for Desertification Control: The United Nations Effort
N.23 Environmental Guidelines for Selected Industrial and Power Development Project
N.24 Environmental Management Report
N.25 Kenya's Efforts to Conserve Soils, Water and Forests 1986
N.26 Kenya's Efforts to Conserve Soils, Water and Forests 1987/88
N.27 Semi-Annual Report
N.28 Work Plan 1988/89
N.29 Miathene Catchment Appraisal Report
N.30 Measurement and Prediction of Soil Erosion in Kiambu and Muranga District of Kenya
N.31 First African Ministerial Conference on the Environment
N.32 Environmental Management Report
N.33 The Role and Functions of the National Environment Secretariat
N.34 Environmental Study of Turukana District
N.35 Nakuru Sewerage
N.36 Environment and Development in Kenya
N.37 Towards Sustainable Coastal Tourism - Environmental Impacts of Tourism on the Kenyan Coast, J. Schoorl and N. Visser, June 1991

TABLES

Table N1.1 Distribution of Rainfall in Kenya

Mean annual rainfall (mm)	Land area (km2)	% total land area
> 1000	64,070	11.2
800-1000	32,960	5.8
700-800	24,260	4.3
500-700	73,140	12.8
300-500	270,410	47.4
< 300	105,730	18.4
Total	570,570	99.9

Source: IGADD (1990)

Table N1.2 Major Drainage Basins and Run-off in Kenya

Drainage basin	Catchment area (km2)	Mean annual rainfall (mm)	Mean annual run-off (mm)	Mean annual run-off (million m3)	Run-off %	% Kenya land area
I. Lake Victoria	47,164	1245	149	7,292	12	8.0
II. Rift Valley	124,723	535	6	810	1	21.8
III. Athi River	57,753	585	19	1,295	3	12.0
IV. Tana River	128,510	535	36	4,700	7	23.7
V. Ewaso Ng'iro	120,288	255	4	739	2	35.1
Total	478,438		214	14,836		100.6

Source: IGADD (1990) & NES State of the Environment (2)
GOK/UNEP/UNDP 1981. NWMP-2 Interim Report 1.

Table N1.3 The Inland Lakes of Kenya

Lake	Surface area (km2)	Depth (m)	Type of water	Type of basin
Victoria	69,500	79	Fresh	Open
Winam Gulf	1,400	5	Fresh	Semi-closed
Naivasha (*)	138-297	6.5	Fresh	Closed
Baringo (*)	130	10	Fresh	Closed
Chala	2	90	Fresh	Closed
Jipe (*)	18-20	2	Fresh	Closed
Turkana (*)	6,405	120	Brackish	Closed
Elementeita (*)	18	1.1	Saline	Closed
Nakuru (*)	26-52	1.3	Saline	Closed
Magadi (*)	100	0.5	Saline	Closed
Bogoria (*)	34	10	Saline	Closed

Source: IGADD (1990)
(*) = seasonally and annually very variable.
Only major lakes are listed.

Table N2.1 Demographic Indicators in Census Years, 1948-79

Population parameters	1948	1962	1969	1979
Population (millions)	5.4	8.6	10.9	16.1
Population growth rate (%p.a.)	2.5	3.0	3.3	3.8
Total fertility rate (no.)	6.7	6.8	7.6	7.9
Crude birth rate (per '000)	50	50	50	52
Crude death rate (per '000)	25	20	17	14
Infant mortality rate (per '000)	184	126	119	104
Life expectancy (years)	35	44	49	54

Source: Republic of Kenya, 1989.
World Bank 1990, Kenya Human Resources

Table N2.2 Population Projections Scenarios, selected indicators 1989-2010

Population indicator	1989	1995	2000	2005	2010
Total fertility rate (Nos)	6.7	5.9	5.2	4.5	3.9
Contraceptive prevalence rate (%) a/	27.0	41.9	51.7	61.0	69.2
Population (millions)	23.5	28.6	33.7	39.3	45.3
0 - 14 years	11.9	14.0	15.7	17.5	19.2
15 - 64 years	10.9	13.8	17.1	20.8	25.0
Over 64 years	0.6	0.8	0.9	1.0	1.1
Population growth rate (%)	---	3.3	3.3	3.1	2.9
Labour force					
New entrants ('000) b/	2473	3245	4104	4543	5057
Growth rate (%)		4.0	4.4	4.0	3.7
Dependency ratio c/	114.7	107.2	97.1	88.9	81.2

a/ Contraceptive prevalence rate for married women of reproductive age (ie. 15 to 49 years).
b/ Defined as age group 15-19.
c/ Dependency ratio is defined as the population over age 64 and those under age 15 divided by the working age population (15-64 years) x 100.
Source: World Bank 1990, Kenya Human Resources, staff estimates.

Note: This table was quoted as a leading projection data obtained during the early stage of this Study. See Sectoral Report A - Part II for the projection separately made in this Study for estimate of future water demand.

Table N2.3 Female Education and Fertility, 1978-89

Education level	Fertility 1979	Fertility 1984	Fertility 1989	% change 1979-89
No education	8.8	8.5	7.1	-18.2
Some education	9.0	9.0	7.5	-16.7
Primary completed	8.1	7.9	6.5	-19.8
Secondary and above	7.3	5.4	4.9	-32.9
TOTAL	7.9	7.7	6.7	-15.2

Source: Republic of Kenya, 1979; and NCPD 1989.

Table N2.4 Projected population total for Kenya 1980-2000 ('000).

Year	Case A	Case B	Case C
1980	16,667	16,667	16,667
1981	17,342	17,342	17,342
1982	18,035	18,047	18,044
1983	18,748	18,784	18,775
1984	19,482	19,555	19,536
1985	20,241	20,365	20,333
1986	21,021	21,212	21,163
1987	21,826	22,100	22,030
1988	22,657	23,032	22,936
1989	23,513	24,009	23,883
1990	24,397	25,034	24,872
1991	25,308	26,109	25,905
1992	26,247	27,236	26,985
1993	27,214	28,418	28,113
1994	28,211	29,657	29,292
1995	29,237	30,956	30,522
1996	30,293	32,315	31,806
1997	31,375	33,738	33,144
1998	32,487	35,226	34,538
1999	33,626	36,782	35,991
2000	34,792	38,409	37,505

Case A = declining fertility & mortality
Case B = constant fertility declining mortality
Case C = constant fertility & mortality

Source: UNICEF 1983.

Note: The above represents the projection based on 1979 census data. See Sectoral Report A for the population projection used for water demand estimate.

Table N2.5 Kenya population size and density by Province and District; 1979-1989.

Province District	Land Area (km2)	1979 Population ('000)	1979 Density (No/km2)	1989 Population ('000)	1989 Density (No/km2)	Inter-censal growth factor
Nairobi Province	684	829	1212	1,346	1968	1.62
Coast Province	83,040	1,343	16	1,850	22	1.38
Kilifi	12,414	431	35	611	49	1.42
Kwale	8,257	288	35	384	47	1.33
Lamu	6,506	42	6	57	9	1.36
Mombasa	210	341	1624	467	2224	1.37
Taita Taveta	16,959	148	9	202	12	1.36
Tana River	38,694	92	2	129	3	1.40
North Eastern Province	126,902	374	3	372	3	0.99
Garissa	43,931	129	3	124	3	0.96
Mandera	26,470	106	4	123	5	1.16
Wajir	56,501	139	2	125	2	0.90
Eastern Province	155,760	2,720	17	3,724	24	1.37
Embu	2,714	263	97	358	132	1.36
Isiolo	25,605	43	2	70	3	1.63
Kitui	29,388	464	16	640	22	1.38
Machakos	14,178	1,023	72	1,393	98	1.36
Marsabit	73,952	96	1	125	2	1.30
Meru	9,922	830	84	1,138	115	1.37
Central Province	13,173	2,346	178	3,110	236	1.33
Kiambu	2,448	686	280	914	373	1.33
Kirinyaga	1,437	291	203	388	270	1.33
Murang'a	2,476	648	262	846	342	1.31
Nyadarua	3,528	233	66	349	99	1.50
Nyeri	3,284	487	148	613	187	1.26
Rift Valley Province	171,108	3,240	19	4,894	29	1.51
Baringo	10,627	204	19	286	27	1.40
Elgeyo Marakwet	2,722	149	55	212	78	1.42
Kajiado	20,963	149	7	262	12	1.76
Kericho	4,890	633	129	859	176	1.36
Laikipia	9,714	135	14	213	22	1.58
Nakuru	7,024	523	74	862	123	1.65
Nandi	2,747	299	109	440	160	1.47
Narok	18,519	210	11	402	22	1.91
Samburu	20,809	77	4	114	5	1.48
Trans-Nzoia	2,468	260	105	394	160	1.52
Turkana	61,769	143	2	179	3	1.25
Uasin Gishu	3,784	301	80	440	116	1.46
West Pokot	5,076	159	31	231	46	1.45
Nyanza Province	12,526	2,644	211	3,558	284	1.35
Kisii	2,196	870	396	1,146	522	1.32
Kisumu	2,093	482	230	674	322	1.40
Siaya	2,523	475	188	643	255	1.35
South Nyanza	5,714	818	143	1,095	192	1.34
Western Province	3,223	1,833	569	2,543	789	1.39
Bungoma	3,074	504	164	731	238	1.45
Busia	1,629	298	183	423	260	1.42
Kakamega	3,520	1,031	293	1,389	395	1.35
TOTAL KENYA	564,162	15,327,061	27.2	21,397	37.9	
Adjusted total	564,162	16,141,061	28.6	No data		1.33

Source: Statistical Abstracts 1989, Economic Review 1991.
NOTE: The 1989 census data are provisional figures.
Land area of Turkana District after revision of northern international boundary should be read as 77,000 km^2 approximately.

Table N2.6 Growth of Urban and Rural Populations 1948-2010.

		1948	1962	1969	1979	1990	2000	2010
Total Population	(millions)	5	9	11	15	24	35	48
Urban population	(thousands)	276	671	1,080	2,309	4,778	9,098	16,418
urban as % of total		5	8	10	15	20	26	34
Rural population	(millions)	5	8	10	13	20	26	31
rural as % of total		95	92	90	85	80	74	66

Source: Various
Note: The above represents the projection in various sources earlier studied. See Sectoral Report A for the latest projection used for water demand estimate.

Table N3.1 Guidelines for evaluating irrigation water quality

TYPE OF PROBLEM Soil or irrigation type	Units	WATER QUALITY GUIDELINES No problems	Some problems	Severe problems
SALINITY				
ECw	mmhos/cm	0.7	0.7-3.0	>3.0
PERMEABILITY				
ECw	mmhos/cm	>0.5	0.5-0.2	<0.2
Adj. SAR				
Montmorillonite-Smectites (2:1 crystal lattice)	adj.SAR	<6	6-9 (1)	>9
Illite-Vermiculite (2:1 crystal lattice)	adj.SAR	<8	8-16 (1)	>16
Kaolinite-sesquioxides (1:1 crystal lattice)	adj.SAR	<16	16-24 (1)	>24
SPECIFIC ION TOXICITY				
Sodium (Na)				
Surface irrigation	adj.SAR	<3	3-9	>9
Sprinkler irrigation	meq/l	<3	>3	
Chloride (Cl)				
Surface irrigation	meq/l	<4	4-10	>10
Sprinkler irrigation	meq/l	<3	>3	
Boron (B)	mg/l	<0.7	0.7-2.0	>2.0
MISCELLANEOUS EFFECTS				
Nitrogen (NO3-N or NH4-N)	mg/l	<5	5-30	>30
Bicarbonate (HCO3) with sprinklers	meq/l	<1.5	1.5-8.5	>8.5
pH			normal range 6.5-8.4	

Note: (1) Use the lower range if ECw <0.4 mmhos/cm; the intermediate if ECw = 0.4-1.6 mmhos/cm; the upper range if ECw >1.6 mmhos/cm.

Source: FAO (1979)

Table N3.2 Classification of water-related diseases

Category	Examples of diseases	Pathogen agent	Pathogen	Vector
1. FAECAL-ORAL				
May be water-borne or water-washed	Bacilliary dysentery	Bacteria	Shigella	None
Infective either via water or may be direct faecal-oral without water involvement.	Amoebic dysentery	Protozoa	Entamoeba hystolitica	None
	Gastroenteritis	Miscel.	Bacteria and viruses	None
	Giardiasis	Protozoa	Giardia	None
	Hepatitis	Virus	Hepatitis virus	None
2. WATER-WASHED				
Diseases which reduce with an increase in water volume available for hygiene.	Conjunctivitis	Miscel.	Various	None
	Leprosy	Bacteria	Mycobacterium leprae	None
Mainly skin and eye infections	Trachoma	Miscel.	Various	None
3. WATER-BORN				
Diseases spread when the pathogen is consumed in drinking water.	Cholera	Bacteria	Vibrio cholerae	None
	Typhoid & Para-T	Bacteria	Salmonella	None
4. WATER-BASED				
Diseases where the pathogen spends part of its life in an intermediate aquatic host. All pathogens are worms.	Schistosomiasis	Helminth	Schistosoma	Snails
	Guinea worm	Helminth	Dracunculus medinensis	Cyclops
5. WATER-RELATED INSECT VECTORS				
Diseases spread by insects which either breedin, or bite near water bodies.	Malaria	Protozoa	Plasmodium	Mosquitoes
	River-blindness	Helminth	Onchocerca volvulus	Simulium damnosun
	Filariasis	Helminth	Nematode filariae	Mosquitoes
	Trypanosomiasis	Protozoa	Trypanosoma spp.	Tsetse fly
	Yellow fever	Virus	Yellow fever virus	Aedes aegypti
	Dengue fever	Virus	Dengue fever virus	Aedes aegypti

Table N4.1 An environmental checklist for hydropower development schemes. (Numbers refer to text sections)

2.1 Environmental effects due to project location

(1) Resettlement and compensation
(2) Encroachment into river catchments
(3) Encroachment into National Parks and Forest Reserves
(4) Impairment of historic and cultural artifacts and sites
(5) Catchment erosion and siltation
(6) Impairment of navigation
(7) Effects on surface and groundwater hydrology
(8) Effects on migrating fish
(9) Inundation of mineral resources
(10) Other adverse inundation effects
(11) Improved access across river via the dam wall
(12) Impaired passage across reservoir away from the dam site

2.2 Problems from oversights in planning and design

(1) Road erosion
(2) Pre-impoundment reservoir site preparation
(3) Water rights conflicts

2.3 Problems during construction stage

(1) Erosion control and silt runoff
(2) Other construction stage hazards
  a. workers safety
  b. sanitation of construction camp
  c. water-related and faecal-oral diseases
  d. dust, noise, fumes etc.
  e. social pressures on local communities

2.4 Problems resulting from deficiencies in project operations

(1) Downstream flow variations and bore hazard
(2) Reduction in downstream fishery yield
(3) Delta fishery impacts
(4) Downstream erosion
(5) Downstream water quality
(6) Lack of reservoir management
(7) Eutrophication and aquatic weeds
(8) Disease vector problems
(9) Reservoir bank stability
(10) Operation monitoring

2.5 Potential environmental enhancement measures

(1) Reservoir fishery management
(2) Drawdown agriculture
(3) Downstream community water supply
(4) Downstream aquaculture
(5) Forestry and wildlife reserves
(6) Tourism and recreation

2.6 Additional considerations for hydropower projects

(1) Design options
(2) Characteristics and environmental impacts of design options

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Table N5.1 Forest cover and agricultural land area by Province and District

PROVINCE	Main Agricultural Districts	Forest area (km2)	District area (km2)	% Forest cover	Available agriculture land (km2)	Agric. land as % of total District area
CENTRAL	Kiambu *	408.2	2,578	15.8	1,422	55.2
	Kirinyaga *	293.7	1,490	19.7	955	64.1
	Murang'a *	293.5	2,529	11.6	1,808	71.5
	Nyandarua *	511.0	3,284	15.6	2,085	63.5
	Nyeri *	1213.5	3,351	36.2	1,589	47.4
COAST	Kilifi	394.0	12,593	3.1	7,113	56.5
	Kwale	189.7	8,317	2.3	7,313	87.9
	Lamu	14.2	5,797	0.2	5,517	95.2
	Mombasa	0.0	210	0.0	0	0.0
	Taita	20.7	17,209	0.1	5,824	33.8
	Tana River	59.4	39,198	0.2	8,550	21.8
EASTERN	Embu	188.9	2,871	6.6	2,014	70.1
	Isiolo	ND	25,60			
	Kitui	10.6	31,099	0.0	20,064	64.5
	Machakos	73.8	14,158	9.5	11,273	79.6
	Marasabit	160.3	76,858	0.2	5,517	0.7
	Meru	981.8	9,528	10.3	5,322	55.9
NAIROBI	Nairobi	21.6	700	3.1	0	0.0
NYANZA	Kisii *	0.9	2,217	0.0	1,925	86.8
	Kisumu *	0.7	2,082	0.0	1,573	75.6
	Siaya *	ND	2,523			
	S.Nyanza *	34.3	5,793	0.6	4,533	78.2
RIFT VALLEY	Baringo	437.1	10,703	4.0	7,185	67.1
	Elgeyo Marakwet	703.7	2,810	25.0	1,578	56.2
	Kajiado	96.2	22,106	0.4	6,656	30.1
	Kericho *	641.9	4,948	13.0	3,375	68.2
	Laikipia	390.1	9,723	4.0	8,087	83.2
	Nakuru *	840.4	7,291	11.5	4,829	66.2
	Nandi *	339.8	2,789	12.2	1,926	69.1
	Narok	2281.2	18,033	12.7	11,916	66.1
	Samburu	815.4	20,804	3.9	0	0.0
	Trans-Nzoia *	275.3	2,495	11.0	1,559	62.5
	Turkana	46.2	66,887	0.7	0	0.0
	Uasin Gishu *	420.5	3,799	11.1	2,781	73.2
	West Pokot	372.0	9,100	4.1	5,569	61.2
WESTERN	Bungoma *	434.6	3,046	14.3	1,992	65.4
	Busia *	ND	1,629			
	Kakamega *	207.4	3,558	5.8	2,548	71.6
NORTH EASTERN	Garissa	0.0	43,931	0.0	0	0.0
	Mandera	0.0	26,470	0.0	0	0.0
	Wajir	0.0	56,501	0.0	0	0.0

* = predominantly high potential land
Sources: Adapted from Doute et al. 1981 & MALD, Farm Handbook of Kenya, 1982.

Table N5.2 Change in forested area for selected forests, to 1980.

FOREST	Starting area (ha)	Period covered (No. years)	Total reduction (%)	Mean annual rate of reduction (%)
Endau				
mist forest	720	20	36.8	1.8
lowland forest	971	20	100.0	(>5.0)
Marsabit	13,675	8	0.0	0.0
Ngong Hills	394	13	60.4	4.6
Kakamega	14,268	8	13.0	1.7
North Nandi	11,460	8	20.6	2.6
South Nandi	18,222	8	21.5	2.7
Total	59,710			

Source: Adapted from Ochanda et. al., 1981

Table N6.1 Comparison of soil loss estimates in Kenya after various authors

Source	Relevant factors	Land use	Soil loss
Dunne et al 1979(a)	Gradients <0.10, slopes >500 m, rainfall 500-700 mm ground cover 40-90%, clays-variable depths		25-31 t/ha/yr over last 15 years
	Gradients <0.10, slopes >500 m, rainfall 450 mm ground cover 10-30%, sandy clays 10-200 cm.	Heavily grazed by wildlife and live-stock (Kajiado District)	17.6 t/ha/yr over last 15 years
	Gradients <0.10, slopes >100 m, rainfall 300 mm ground cover 10-40%, sandy clays 50-150 cm.		113 t/ha/yr over last 15 years
Dunne et al 1979(b)	rainfall 750 mm/yr runoff 100 mm/yr	Forests	0.2 t/ha/yr
Ongweny 1978	rainfall > 1,800 mm/yr rainfall 1800-1900 mm/yr rainfall 400-900 mm/yr	Forests densely cropped grazed	0.2 t/ha/yr 2-47 t/ha/yr 9.5 t/ha/yr
Thomas et al 1979	steeply sloping (22-35% of land cover) rainfall 900 mm/yr erosivity c.190, mixed soils	Cropped with 7% poorly managed for soil conservation (Machakos District)	27 t/ha/yr
		Degraded pasture (overgrazed)	94 t/ha/yr
		Pasture in good condition	1.8 t/ha/yr
Moore 1980	steeply sloping (22-35% of land cover) rainfall 900 mm/yr erosivity c.190, mixed soils	All land use in the Athi catchment (Machakos District)	27-80 t/ha/yr

Source: adapted from Ref:C13 Annex 17.

Table 6.2 Actual yields from Harvested Area in Kalia Sublocation; Kitui District (kg/ha).

Crops	With soil conservation	Without soil conservation
Maize		
October 1983	208	130
October 1884	1457	625
Beans		
October 1983	57	27
October 1884	169	134

Source: Ref:B54.

Table N6.3 The economic value of soil conservation for farmers, (Kenya shillings).

Parameter	Without conservation	Average soil conservation	Good soil conservation
Total revenue	7,550	12,187	14,732
Variable costs			
Food crops	853	853	853
Soil conservation crops	0	170	230
Total variable cost	853	1,023	1,083
Gross margin	6,697	11,164	13,649
Annual cost of soil conservation	0	165	165
Net return per man-day of labour	11.44	16.15	18.29

Source: Ref:B54.

Table N7.1 Major Drainage Basins and Run-off in Kenya

Drainage basin	Catchment area (km2)	Mean annual rainfall (mm)	Mean annual run-off (mm)	Mean annual run-off (million m3)	Run-off %	% Kenya land area
I. Lake Victoria	47,164	1245	149	7,292	12	8.0
II. Rift Valley	124,723	535	6	810	1	21.8
III. Athi River	57,753	585	19	1,295	3	12.0
IV. Tana River	128,510	535	36	4,700	7	23.7
V. Ewaso Ng'iro	120,288	255	4	739	2	35.1
Total	478,438		214	14,836		100.6

Source: IGADD (1990) & NES State of the Environment (2)
GOK/UNEP/UNDP 1981. NWMP-2 Interim Report 1.

Table N7.2 Characteristics of Major Kenyan Rivers

Drainage basin	Drainage Catchment area (km2)	Main River Basin: River name	Catchment area (km2)	River length (km)	Mean annual discharge
I. Lake Victoria Basin	47,164				
		Nzoia	12,696	355	122.7
		Yala	3,262	261	16.5
		Nyando	3,450	153	23.1
		Sondu	3,489	157	54.0
		Kuja	6,868	203	57.1
		Mara	9,547	198	59.2
		Total	39,312	1,327	332.6
II. Rift Valley Basin	124,723				
		Turkwel	20,283	390	13.7
		Kerio	14,172	403	21.4
		E.Ngiro (S)	8,534	213	15.1
		Total	42,989	1,006	50.2
III. Athi River Basin & coast	57,753				
		Athi	36,903	631	18.1
IV. Tana River Basin	128,510				
		Tana	95,430	934	40.3
V. Ewaso Ng'iro North Basin	120,288				
		E.Ngiro (N)	91,428	698	10.1
Total	478,438		306,062	4,596	451.3

Source: NWMP-2 Interim Report 1.

Table N7.3 Inland Lakes of Kenya

Lake	Surface area (km2)	Depth (m)	Type of water	Type of basin
Victoria	69,500	79	Fresh	Open
Winam Gulf	1,400	5	Fresh	Semi-closed
Naivasha (*)	138-297	6.5	Fresh	Closed
Baringo (*)	130	10	Fresh	Closed
Chala	2	90	Fresh	Closed
Jipe (*)	18-20	2	Fresh	Closed
Turkana (*)	6,405	120	Brackish	Closed
Elementeita (*)	18	1.1	Saline	Closed
Nakuru (*)	26-52	1.3	Saline	Closed
Magadi (*)	100	0.5	Saline	Closed
Bogoria (*)	34	10	Saline	Closed

Source: IGADD (1990)
(*) = seasonally and annually very variable.

Table N7.4 Groundwater Utilization in Kenya

Borehole use	Number of boreholes	Percentage of total
Public Water Supply	2,137	22.6
Agriculture	948	10.0
Domestic	434	4.6
Industrial & Commercial	224	2.4
Livestock	177	1.9
Observation	62	0.6
Exploratory	52	0.5
Other	973	10.3
Unknown	2,496	26.4
Undescribed	1,959	20.7
Total	9,462	100.0

Table N7.5 WHO Guidelines for Drinking - water Quality

A: Inorganic constituents of health significance.

Parameter	Unit	Guideline value	Remarks
Arsenic	mg/l	0.05	
Asbestos		no value set	
Barium		no value set	
Beryllium		no value set	
Cadmium	mg/l	0.005	
Chromium	mg/l	0.05	
Cyanide	mg/l	0.1	
Fluoride	mg/l	1.5	natural or deliberately added; local or climatic conditions may necessitate adaptation.
Hardness	mg/l	no health related value set	
Lead	mg/l	0.05	
Mercury	mg/l	0.001	
Nickel	mg/l	no value set	
Nitrate	mg/l(N)	10 (= 44 mg/l NO3)	
Selenium	mg/l	0.01	
Silver	mg/l	no value set	
Sodium	mg/l	no value set	

Source: WHO 1984.

Table N7.6 WHO Guidelines for Drinking Water Quality

B: Constituents of aesthetic significance

Parameter	Unit	Guideline value	Remarks
Aluminium	mg/l	0.2	
Chloride	mg/l	250	
Colour	TCU	15	
Copper	mg/l	1.0	
Detergents	--	ngvs	no foaming seen
Hardness	mg/l	500	
Hydrogen sulphide	--	not detectable by consumers	
Iron	mg/l	0.3	
Manganese	mg/l	0.1	
Oxygen-dissolved	--	ngvs	
pH	--	6.5-8.5	
Sodium	mg/l	200	
Solids-dissolved	mg/l	1000	
Sulphate	mg/l	400	
Taste & odour	--	inoffensive to most consumers	
Temperature	--	ngvs	
Turbidity	NTU	5	preferably <1 for good disinfection
Zinc	mg/l	5.0	

Source: WHO 1984.

Table N7.7 WHO Guidelines for Drinking - water Quality

C: Microbiological and biological constituents

Organism	Unit	Guideline value	Remarks
I. MICROBIOLOGICAL QUALITY			
A: Piped water supplies			
A1: Treated water entering the distribution system			
faecal coliforms	no/100ml	0	turbidity <1 NTU; for disinfection with chlorine, pH preferably <8.0;
coliform organisms	no/100ml	0	free chlorine residual 0.2-0.5mg/l following 30 mins. minimum contact
A2: Untreated water entering the distribution system			
faecal coliforms	no/100ml	0	
coliform organisms	no/100ml	0	in 98% of samples examined through out the year-in the case of large supplies when sufficient samples are examined
coliform organisms	no/100ml	3	in an occasional sample, but not in consecutive samples
A3: Water in the distribution system			
faecal coliforms	no/100ml	0	
coliform organisms	no/100ml	0	in 95% of samples examined through out the year-in the case of large supplies when sufficient samples are examined
coliform organisms	no/100ml	0	in an occasional sample, but not in consecutive samples
B: Unpiped water supplies			
			in consecutive samples
faecal coliforms	no/100ml	0	
coliform organisms	no/100ml	10	should not occur repeatedly, if occurrence is frequent and if sanitary protection cannot be improved, an alternative source must be found if possible
C: Bottled drinking-water			
			be found if possible
faecal coliforms	no/100ml	0	source should be free from faecal
coliform organisms	no/100ml	0	contamination
D: Emergency water supplies			
faecal coliforms	no/100ml	0	advise public to boil water in case
coliform organisms	no/100ml	0	of failure to meet guideline values
II. BIOLOGICAL QUALITY			
protozoa (pathogenic)	–	ngvs	
helminths (pathogenic)	–	ngvs	
free-living organisms (algae, worms, others)	–	ngvs	

ngvs = no guideline value set.
Source: WHO 1984.

Table N7.8(a) Water Quality of the Nyando River: 1974-1988

Parameter	Units	Upper zone Maximum	Upper zone Minimum	Middle zone Maximum	Middle zone Minimum	Lower zone Maximum	Lower zone Minimum
pH	–	8.7	7.1	8.3	6.6	8.6	7.1
Turbidity	NTU	900	5	320	53	2700	10
Colour	mg/Pt/l	1000	5	660	15	1000	5
Conductivity	uS/cm	3900	100	1180	140	315	140
Iron	mg/l	6.0	0.1	16.0	0.1	8.0	0.1
Manganese	mg/l	11.0	0.0	5.0	0.2	1.1	0.1
Calcium	mg/l	32.0	6.8	35.0	7.6	36.8	12.6
Magnesium	mg/l	18.0	3.0	50.0	4.0	49.0	3.0
Sodium	mg/l	25.0	16.0	30.0	15.0	27.0	11.8
Total Hardness	mg/l	436	38	242	20	234	4
Tot. alkalinity	mg/l	202	26	164	30	136	66
Chloride	mg/l	60.0	2.0	12.0	1.0	25.0	3.0
Fluoride	mg/l	0.0	4.0	1.5	0.3	0.0	1.0
Nitrate	mg/l	2.7	0.1	2.8	0.1	1.7	0.0
Sulphate	mg/l	119.0	0.3	18.7	0.2	24.0	1.3
Phosphate	mg/l	0.7	0.2	2.0	0.1	0.4	0.1
TDS	mg/l	280	145	270	19	320	84

Source: MOWD data; various dates from 1974-1988.

Table N7.8(b) Water Quality of the Nyando River (1983-1984).

Parameter	Unit	Upper zone	Middle zone	Lower zone
pH	---	7.8	7.8	7.7
Colour	mg Pt/l	360	45	25
Turbidity	NTU	46	25	15
Oxygen absorbed	mg/l	40	27	18
Conductivity	uS/cm	297	215	255
Iron	mg/l	0.87	2.10	2.10
Manganese	mg/l	0.02	0.10	0.02
Total hardness	mg/l CaCO3	103	178	88
Total alkalinity	mg/l CaCO3	132	93	114
Chloride	mg/l	6.4	5.3	7.9
Fluoride	mg/l	0.46	0.32	0.52
Sulphate	mg/l	3.0	2.3	0.9
Orthophosphate	mg/l	0.56	0.13	0.14
TDS	mg/l	172	129	120

Source: Ministry of Water Development, NES 1987.
Values given are mean values.

Table N7.9 Water Quality of the Nzoia River (1983-1984).

Parameter	Unit	Upper zone (Kipkaren)	Middle zone (Siranga))	Lower zone (L.Victoria)
pH	---	7.4	7.0	7.7
Colour	mg Pt/l	50	150	30
Turbidity	NTU	12	65	10
Oxygen absorbed	mg/l	28.0	30.0	23.0
Conductivity	uS/cm	125	83	162
Iron	mg/l	---	---	2.5
Manganese	mg/l	0.20	0.10	0.03
Calcium	mg/l	9.4	3.7	12.0
Magnesium	mg/l	4.4	1.8	4.2
Sodium	mg/l	---	---	---
Potassium	mg/l	---	---	---
Total hardness	mg/l CaCO3	37	27	48
Total alkalinity	mg/l CaCO3	56	36	77
Chloride	mg/l	4.0	3.0	12.0
Fluoride	mg/l	0.20	0.17	0.15
Sulphate	mg/l	---	---	2.2
Orthophosphate	mg/l	0.02	0.03	0.03
TDS	mg/l	73	48	97

Source: Ministry of Water Development
Values given are mean values.

Table N7.10 Water Quality of the Sondu-Miriu River (1983-1984).

Parameter	Unit	Upper zone	Middle zone
pH	---	7.0	7.1
Colour	mg Pt/l	20	10
Turbidity	NTU	8	7
Oxygen absorbed	mg/l	15	12
Conductivity	uS/cm	58	69
Iron	mg/l	0.9	1.2
Manganese	mg/l	0.01	0.01
Calcium	mg/l	3.2	4.0
Magnesium	mg/l	1.0	1.3
Sodium	mg/l	---	---
Potassium	mg/l	---	---
Total hardness	mg/l CaCO3	12	15
Total alkalinity	mg/l CaCO3	21	32
Chloride	mg/l	6.3	7.0
Fluoride	mg/l	0.58	0.45
Sulphate	mg/l	0.8	6.0
Orthophosphate	mg/l	0.03	0.02
TDS	mg/l	35	42

Source: Ministry of Water Development
Values given are mean values.

Table N7.11 Water Quality of the Yala River: 1985-1986.

Parameter	Unit	DAMSITE			KIMONDI			MOKONG		
		MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN
Temperature	oC	18.7	20.1	17.2	18.0	20.0	17.5	18.4	20.1	16.5
Conductivity	uS/cm	107	130	90	79	99	55	144	160	130
pH	--	7.8	8.8	7.0	7.4	8.3	6.8	7.4	8.5	6.7
Colour	mg Pt/l	79	110	40	40	78	10	59	112	10
Turbidity	NTU	49	88	22	17	24	12	54	90	28
Dissolved oxygen	mg/l	8.9	10.8	7.3	8.3	9.9	7.1	7.6	8.9	7.1
DO % saturation	%	119	140	100	113	130	96	102	115	96
Carbon dioxide	mg/l	2.8	2.9	ND	3.5	4.0	ND	6.9	9.0	4.5
Alkalinity-total	mg/l	47.3	52.0	35.0	38.1	52.0	21.0	72.3	89.0	66.0
Harness-total	mg/l	41.4	58.0	34.0	24.2	34.0	14.3	57.5	103.6	36.0
Chloride	mg/l	3.4	7.2	<1.0	3.3	8.3	ND	3.4	7.7	1.0
Fluoride	mg/l	0.34	0.62	ND	0.27	0.53	ND	0.43	0.67	0.15
Manganese	mg/l	0.047	0.090	0.020	0.055	0.120	0.020	0.064	0.135	0.030
Iron	mg/l	1.430	2.500	0.700	1.320	2.200	0.680	1.020	2.360	0.560
Ammonia-N	mg/l	0.096	0.280	0.001	0.099	0.220	ND	0.108	0.230	0.022
T.S.S.	mg/l	41.0	76.0	11.0	13.3	31.2	6.1	62.8	149.0	14.2

Source: Ministry of Water Development.

Table N7.12 Water Quality data for the Arror River (RGS 2C5)

Parameter	Units	Mean	Max	Min
pH	--	7.4	7.9	6.9
Colour	mg Pt/l	17.5	70.0	5.0
Turbidity	NTU	14.2	29.0	1.5
Conductivity	uS/cm	238	420	132
Iron	mg/l	2.1	8.5	0.2
Manganese	mg/l	0.2	0.4	0.1
Calcium	mg/l	17.6	38.0	6.6
Magnesium	mg/l	6.6	11.0	0.4
Sodium	mg/l	8.7	17.0	4.0
Total Hardness	mg/l	79.5	158.0	2.4
Tot. alkalinity	mg/l	88.3	150.0	52.0
Chloride	mg/l	10.8	80.0	2.0
Fluoride	mg/l	0.4	4.0	0.1
Sulphate	mg/l	1.9	6.5	0.1
Phosphate	mg/l	0.02	0.10	0.01
TDS	mg/l	142	252	79

Source: Feasibility Study on the Integrated Development of the Arror River Basin (1990)

Table N7.13 Water Quality of the Kerio River; (1983-1984)

Parameter	Unit	Upper zone	Middle zone
pH	---	7.6	8.0
Colour	mg Pt/l	---	---
Turbidity	NTU	104	76
Oxygen absorbed	mg/l	27	28
Conductivity	uS/cm	145	230
Iron	mg/l	---	---
Manganese	mg/l	---	0.06
Calcium	mg/l	13.0	23.0
Magnesium	mg/l	15.0	5.9
Sodium	mg/l	---	---
Potassium	mg/l	---	---
Total hardness	mg/l CaCO3	81	86
Total alkalinity	mg/l CaCO3	114	102
Chloride	mg/l	3.0	6.0
Fluoride	mg/l	0.50	0.50
Sulphate	mg/l	2.5	---
Orthophosphate	mg/l	0.13	0.23
TDS	mg/l	100	120

Source: Ministry of Water Development
Values given are mean values.

Table 7.14(a) Water Quality data: Malewa River Basin; JUNE 1990.

Parameter	Units	R.Malewa tributaries above dam		River Malewa			
		River Kimuru	River Olkalou	15 km above damsite	Malewa damsite	13 km below damsite	28 km below damsite
Temperature	oC	14.3	18.0	16.5	15.7	17.0	18.5
pH	--	8.01	7.78	7.95	8.24	8.09	8.08
Colour	mg Pt/l	16	16	16	17	18	18
Turbidity	NTU	14	40	24	25	70	28
Suspended solids	mg/l	13	39	35	25	27	35
Conductivity	uS/cm	110	160	130	130	240	200
Dissolved oxygen	mg/l	8.4	6.8	6.8	7.4	7.2	7.2
COD	mg/l	8	15	4	8	7	10
Total nitrogen	mg/l	2.260	3.391	3.166	2.700	-	3.577
Kjeldhal-N	mg/l	1.05	2.25	2.25	2.70	--	2.55
Ammonia-N	mg/l	-	-	-	-	-	-
Nitrate-N	mg/l	1.20	1.10	0.90	<0.01	0.90	1.00
Nitrite-N	mg/l	0.010	0.041	0.016	<0.001	0.018	0.027
Phosphate-P	mg/l	0.13	0.09	0.04	0.12	0.09	0.10

ND = not detectable
Source: JICA 1990.

Table N7.14(b) Water Quality Data: Malawa Damsite; 1990.

Parameter	Units	June 15	July 5	July 11	July 17	July 25	MEAN
Temperature	oC	15.7	--	--	--	--	15.7
pH	--	8.24	-	8.27	7.88	8.08	8.08
Colour	mg Pt/l	17	16	-	19	19	18
Turbidity	NTU	25	-	-	-	-	25
Conductivity	uS/cm	130	104	65	71	74	89
Dissolved oxygen	mg/l	7.4	-	-	-	-	7.4
COD	mg/l	8	16	18	65	13	24
Total nitrogen	mg/l	2.700	-	-	-	-	2.7
Kjeldhal-N	mg/l	2.70	-	-	-	-	2.7
Ammonia-N	mg/l	-	0.04	0.05	0.26	0.06	0.10
Nitrate-N	mg/l	<0.01	1.00	0.60	2.00	0.50	0.84
Nitrite-N	mg/l	<0.001	0.017	0.026	0.154	0.005	0.041
Total phosphorus	mg/l	-	0.49	ND	1.54	0.63	0.89
Phosphate-P	mg/l	0.12	0.12	0.21	0.16	0.17	0.16
Suspended solids	mg/l	25	23	36	323	62	94

ND = not detectable
Source: JICA 1990.

Table N7.15 Water Quality of the Turkwel River (1983-1984).

		Upper zone	Middle zone	Lower zone
pH	---	7.4	7.7	7.7
Colour	mg Pt/l	13	250	500
Turbidity	NTU	4	22	600
Oxygen absorbed	mg/l	4.0	5.5	0.4
Conductivity	uS/cm	78	100	208
Iron	mg/l	0.4	0.9	0.0
Manganese	mg/l	0.10	0.06	0.01
Calcium	mg/l	9.4	14.5	23.0
Magnesium	mg/l	4.4	4.3	0.5
Sodium	mg/l	4.8	5.4	7.5
Potassium	mg/l	2.4	2.7	3.5
Total hardness	mg/l CaCO3	42	53	60
Total alkalinity	mg/l CaCO3	53	76	96
Chloride	mg/l	1.0	1.0	2.0
Fluoride	mg/l	0.21	0.19	2.00
Sulphate	mg/l	4.1	1.0	2.5
Orthophosphate	mg/l	0.53	0.63	0.05
Nitrate	mg/l	0.67	0.75	0.44
TDS	mg/l	40	68	120

Source: Ministry of Water Development
Values given are mean values.

Table N7.16 Water Quality of the Athi River(1983-1984).

Parameter	Unit	Upper zone (14 Falls)	Middle zone (Kibwezi)	Lower zone (Coast)
pH	---	6.8	7.8	8.0
Colour	mg Pt/l	70	---	90
Turbidity	NTU	20	90	65
Oxygen absorbed	mg/l	35	47	42
Conductivity	uS/cm	245	305	594
Iron	mg/l	2.0	---	---
Manganese	mg/l	0.60	---	---
Calcium	mg/l	8.2	16.0	26.0
Magnesium	mg/l	3.5	8.5	19.0
Sodium	mg/l	58.0	---	---
Potassium	mg/l	9.0	---	---
Total hardness	mg/l CaCO3	45	76	161
Total alkalinity	mg/l CaCO3	64	123	193
Chloride	mg/l	22.0	14.0	63.0
Fluoride	mg/l	0.72	0.53	1.10
Sulphate	mg/l	7.3	6.8	42.0
Orthophosphate	mg/l	0.36	0.23	0.06
TDS	mg/l	147	183	371

Source: Ministry of Water Development
Values given are mean values.

Table N.7.17 Water Quality of the Tsavo River and Mzima Springs: April 1980.

		Tsavo River			Mzima Springs	
Parameter	Unit	Upper	Middle	Lower	Upper	Lower
pH	--	8.7	8.8	8.2	8.6	8.4
Turbidity	NTU	250	64	2000	0.5	1.6
PV (*)	mg/l	235	391	94	Nil	Nil
Conductivity	uS/cm	820	610	600	600	550
Manganese	mg/l	0.6	0.6	1.6	0.1	0.1
Total hardness	mg/l	174	162	360	105	100
Total alkalinity	mg/l	281	238	259	202	216
Chloride	mg/l	95.9	32.0	22.5	8.5	12.9

(*) = permanganate value
Source: Ref:C36.

Table N7.18(a) Water Quality of the Tana River (1983-1984).

Parameter	Unit	Upper zone (Masinga dam)	Middle zone (Garsen)	Lower zone (Coast)
pH	---	7.1	8.0	7.7
Colour	mg Pt/l	55	---	---
Turbidity	NTU	28	---	80
Oxygen absorbed	mg/l	25	0	42
Conductivity	uS/cm	77	170	151
Iron	mg/l	2.2	---	---
Manganese	mg/l	0.13	---	0.07
Calcium	mg/l	5.0	20.0	18.0
Magnesium	mg/l	2.5	9.6	10.0
Sodium	mg/l	7.0	---	---
Potassium	mg/l	---	15.0	---
Total hardness	mg/l CaCO3	33.0	90.0	87.0
Total alkalinity	mg/l CaCO3	20.0	216.0	90
Chloride	mg/l	6.6	14.0	6.9
Fluoride	mg/l	0.25	0.25	0.50
Sulphate	mg/l	5.8	5.0	---
Orthophosphate	mg/l	0.04	---	0.07
TDS	mg/l	44	285	91

Source: Ministry of Water Development
Values given are mean values.

Table N.7.18(b) Water Quality of Tana Tributary Rivers; 1990.

Parameter	Unit	River Mutonga (4EA6)	Mutonga River (4EA7)	Thanantu River (4F20)	Kazita River (4F18)	Kithenu River	Thingithu River at Mitungu	Thanantu River at Mukothima
pH	---	6.9	6.7	7.8	7.5	8.2	7.7	7.9
Colour	mg Pt/l	brown	brown	brownish	brownish	<5	10	<5
Turbidity	NTU	25	140	50	45	0	10	<5
Conductivity	uS/cm	95	82	180	150	100	100	240
Iron	mg/l	2.6	2.0	1.6	2.0	0.8	0.3	trace
Manganese	mg/l	0.10	0.10	0.20	0.3	0.0	0.0	0.0
Calcium	mg/l	2.2	2.2	11.0	14.0	10.0	6.4	2.4
Ammonia-N	mg/l	0.01	0.00	0.80	0.00	0.00	0.04	0.00
Nitrate-N	mg/l	<0.01	trace	0.0	<0.01	0.0	0.0	0.0
Nitrite-N	mg/l	<0.01	trace	0.0	<0.01	0.0	---	0.0
Total hardness	mg/l CaCO3	40	19	35	46	28	20	112
Total alkalinity	mg/l CaCO3	34	28	80	65	50	44	156
Chloride	mg/l	5.0	6.0	7.0	6.0	30.0	15.0	2.0
Fluoride	mg/l	0.25	0.25	0.50	0.35	0.00	0.20	0.40
Sulphate	mg/l	<0.3	<0.3	51.0	4.0	0.0	4.0	0.0
Total phosphorus	mg/l	0.01	<0.03	0.05	0.05	---	---	---
TDS	mg/l	57	49	108	90	70	80	170
Suspended solids	mg/l	20	512	30	510	---	---	---

Source: MOWD/SIDA; Greater Tharaka Water & Sanitation Project, June 1990.

Table N.7.19 Water Quality of the Ewaso Ngiro (North), (1983-1984).

Parameter	Unit	Upper zone	Middle zone
pH	---	7.5	8.0
Colour	mg Pt/l	245	40
Turbidity	NTU	30	28
Oxygen absorbed	mg/l	24	53
Conductivity	uS/cm	198	313
Iron	mg/l	---	2.2
Manganese	mg/l	---	0.20
Calcium	mg/l	13.0	21.0
Magnesium	mg/l	8.8	13.0
Sodium	mg/l	---	---
Potassium	mg/l	---	---
Total hardness	mg/l CaCO3	67	96
Total alkalinity	mg/l CaCO3	79	57
Chloride	mg/l	9.0	14.0
Fluoride	mg/l	0.30	0.40
Sulphate	mg/l	1.7	1.2
Orthophosphate	mg/l	0.08	0.27
TDS	mg/l	119	188

Source: Ministry of Water Development
Values given are mean values.

Table N.7.20 Water Quality of Kenyan Saline Lakes; 1983-1984.

Parameter	Unit	Lake Elmenteita	Lake Nakuru	Lake Magadi	Lake Bogoria
pH	---	10.2	9.5	9.7	9.7
Turbidity	NTU	6	21	--	253
Oxygen absorbed	mg/l	172	197	200	115
Conductivity	uS/cm	21,000	9,158	58,500	41,380
Iron	mg/l	--	1.2	--	0.6
Manganese	mg/l	--	0.7	--	0.2
Calcium	mg/l	1.5	5.7	13.0	1.1
Magnesium	mg/l	2.0	2.4	16.0	0.3
Sodium	mg/l	--	--	--	15,400
Total hardness	mg/l CaCO3	4	16	88	130
Total alkalinity	mg/l CaCO3	7,384	5,747	23,500	38,920
Chloride	mg/l	2,432	1,049	6,325	2,818
Fluoride	mg/l	598	167	112	899
Sulphate	mg/l	369	55	140	142
Orthophosphate	mg/l	--	0.30	--	--
TDS	mg/l	12,900	5,494	32,100	24,830

Note: closed basin saline lakes fluctuate substantially in water level and chemical concentration; the data shown here are mean values.
Source: Ministry of Water Development; NES 1987.

Table N7.21(a) Water Quality of Kenyan Freshwater Lakes; 1983-1984.

Parameter	Unit	Lake Naivasha	Lake Victoria	Lake Baringo	Lake Turkana
pH	---	8.3	8.0	8.6	9.3
Turbidity	NTU	25	4	70	21
Oxygen absorbed	mg/l	38	20	21	35
Conductivity	uS/cm	429	140	838	2730
Iron	mg/l	16.0	--	10.0	--
Manganese	mg/l	0.60	--	0.15	--
Calcium	mg/l	16.0	5.7	8.1	4.3
Magnesium	mg/l	8.4	5.5	4.5	2.6
Sodium	mg/l	32.7	--	--	189.3
Total hardness	mg/l CaCO3	96	37	50	22
Total alkalinity	mg/l CaCO3	125	53	360	914
Chloride	mg/l	20.0	9.3	48.0	400.0
Fluoride	mg/l	1.80	0.35	5.5	8.80
Sulphate	mg/l	1.3	2.6	7.1	28.0
Orthophosphate	mg/l	0.88	0.01	0.35	1.30
TDS	mg/l	259	86	510	2138

Source: Ministry of Water Development
Values given are mean values.
* Lake Turkana is virtually semi-saline;brackish and undrinkable.
Herein included in this table in view of low salinity compared with the lakes listed in Table N7.20.

Table N.7.21(b) Summary of Water Quality in Kisumu Bay: 1985-1986.

Parameter	Unit	Study mean	SD as % of mean	WHO guide-line value
Temperature	oC	26.2	3.1	ngs
Conductivity	uS/cm	160	21	ngs
pH	---	7.9	2.5	6.5-8.5
Secchi depth	cm	50	20	ngs
Turbidity	NTU	15	40	5
Dissolved oxygen	mg/l	6	14	ngs
DO % saturation	%	89.5	14.7	ngs
Total hardness	mg/l CaCO3	24	26	500
Total alkalinity	mg/l CaCO3	71	16	ngs
Chloride	mg/l	7.5	42.7	250
Chlorophyll a	um/l	16.7	33.5	ngs
Phytoplankton	no/ml	1238	36	ngs
Zoolplankton	no/l	822	84	ngs

ngs = no guideline set
Source: Ministry of Water Development.

Table N.7.22 Groundwater Quality in Kenya: 1983-1984.

Paramater	Unit	PROVINCE							
		Nairobi	Central	Coast	Estern	North-Eastern	Nyanza	Rift Valley	Western
pH	---	7.9	7.5	7.5	7.4	7.9	7.8	7.9	6.7
Turbidity	NTU	28.9	42.9	36.2	26.2	32.8	39.3	25.6	27.6
Oxygen absorbed	mg/l	3.05	2.66	1.12	1.86	0164	4.83	11.3	0.16
Conductivity	uS/cm	859	494	3291	1109	2315	719	1074	354
Iron	mg/l	1.48	2.00	1.26	2.3	0.99	1.25	1.57	0.89
Manganese	mg/l	0.70	0.42	27.9	2.9	29.2	2.90	0.79	1.52
Calcium	mg/l	43.3	17.3	135.1	63.4	151.9	57.6	52.2	18.6
Magnesium	mg/l	8.16	7.13	117.3	41.3	123.7	34.6	31.9	13.5
Sodium	mg/l	164.0	77.2	746.7	143.3	375.6	106.0	209.0	13.7
Potassium	mg/l	19.3	12.3	16.5	23.8	17	15.1	15.4	4.0
Hardness	mg/l CaCO3	48.4	68.4	369.8	348.7	239.8	238.7	161.9	78.4
Chloride	mg/l	72.4	35.4	1063	142.5	793.6	117.8	153.8	15.6
Fluoride	mg/l	6.59	1.78	1.16	1.9	5.69	2.38	3.33	2.04
Sulphate	mg/l	32.3	11.1	160.2	151.0	259.9	107.2	102.0	20.6
TDS	mg/l	521	314	2122	750	2101	585	916	181

Source : Ministry of Water Development, NES 1987. Values given are mean values.

Table N7.23 Summmary of Groundwater Quality by Major River Basin

	pH (pH scale)	Turbidity (T. scale)	Conductivity (microS/cm)	TDS	Nitrates N-NO3	Nitrites N-NO2	Hardness (Carbonate)	Chloride (Cl)	Sulphate (SO4)	Silica (SiO2)	Flouride (F)	Potassium (K)	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (F)	Orthopho (co4)
Lake Victoria Basin (Total number of boreholes =69)																		
No. of data	61	42	60	55	16	35	33	67	59	32	65	47	50	56	53	37	47	27
Data percentage	88.41	60.87	86.96	79.71	23.19	50.72	47.83	97.1	85.51	46.38	94.2	68.12	72.46	81.16	76.81	53.62	68.12	39.13
Minimum	5.9	0.4	0.3	33	0.06	0.008	11.9	0.4	0	0.3	0.05	0.1	2	0.2	0.01	0.01	0.1	0.01
Maximum	10.87	190	7140	4284	70	5.54	560	1980	1232	103	204	208	1180	770	560	44	21	2
Average	7.61	31	625.39	497.65	17.51	0.3715	163.3455	88.3104	94.2278	43.4188	6.2738	12.1553	102.1648	46.3911	26.9136	2.3938	1.33	0.1178
Standard deviation	0.92	48.21	1219.06	814.39	23.38	1.0391	153.706	284.4479	246.6997	26.4315	25.8636	31.3582	243.4613	107.3219	77.4722	7.4131	3.9988	0.3793
Rift Valley Basin (Total number of boreholes = 156)																		
No. of data	148	107	145	136	36	67	60	146	135	65	134	115	132	137	133	89	123	50
Data percentage	94.87	68.99	92.55	87.18	23.08	42.95	38.46	93.59	86.54	41.67	85.9	76.28	84.62	87.82	85.26	57.05	78.85	32.05
Minimum	6.3	0.2	1	57	0.01	0.007	8	1	0.3	0.2	0.1	0.4	1	0.1	0.1	0.01	0.01	0.01
Maximum	9.5	603	7217	43485	7.5	3	426	6100	7600	110	28	200	5240	680	175	29	32	0.4
Average	7.84	23.65	1047.9	988.18	1.36	0.0804	108.75	154.2397	56.5856	47.8646	2.673	14.4427	215.4364	33.265	19.1086	0.5596	1.1039	0.065
Average	0.63	66.77	1163.22	3737.84	1.72	0.3773	100.7337	597.0787	654.4148	28.5845	3.7861	20.9505	494.6801	64.6612	26.4089	3.0825	3.1104	0.0857
Athi liver Basin (Total number of boreholes = 399)																		
No. of data	359	156	344	286	122	163	183	353	303	201	318	268	291	308	281	129	271	50
Data percentage	89.97	39.1	86.22	71.68	30.58	40.85	45.86	88.47	75.94	50.38	79.7	67.17	72.93	77.19	70.43	32.33	67.92	12.53
Minimum	1.4	0.4	0.6	14	0.01	0.006	2	0.2	0.01	0.19	0.1	0.2	2.8	0.1	0.02	0.01	0.05	0.01
Maximum	9.8	650	20206	12124	155.1	14.2	2300	11500	2057	130	114	298	19550	3200	2010	1120	51	7
Average	7.64	36.02	1425.34	927.5	9.86	0.3171	161.5404	319.1232	106.7607	47.7231	3.4382	17.3837	289.0986	68.2126	48.0721	10.0925	1.2437	0.188
Standard deviation	0.96	82.65	2161.41	1356.57	21.42	1.5758	275.0074	893.3777	259.037	28.3238	7.6186	30.0714	1218.0228	205.8448	152.5918	98.7116	3.9787	0.9846
Tana River Basin (Total number of boreholes = 111																		
No. of data	106	89	104	99	29	77	25	110	103	29	103	78	91	103	104	86	93	10
Data percentage	55.5	80.18	93.69	89.19	26.13	69.37	22.52	99.1	92.79	26.13	92.79	70.27	81.98	92.79	93.69	77.48	83.78	9.01
Minimum	5.9	0.2	6.3	38	0.01	0.01	21 6000	1.9	0	0.5	0.01	0.2	2.5	0.3	0.1	0.01	0.05	0.01
Maximum	9.6	370	15300	13140	56	14.2	752	7900	933	100	55	85	3800	440	450	7.3	93	1.2
Average	7.23	25.46	991.96	792.44	6.04	0.3421	203.96	227.1064	56.4466	35.0828	1.2683	14.6231	180.1967	38.9175	30.166	0.4295	1.8267	0.303
Standard deviation	0.79	56.65	1868.18	1773.84	13.49	1.7351	173.7653	929.9141	164.3007	24.6871	5.4354	14.8681	545.5225	78.38	65.2433	0.9693	9.6511	0.4474
Ewaso N giro Basin (Total number of boreholes = 133)																		
No. of data	122	79	125	124	57	64	59	132	125	65	128	87	91	118	115	78	103	47
Data percentage	91.73	59.4	93.98	93.23	42.86	48.12	44.36	99.25	93.98	48.87	96.24	65.41	68.42	88.72	86.47	58.65	77.44	35.34
Minimum	6.2	0.3	0.5	20	0.01	0	4	1.2	0	1	0	0.1	3.2	0.8	0.1	0.01	0.05	0.01
Maximum	9.6	130	20600	17490	443	6.202	4090	7500	1767	133	28.9	1540	3920	1776	1334	294	175	1.2
Average	7.93	11.24	1356.11	1189.75	36.43	0.4794	312.2475	322.8106	162.1203	44.4092	2.5853	32.8414	261.6022	103.1627	67.3339	9.3196	3.3955	0.0581
Standard deviation	0.68	22.89	2272.08	2318.67	77.86	1.1909	528.5434	1028.3979	316.5993	27.792	5.5457	164.505	567.7708	208.1674	163.2654	38.222	20.5461	0.1739

Table N7.24 Effluent Type and Ecological Effects

Type of Pollutant	Ecological effect				
	De-oxy genation	Eutroph- ication	Poison- ing	Physical habitat modification	Disease hazard
1. Organic residues	+++	+++	-	-	-
2. Inert suspensions	-	-	-	++	-
3. Toxic wastes	-	-	+++	-	-
4. Detergents & fertilizers	-	+++	-	-	-
5. Inorganic reducing agents	++	-	-	-	-
6. Petroleum products	++	-	+	+	-
7. Heat.	++	-	-	-	-
8. Micro-organisms	-	-	+	-	+++
9. Macro-organisms	-	-	-	-	+++

+++ = major effect
++ = moderate effect
+ = minor effect
- = no effect

Table N7.25 Effluent Source and Ecological Effects

Source of Pollutant	Ecological effect				
	De-oxy genation	Eutroph- ication	Poison- ing	Physical habitat modification	Disease Hazard
1. Agricultural production	+++ (1)	+++ (2)	+++ (3)	---	---
2. Agricultural and forest products processing	++ (4)	++ (4)	---	---	---
3. Industrial processing	---	---	++ (5)	+ (6)	---
4. Domestic waste	+++ (7)	+++ (7)	---	---	+++ (7)
5. Soil erosion	---	---	---	+++ (8)	---

+++ = major effect + = minor effect
++ = moderate effect --- = no effect

NOTE: these are respresentative examples only.
(1) organic wastes, especially animal wastes
(2) fertilizer leaceates
(3) biocide residues in run off
(4) organic wastes

Table N7.26 Transect of Water Quality in Kisumu Bay, 1984-1985

Parameter	Unit	1 Kisat	2 Unga	3 Railway	4 Sunset	5 Yacht Club	6 Hippo Point	7 Offshore
Conductivity	uS/cm	226 ± 44	156 ± 16	144 ± 12	142 ± 11	157 ± 23	143 ± 12	142 ± 12
pH	--	7.7 ± 0.3	7.9 ± 0.3	8.1 ± 0.3	8.1 ± 0.2	7.6 ± 0.4	7.9 ± 0.3	7.9 ± 0.2
Turbidity	NTU	25.1 ± 8.3	15.5 ± 5.3	11.9 ± 3.9	12.1 ± 4.2	19.5 ± 15.8	11.1 ± 4.1	12.5 ± 5.7
Dissolved oxygen	mg/l	5.7 ± 0.8	6.3 ± 0.7	7.3 ± 0.7	7.5 ± 0.7	5.7 ± 1.3	6.8 ± 0.8	7.2 ± 0.5
Total alkalinity	mg/l CaCO3	91 ± 17	70 ± 4	68 ± 4	67 ± 4	69 ± 3	66 ± 3	66 ± 3
Total hardness	mg/l CaCO3	28.1 ± 3.8	23.8 ± 4.7	22.4 ± 4.9	22.3 ± 5.2	26.2 ± 6.4	21.2 ± 5.9	21.1 ± 6.9
Chloride	mg/l	14.0 ± 6.4	7.4 ± 0.7	5.9 ± 0.6	5.6 ± 0.6	7.8 ± 2.1	5.9 ± 0.5	5.8 ± 0.4
Chlorophylla	mg/m3	25.4 ± 11.7	21.6 ± 7.4	15.6 ± 6.9	15.2 ± 6.7	11.1 ± 4.0	13.6 ± 5.8	14.7 ± 4.8
Total algae	no/l	1284 ± 431	1412 ± 645	1381 ± 745	1537 ± 551	1274 ± 531	1135 ± 623	977 ± 94

Source: MOWD Kisumu Water and Sanitation Study 1984-85.

Table N7.27(a) Generalized Effluent Quality Standards

Parameter	Maximum permitted in effluent discharge
BOD5 (20oC)	20 mg/l
Suspended solids	30 mg/l
Cyanide (as HCN)	0.1 mg/l
Sulphide (as S')	0.1 mg/l
Oil and grease	nil
Phenols	0.5 mg/l
Total toxic metals (alone or in combination)	0.5 mg/l
pH	6.5-9.0
Temperature	+/- 3oC of receiving water

Note: (1) an 8 or 10 to 1 dilution of the effluent by the receiving water is assumed
(2) the receiving water BOD is assumed to be <2 mg/l.

Source: Omwenga J.M. 1990. 4th African Water Technology Conference "Water in Africa in the next Decade."

Table N7.27(b) Specific MOWD standards for paper mill and sugar factory effluents.

Parameter	Unit	Pan African Paper Mill	Sugar Factories
BOD5	mg/l	80	40
Vol. SS	mg/l	60	60
Non-vol. SS	mg/l	no limit	no limit
NH4 less than	mg/l	6	15
PV (4 hour)	mg/l	25	25
Heavy metals	mg/l	1.0	1.0
Mercury	mg/l	0.05	--
Free chlorine	mg/l	1.0	--
Organo-chlorines (out-in)	mg/l	0.001	--
pH		5.0-8.5	6.0-8.5
Oil		no trace	--
Temperature rise in river after dilution		<2 °C	<2 °C

Toxicity: *no effect at 1.5 dilution on Barbus sp. and Alestes sp. after 48 hours.*

Source: DANIDA Nzoia River Report 1990.

Table N7.28 Quality Standards for Effluents Discharged into Public Waters in Japan

According to EA 1972a, the quality standards for effluents discharged into public waters in Japan are intended to safeguard public health and preserve the environment.

a) Standards relating to protection of public health

Item	Permissible value (mg/l)
Cadmium and its compounds	< 0.1
Cyanide compounds	< 1
Organic phosphorus compounds (parathion, methyl parathion, methyl dimeton and EPN only)	< 1
Lead and its compounds	< 1
Hexavalent chromium compounds	< 0.5
Arsenic and its compounds	< 0.5
Total mercury	not detectable (*)
Alkyl mercury compounds	not detectable (*)

b) Standard relating to preservation of the environment

Item	Permissible value (mg/l)	
pH	5.8 - 8.6	for effluents discharged into public water bodies other than coastal waters
	5.0 - 9.0	for effluents discharged into coastal waters
Biochemical oxygen demand, chemical oxygen demand	< 160	(daily average < 120)
Suspended solids	< 200	(daily average ~ 150)
N-hexane extract	< 5	(mineral oil)
	< 30	(animal and vegetable fats)
Phenols	< 5	
Copper	< 3	
Zinc	< 5	
Dissolved iron	< 10	
Dissolved manganese	< 10	
Chromium	< 2	
Fluorine	< 15	
Coliform bacteria (MPN/cm3)	3000	(daily average)

The standards relating to preservation of the environment apply to effluents from industrial plants and other establishments,when their flow is at least 50 m3/day. The standards for pH and the dissolved iron content do not apply to effluents from industrial plants and other establishments engaged in sulfur mining or processing, including mining for iron pyrites when coexistent with sulfur. The standards relating to biochemical oxygen demand apply to all public waters other than coastal and lake waters. The standards for chemical oxygen demand apply exclusively to effluents discharged in coastal and lake waters.

(*) "Not detectable" means that the substance is below the level detectable by the method designated by the Director General of the Environment Agency.

Source : English translation quated from "Management and Law for Water Resources", Luis V. Gunha, etc., Water Resource Publications, USA, 1977

Table N7.29 Water Quality Standards Used in Japan (Receiving Water)

According to EA 1972a, the water quality standards used in Japan are intended to protect public health and the environment.

a) Standards relating to protection of public health

Item	Permissible value (mg/l)
Cyanide	not detectable
Alkyl mercury	not detectable
Organic phosphorus (parathion, methyl parathion,methyl dimeton and EPN only)	not detectable
Cadmium	< 0.01
Lead	< 0.1
Hexavalent Chromium	< 0.05
Arsenic	< 0.05
Total mercury	not detectable

b) Standards relating to preservation of the environment

b1) Rivers

Category	Use	Daily average value				
		pH	Biochemical Oxygen (mg/l)	Suspended solid (mg/l)	Dissolved oxygen (mg/l)	Coliform bacteria (MPN/100 ml)
M	Water supply, class I; conservation of natural environment and uses of categories A to E	6.5 - 8.5	< 1	< 25	> 7.5	< 50
A	Water supply, class 2; fishery,class 1; bathing and uses of categories B to E	6.5 - 8.5	< 2	< 25	> 7.5	< 1000
B	Water supply, class 3; fishery,class 2; and uses of categories C to E	6.5 - 8.5	< 3	< 25	> 5	< 5000
C	Fishery,class 3; industrial water class 1, and uses of categories D to E	6.5 - 8.5	< 5	< 50	> 5	-
D	Industrial water, class 2; agricultural water(1), and uses of category E	6.0 - 8.5	< 8	< 100	> 2	-
E	Industrial water, class 3; conservation of environment	6.0 - 8.5	< 10	Floating matter should not be observed	> 2	-

(1) For agricultural water, pH shall be between 6.0 and 7.5 and dissolved oxygen shall not be less than 5 mg/l (The same applies to the standard for lakes).

to be continued

b2) Lakes

(natural, Lakes, reservoirs, marshes and artificial Lakes with more than 10 million m3)

Category	Use	Daily average value				
		pH	Biochemical Oxygen (mg/l)	Suspended solid (mg/l)	Dissolved oxygen (mg/l)	Coliform bacteria (MPN/100 ml)
AA	Water supply, class I; fishery,class I; conservation of natural environment and uses of categories A to C	6.5 - 8.5	< 1	< 1	> 7.5	< 50
A	Water supply,classes 2 and 3; fishery, class 2;bathing and uses of categories B to C	6.5 - 8.5	< 3	< 5	> 7.5	< 1000
B	Fishery,class 3; in dustrial water, class I; agricultural water, and uses of category C	6.5 - 8.5	<.5	< 15 Floating matter	> 5	-
C	Industrial water, class 2; conservation of environment	6.0 - 8.5	< 8	should be not observed	> 2	-

b3) Coastal Waters

Category	Use	Daily average value				
		pH	Biochemical Oxygen (mg/l)	Suspended solid (mg/l)	Dissolved oxygen (mg/l)	Coliform bacteria (MPN/100 ml)
A.	Fishery, class 1; bathing and uses of categories 8 to C	7.8 - 8.3	< 2	> 7.5	< 1000(*)	not detectable
B.	Fishery, class 2; industrial water and uses of category C	7.8 - 8.3	< 3	> 5	-	not detectable
C.	Conservation of environment	7.0 - 8.3	< 8	> 2		

(*) For oyster culture this must be < 70.

Source : English translation quated from "Management and Law for Water Resources", Luis V. Gunha, etc., Water Resource Publications, USA, 1977

Table N7.30 Quality of crude and final effluents from Nakuru town and Njoro sewage works.

Parameter	Unit	Njoro treatment works Crude	Njoro treatment works Final	Town treatment works Crude	Town treatment works Final
pH		7.4	8.7	7.5	7.6
Conductivity	uS/cm	1060	278	990	960
Turbidity	mg/l	230	19	165	51
Suspended solids	mg/l	483	36	580	136
Dissolved oxygen	mg/l	1.2	6.9	0.8	0.8
COD	mg/l	128	196	364	201
Total nitrogen	mg/l	117	24	107	79
Kjeldhal-N	mg/l	76	20	74	59
Nitrate-nitrogen	mg/l	40	4	33	20
Nitrite-nitrogen	mg/l	0.3	0.02	0.3	0.1
Total phosphorus	mg/l	0.34	0.32	36	23

Source: JICA September 1990.

Parameter	Unit	Njoro treatment works Final	Njoro treatment works MOWD	Town treatment works Final	Town treatment works MOWD
Suspended solids	mg/l	36	(30)	136	(30)
COD	mg/l	196	(50)	201	(80)

MOWD (30) = Ministry of Water Development standard; level not to be exceeded.
Source: JICA September 1990.

Table N7.31 Effluent Quality from Kenya Creameries, Dandora, Nairobi

Parameter	Unit	Kenya Creameries Range	Kenya Creameries Mean
pH	---	4.5 - 11.1	6.6
Nitrite-N	mg/l	0.0 - 12.0	5.1
Nitrate-N	mg/l	0.0 - 12.5	7.3
Ammonia(albumoid)	mg/l	5.6 - 76.0	26.3
Chloride	mg/l	6.5 - 230	36.1
Suspended solids	mg/l	98 - 2104	424
Dissolved solids	mg/l	284 - 2332	962
BOD5	mg/l	150 - 3200	884
COD	mg/l	594 - 1849	---

Source: Kilani J.S. J.Gecaga, & J.M. Nzainga
Characteristics of Selected Industrial Wastes in Kenya.

Table N7.32 Effuluent Quality from Three Textile Factories in Eldoret

Parameter	Unit	Raymond Woollen Mills Range	Raymond Woollen Mills Mean	Rivatex Range	Rivatex Mean	Ken-Knit Range	Ken-Knit Mean
Temperature	oC	21 - 36	28	20 - 36	26	21 - 32	28
pH	---	4.8 - 8.7	6.7	11.6 - 12.5	12.1	4.5 - 9.1	6.8
Phosphate-P	mg/l	– - –	6.4	--- - –	17.6	9.1 - 35.6	22.4
Nitrate-N	mg/l	2.3 - 46.8	17.7	40.0 - 67.5	53.0	3.6 - 11.9	7.8
Ammonia-N	mg/l	2 - 386	155	--- - –	--	1.4 - 213	105
Chloride	mg/l	50 - 280	124	100 - 225	167	15 - 225	98
Settleable solids	mg/l	0.3 - 6.7	17.7	--- - –	0.33	0.3 - 4.3	2.08
BOD5	mg/l	25 - 1200	404	100 - 1220	840	--- - –	580
COD	mg/l	450 - 2660	1876	2875 - 4405	3816	380 - 2555	1706
Waste flow	m3/d		540		805		76

Source: Kilani J.S. J.Gecaga, & J.M. Nzainga
Characteristics of Selected Industrial Wastes in Kenya.

Table N7.33 Effluent Quality from Tusker Brewery, Ruaraka

Parameter	Unit	Final Effluent Range	Final Effluent Mean
pH	---	4.7 - 9.8	6.3
Total alkalinity	mg/l	37 - 245	117
Nitrite-N	mg/l	0.0 - 0.0	0.0
Nitrate-N	mg/l	0.0 - 0.0	0.0
Ammonia-N	mg/l	19.2 - 160	64.5
Chloride	mg/l	4 - 52	24
Suspended solids	mg/l	96 - 4824	1928
Dissolved solids	mg/l	892 - 5480	2360
BOD5	mg/l	800 - 6600	3555
COD	mg/l	1204 - 12950	6453

Source: Kilani J.S. J.Gecaga, & J.M. Nzainga
Characteristics of Selected Industrial Wastes in Kenya.

Table N8.1 East - west Transect of the Winam Gulf
(Surface samples)

		MAIN LAKE		RUSINGA CHANNEL			WINAM GULF			KISUMU BAY						
Station number		56	55	57	59	63	68	69	71	72	76	80	82	78	77	83
Kilometres from Kisumu		98	76	73	70	66	58	44	28	17	6	4	2	1	0.3	0.1
Sodium	mg/l	9.3	6.7	10.0	8.9	9.8	13.4	16.0	19.2	13.0	21.0	14.3	22.0	19.0	18.0	15.2
Potassium	mg/l	3.8	2.5	3.4	3.1	3.0	3.4	3.6	5.0	3.8	5.6	4.4	6.4	5.0	3.8	3.7
Fluoride	mg/l	0.08	0.25	0.36	0.27	0.14	0.41	0.49	0.16	0.13	0.33	0.28	0.25	0.55	0.42	0.39
Nitrate-N	ug/l	0	0	15	0	23	0	0	8	0	0	8	11	0	68	0
Nitrite-N	ug/l	0	6	0	2	5	0	0	4	0	2	0	8	0	0	—
Ammonia-N	ug/l	2	2	2	0	4	4	0	4	0	0	4	0	8	0	—
TKN	ug/l	1054	579	757	897	803	939	914	855	1019	1225	1089	834	1134	810	—
TP	ug/l	44	69	54	107	70	60	70	49	52	59	43	77	88	67	—
CHL a	mg/l	10.0	19.3	8.9	16.2	14.4	12.5	19.2	12.7	12.0	19.6	19.2	15.6	31.6	23.3	—
Secchi depth	m	2.0	1.8	1.3	1.2	1.4	—	—	0.8	0.8	0.8	0.6	0.6	0.4	0.4	0.3
Total algae	no/l	2537	2541	2686	2243	1368	2043	2246	1861	1869	1619	1687	2987	1767	1613	1659
Total zooplankton	no/l	160	161	113	234	180	277	321	217	194	279	397	380	789	774	910

TKN = total Kjeldhal nitrogen
TP = total phosphorus
CHL a = chlorophyll a

Note: the data presented in this table are for surface samples only; they have not been used to plot Figures @-@ where depth integrated mean data have been used, and additional main lake sampling stations included.

Source: Winam Gulf Baseline Study 1985.

Table N8.2 Range of Mean Values of Nutrient and Phytoplankton Parameters June - July 1984.

Location	Sample zone description		NO3-N ug/l	NO2-N ug/l	NH3-N ug/l	TKN ug/l	TN ug/l	SRP ug/l	TP ug/l	CHL_a ug/l	Algae nos/ml
Kisumu Bay	I.	Polluted, inshore river influenced	103	2-8	9-38	328-526	631	8-10	20-32	17.1-19.1	638-1500
Winam Gulf	II.	Unpolluted, inshore, river influenced	38-327	1-8	2-55	330-471	450-629	6-19	24-60	11.4-24.1	841-1304
Winam Gulf	III.	Unpolluted, inshore no river influence	53-129	1-10	19-47	305-438	429-563	7-10	18-29	11.9-16.8	867-1376
Winam Gulf	IV.	Unpolluted, offshore deep water	21-110	1-5	20-102	382-483	404-526	6-23	21-36	6.1-14.6	588-986
Lake Victoria	V.	Unpolluted, offshore Main Lake	100-109	1	35-42	358-365	459-496	50-75	52-79	4.7-7.0	800-922

TKN = total Kjeldhal nitrogen
TN = total nitrogen
SRP = soluble reactive phosphorus
TP = total phosphorus
CHL_a = chlorophyll_a.

Source: Winam Gulf Baseline Study 1984.

Table N8.3 Lake Naivasha: general characteristics.

	Description	Values	Unit
(a)	Water level fluctuation: 1961-1984		
	- Maximum	1,886.9	El. m.
	- Minimim	1,883.2	El. m.
	- Average	1,885.2	El. m.
	- As of July 1990	1,884.6	El. m.
(b)	Maximum water depth at average level		
	- Crescent Island Bay	13	m.
	- Main lake	8	m.
(c)	Lake surface area at average level	170	km2.
(d)	Water volume at average level	760	10^6 m3.
(e)	Average river discharge		
	- Malewa river	7.6	m3/sec.
	- Gilgil river	0.3	m3/sec.
(f)	Average annual rainfall on the lake	670	mm/yr.
(g)	Average evaporation	1,900	mm/yr.

Source: JICA September 1990.

Table N8.4 Lake Nakuru: general characteristics.

	Description	Values	Unit
(a)	Water level fluctuation: 1959-1982		
	- Maximum	1,760.6	El. m.
	- Minimim	1,756.3	El. m.
	- Average	1,758.6	El. m.
	- As of July 1990	1,758.5	El. m.
(b)	Maximum water depth at average level	2.3	m.
(c)	Lake surface area at average level	43	km2.
(d)	Water volume at average level	72	10^6 m3.
(e)	Average river discharge		
	- Njoro river	0.8	m3/sec.
	- Other rivers	0.4	m3/sec.
(f)	Average annual rainfall on the lake	900	mm/yr.
(g)	Average evaporation	1,970	mm/yr.

Source: JICA September 1990.

Table N8.5 River Malewa : water quality data, 1990.

Parameter	Unit	Mean value	Range of values
Colour		No:16 to 18,brown muddy colour	
Temperature	oC	16.8	14.3 - 18.5
pH	--	8.04	7.78 - 8.24
Conductivity	uS/cm	157	110 - 240
Turbidity	mg/l	34	14 - 70
Dissolved oxygen	mg/l	7.2	6.8 - 8.4
COD	mg/l	9	4 - 15
Nitrate-nitrogen	mg/l	0.89	0.10 - 1.20
Nitrite-nitrogen	mg/l	0.021	0.001 - 0.040
Kjeldahl nitrogen	mg/l	2.20	1.05 - 2.70
Total-nitrogen	mg/l	3.088	2.260 - 3.577
Phosphorus	mg/l	0.10	0.04 - 0.13

Source: JICA September 1990.

Table N8.6 Lake Naivasha: surface water quality data, 1990.

Parameter	Unit	Mean value	Range of values
Colour		No:15 to 17, brown colour	
Secchi depth	m		0.7 - 1.0
Temperature	oC	20.7	20.1 - 21.2
pH	--	8.68	8.31 - 9.03
Conductivity	uS/cm	275	250 - 300
Suspended solids	mg/l	13	10 - 15
Dissolved oxygen	mg/l	8.3	7.4 - 11.1
COD	mg/l	39	29 - 61
Nitrate-nitrogen	mg/l	0.89	0.50 - 0.90
Nitrite-nitrogen	mg/l	0.011	0.009 - 0.015
Phosphorus	mg/l	0.05	0.02 - 0.10

Source: JICA September 1990.

Table N8.7 Lake Naivasha commercial fishery yields 1980-1989.

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	MEAN
Yield ('000 kg)	1250	484	117	62	39	44	78	71	225	483	285
Value (K£ '000)											

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	MEAN
Yield ('000 kg)	477	269	411	692	320	245	576	316	52	263	362
Value (K£ '000)	---	---	---	468.9	216.2	173.1	225.9	164.0	49.7	213.5	215.9

Source: Fisheries Department.

Table N8.8 Lake Nakuru: surface water quality data, 1990.

Parameter	Unit	Mean value	Range of values
Colour		No:18 to 21,dark brown colour	
Secchi depth	m	0.3	0.2 - 0.5
Temperature	oC	25.7	24.2 - 26.8
pH	--	10.42	10.34 - 10.62
Conductivity	uS/cm	17,564	16,960 - 17,760
Suspended solids	mg/l	24	13 - 69
Dissolved oxygen	mg/l	9.7	6.3 - 13.2
COD	mg/l	191	179 - 197
Nitrate-nitrogen	mg/l	18.5	15.5 - 25.0
Nitrite-nitrogen	mg/l	0.026	0.019 - 0.044
Phosphorus	mg/l	1.55	1.28 - 1.82

Source: JICA September 1990.

Table N8.9 Quality of crude and final effluents from Nakuru town and Njoro sewage works.

Parameter	Unit	Njoro treatment works Crude	Njoro treatment works Final	Town treatment works Crude	Town treatment works Final
pH		7.4	8.7	7.5	7.6
Conductivity	uS/cm	1060	1,250	990	960
Turbidity	mg/l	230	19	165	51
Suspended solids	mg/l	483	36	580	136
Dissolved oxygen	mg/l	1.2	6.9	0.8	0.8
COD	mg/l	128	196	364	201
Total nitrogen	mg/l	117	24	107	79
Kjeldhal-N.	mg/l	76	20	74	59
Nitrate-nitrogen	mg/l	40	4	33	20
Nitrite-nitrogen	mg/l	0.3	0.02	0.3	0.1
Total phosphorus	mg/l	0.34	0.32	36	23

Source: JICA September 1990.
Note: Njoro treatment works: Lagoon type Town treatment works: Sprinklar type

Table N8.10 Comparison of final effluents and MOWD standards.

Parameter	Unit	Njoro treatment works Final	Njoro treatment works MOWD	Town treatment works Final	Town treatment works MOWD
Suspended solids	mg/l	36	(30)	136	(30)
COD	mg/l	196	(50)	201	(80)

MOWD (30) = Ministry of Water Development standard; level not to be exceeded.

Source: JICA September 1990.

Table N8.11 Lake Naivasha: simulation of water level changes under different rates of diversion.

Item	Without project	With project		
Water supply (m3/d)	0	56,000	121,000	166,000
Percent of AD2015 level	0	34	73	100
Lake level (El.m)				
Maximum	1,886.9	1,886.4	1,886.0	1,885.5
Mean	1,885.2	1,884.8	1,883.9	1,883.1
Minimum	1,883.2	1,883.0	1,882.0	1,880.0
Fall in lake level (m)				
Highest	0.0	0.5	0.9	1.4
Average	0.0	0.4	1.3	2.1
Lowest	0.0	0.0	1.0	3.0
Lake area (km2)				
Highest	297	257	226	198
Average	185	170	150	139
Lowest	138	138	129	101

Source: JICA September 1990.

Table N8.12 Lake Nakuru: simulation of water level changes under different rates of effluent input.

Item	Without project	With project		
Sewage inflow (m3/d)	8,840	17,400	52,000	95,000
Percent of AD2015 level	9	18	55	100
Lake level (El.m)				
Maximum	1,760.6	1,761.2	1,765.1	1,771.7
Mean	1,758.6	1,759.3	1,763.3	1,770.1
Minimum	1,756.6	1,757.5	1,762.0	1,768.9
Rise in lake level (m)				
Highest	0.0	0.9	5.4	12.3
Average	0.0	0.7	4.7	11.5
Lowest	0.0	0.6	4.5	11.1
Lake area (km2)				
Highest	52.0	53.9	65.4	90.0
Average	43.7	46.7	59.9	81.2
Lowest	26.0	36.9	56.1	76.9

Source: JICA September 1990.

Table N9.1 Rainfall Expectancy in ASAL Areas by Agro-ecological Zone.

Zone	Average rainfall (mm/year)	50% Probability (mm)		%r/EO
		1st season	2nd season	
VII, very arid	200-300			15
VI, arid	300-500	100-200	50-150	15-25
V, semi-arid	550-700	150-300	150-200	25-40
IV, semi-humid	700-850	250-350	250-300	40-50

Source: IGADD (1990)

Table N9.2 ASAL Land Areas and Populations in Kenya by District.

ASAL DISTRICTS		%Total ASAL area	Area (km2)	Population size	Population density (no/km2)
CATEGORY A:	6 Districts: 100% ASAL				
Isiolo	Eastern Province	}	25,605	43,478	1.7
Marsabit	Eastern Province	}	73,952	96,216	1.3
Garissa	North-Eastern Province	} 62%	43,931	128,867	2.9
Mandera	North-Eastern Province	}	26,470	105,601	4.0
Wajir	North-Eastern Province	}	56,501	139,319	2.5
Turkana	Rift Valley Province	}	61,769	142,702	2.3
	Category total:		288,228	656,183	2.4
CATEGORY B:	5 Districts: 85% ASAL				
Kitui	Eastern Province	}	29,338	464,283	15.8
Tana River	Coast Province	}	38,694	92,401	2.4
Taita Taveta	Coast Province	} 25%	16,959	147,597	8.7
Kajiado	Rift Valley Province	}	20,963	149,005	7.1
Samburu	Rift Valley Province	}	20,809	76,908	3.7
	Category total:		126,763	930,194	7.5
CATEGORY C:	8 Districts: 50-85% ASAL				
Embu	Eastern Province	}	2,714	263,173	97.0
Machakos	Eastern Province	}	14,178	1,022,522	72.1
Meru	Eastern Province	}	9,922	830,179	83.7
Kilifi	Coast Province	} 10%	12,414	430,986	34.7
Kwale	Coast Province	}	8,257	288,363	34.9
Baringo	Rift Valley Province	}	10,627	203,792	19.2
Laikipia	Rift Valley Province	}	9,718	134,534	13.8
West Pokot	Rift Valley Province	}	5,076	158,652	31.3
	Category total:		72,906	3,332,201	48.3
CATEGORY D:	3 Districts: 30-50% ASAL				
Lamu	Coast Province	}	6,506	42,299	6.5
Elg/Marakwet	Rift Valley Province	} 3%	2,722	148,868	54.7
Narok	Rift Valley Province	}	18,519	210,306	11.4
	Category total:		27,747	401,473	24.2
	Grand total:		515,644	5,320,051	20.6

Source: IGADD 1990 Volume II; Country Reports; Statistical Abstract 1989. (Adapted)

Table N9.3 Climatic data for selected ASAL stations.

Station	Rain fall (mm)	Evapotran-spiration (mm)	Mean temp (oC)	Dry days (no.)	Wet days (no.)	Altitude (m)
Lokitaung	395	2,111	27	333	32	730
Lodwar	220	2,213	29	365	0	515
Mandera	228	1,950	29	340	25	331
Marsabit	817	1,292	24	197	168	1,345
Narok	718	1,351	17	161	204	1,890
Magadi	398	1,858	29	330	35	622
Kitui	1,031	1,571	21	216	149	1,090
Machakos	908	1,360	19	200	165	1,680
Maralal	620	1,170	16 (23)	180 (257)	185 (108)	1,950 (2,000)
Wajir	254	1,784	28	355	10	244
Isiolo	613	1,904	23	262	103	1,104
Garissa	282	1,829	29	348	17	147
Lamu	895	1,646	26	258	107	30
Voi	538	1,575	25	257	108	579

Source: Ref. C-14.
( ) Figures expressed by MOWD Mararal

Table N9.4 Average land holding for cultivation in selected ASAL Districts (ha per person)

District	1969	1979	1989	% reduction (1969 - 89)
Narok	7.32	4.30	2.66	36.3
Lamu	3.36	1.76	0.98	29.2
Laikipia	2.09	1.03	0.55	26.3
Nakuru	1.03	0.58	0.34	33.0
Kitui	0.89	0.66	0.50	56.2
Kwale	0.79	0.57	0.42	53.2
Embu	0.58	0.39	0.28	48.3
Kilifi	0.53	0.38	0.28	52.8
Taita	0.45	0.34	0.26	57.8
Machakos	0.40	0.28	0.20	50.0
Mean	1.74	1.03	0.65	37.1
Stan.dev.	2.06	1.17	0.70	--

Source: Livingstone (1989)
Min.Rec Dev ASAL & W ASAL Policy Devel.

FIGURES

Fig.

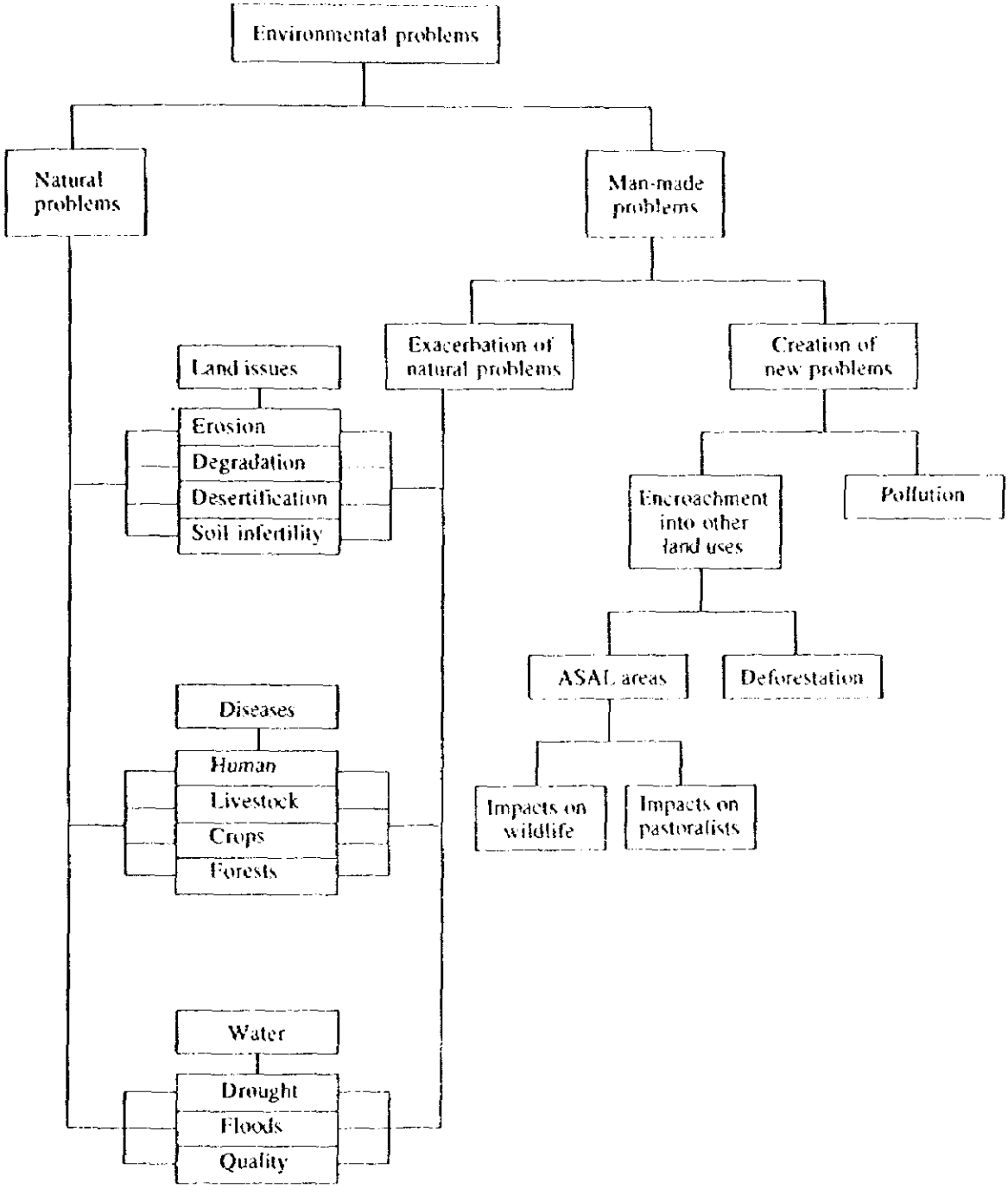

Figure N1.1 Environmental Problems in Kenya

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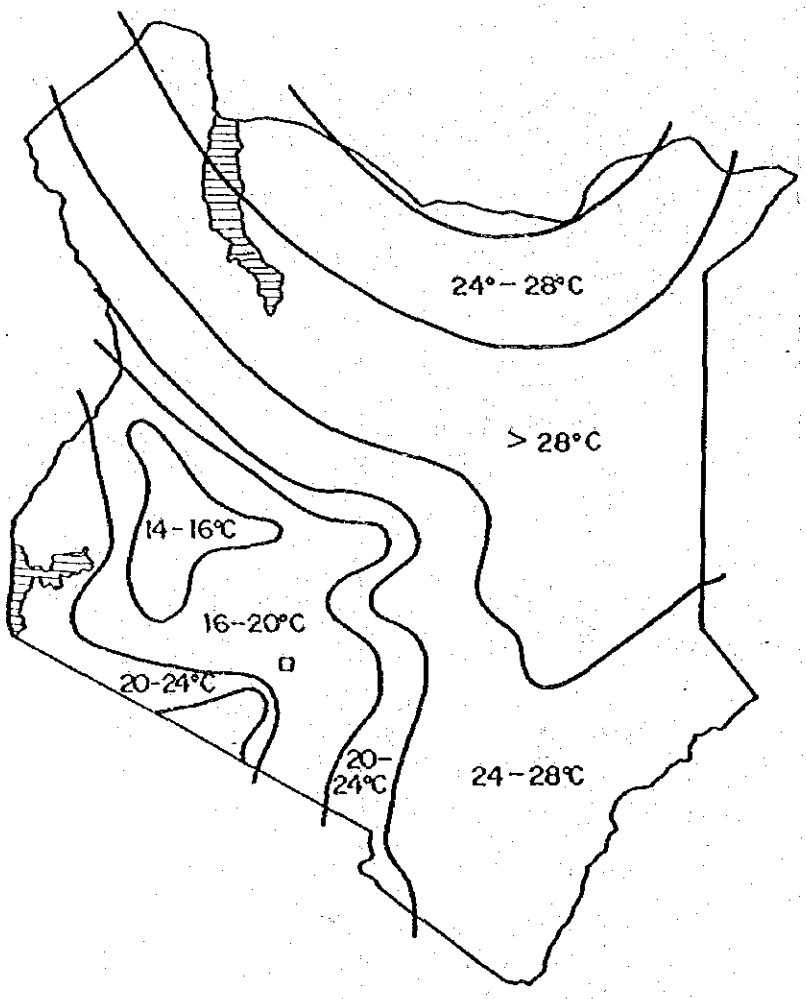
Fig.



MEAN ANNUAL TEMPERATURE °C

Figure N1.2 Mean Annual Temperature

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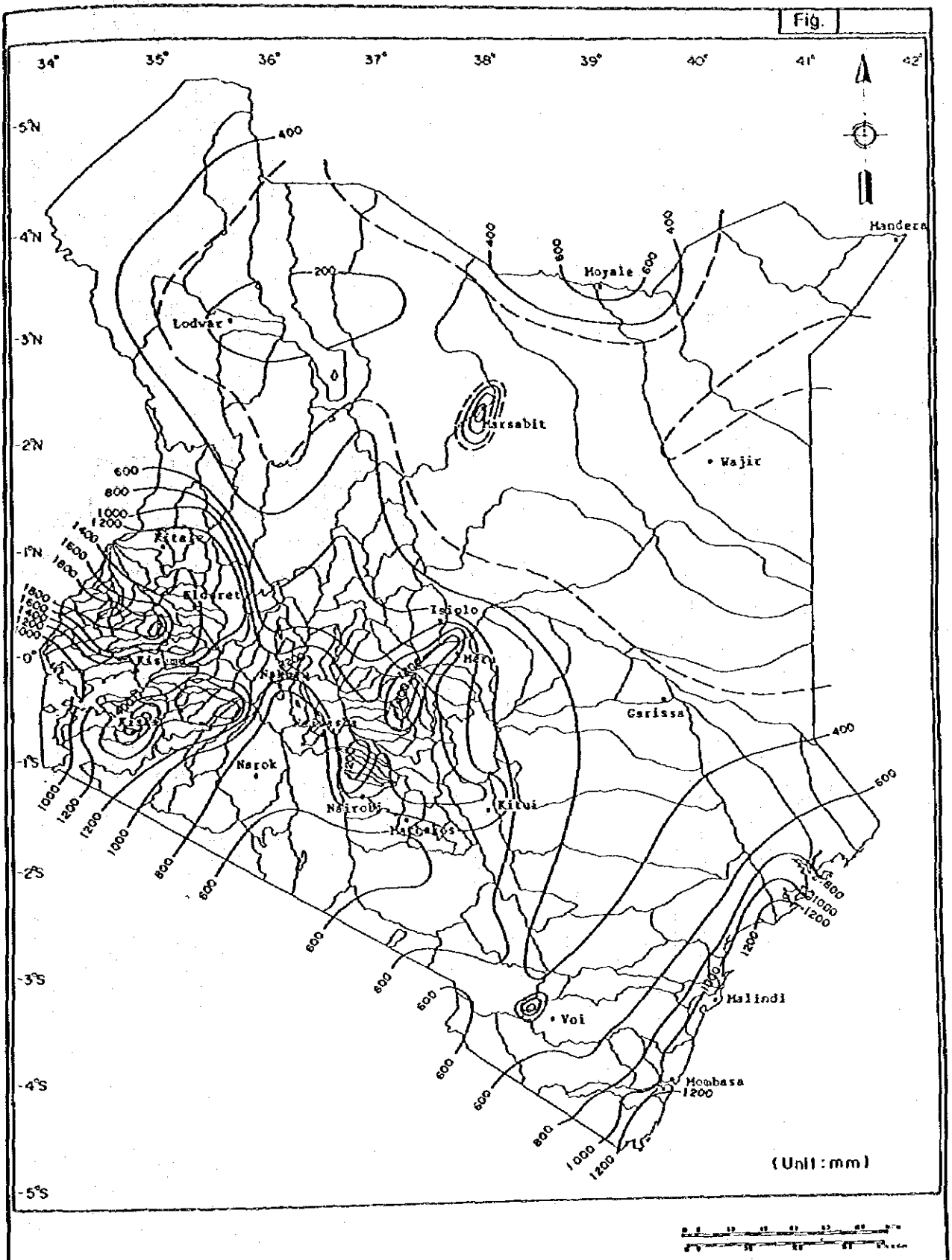

Figure N1.3 Isohyetal Map of Annual Rainfall Depth

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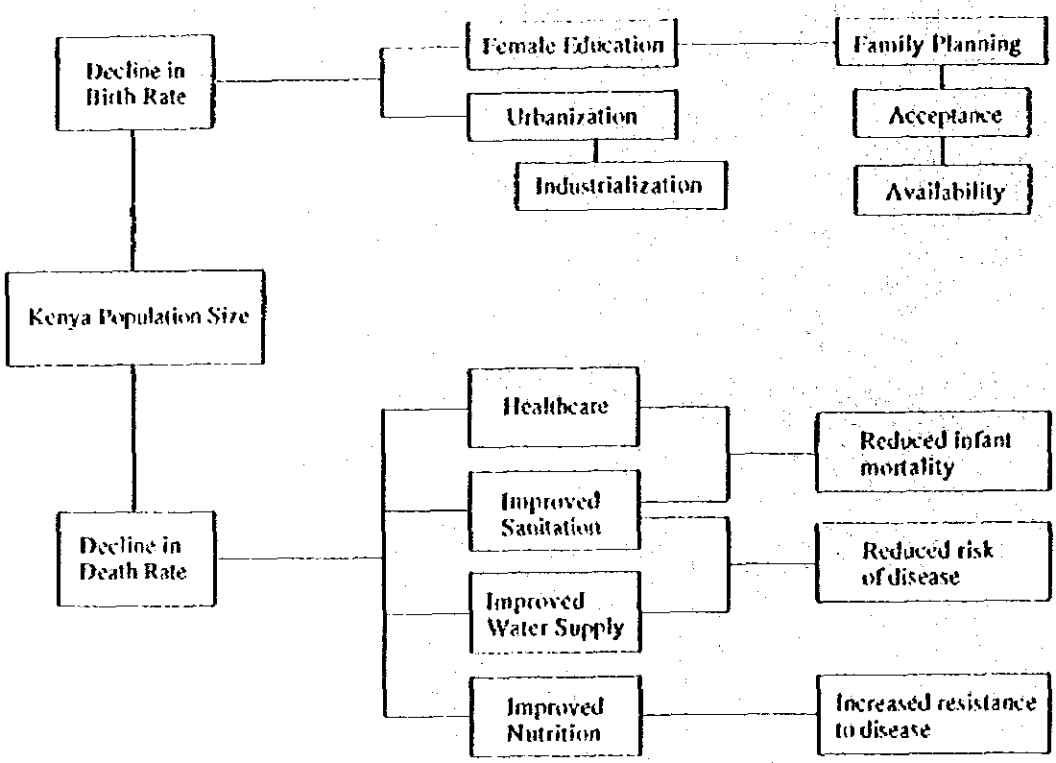

Figure N2.1 Factors Affecting Birth and Death Rates

Fig.

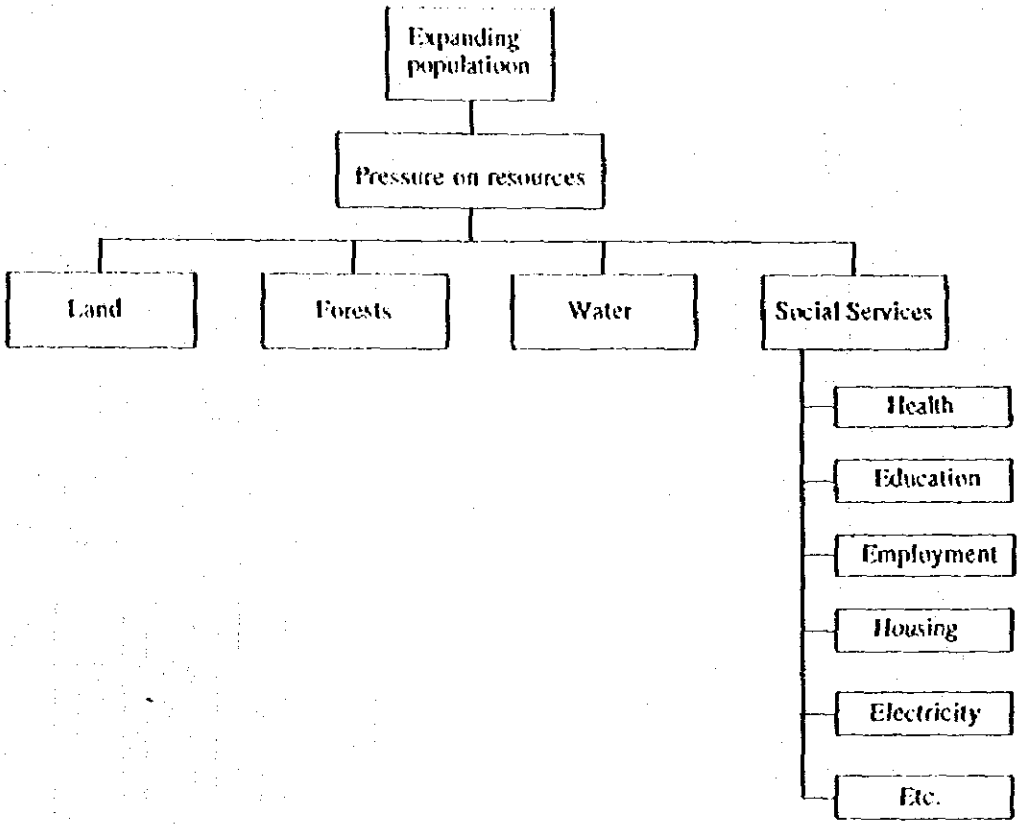

Figure N2.2 The Consequences of Population Growth

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Fig.

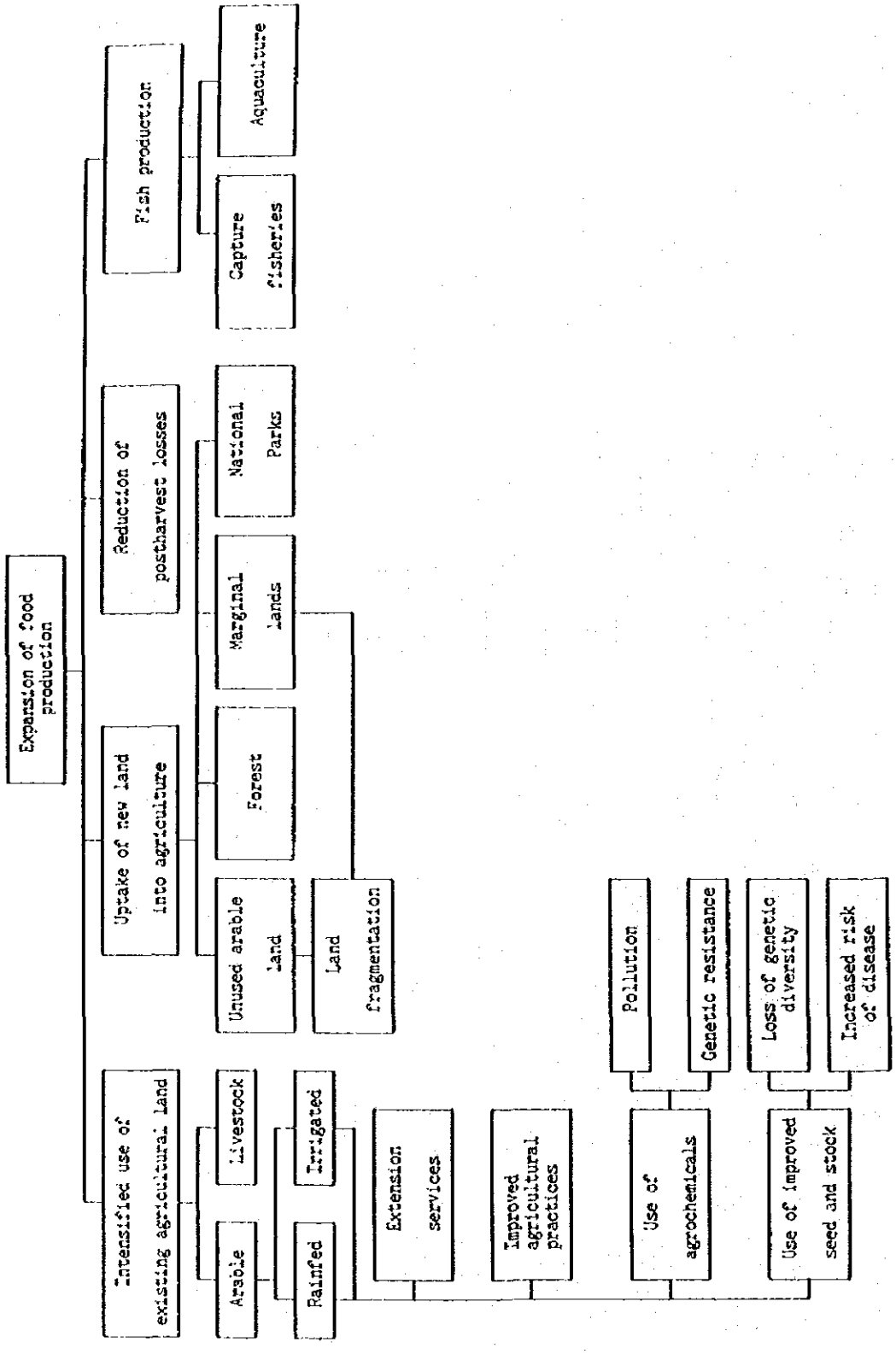

Figure N2.3 Environmental Implications of Expanding Food Production

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Fig.

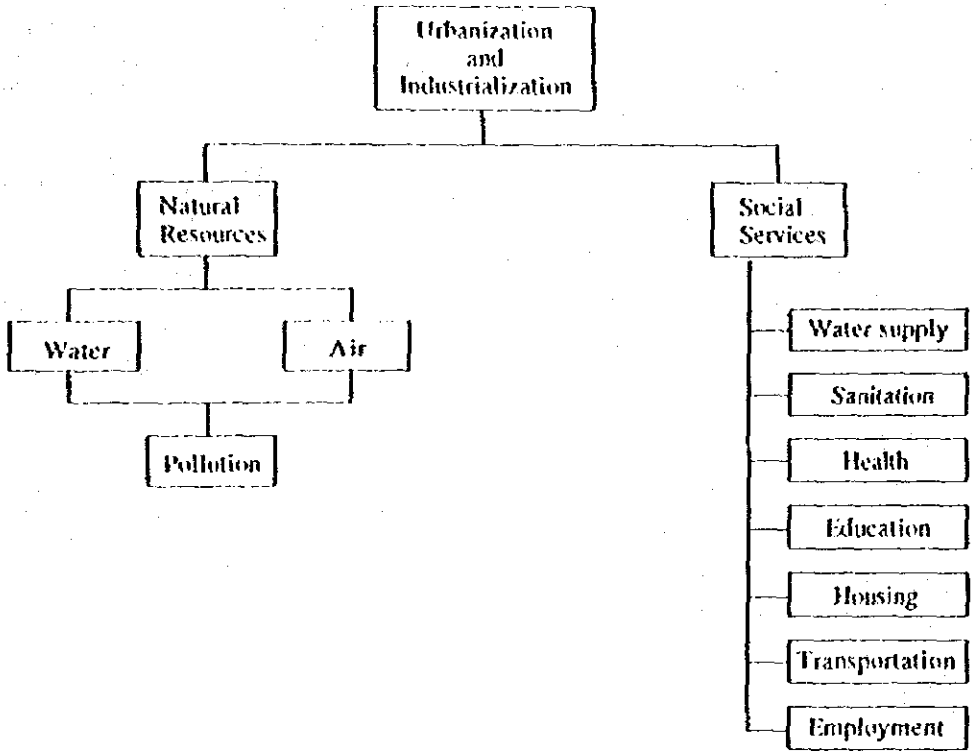

Figure N2.4 The Environmental Impacts of Urbanization and Industrialization

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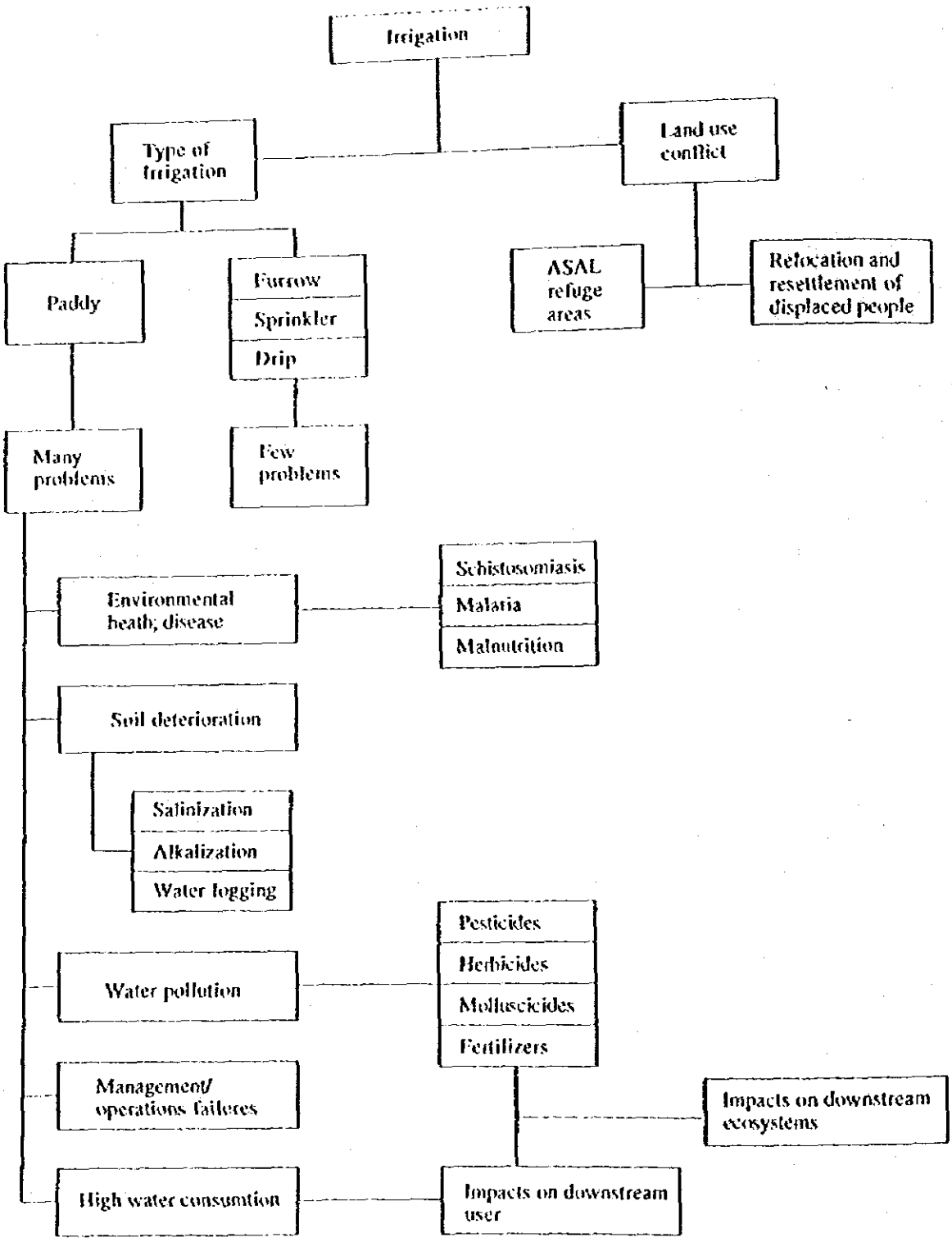
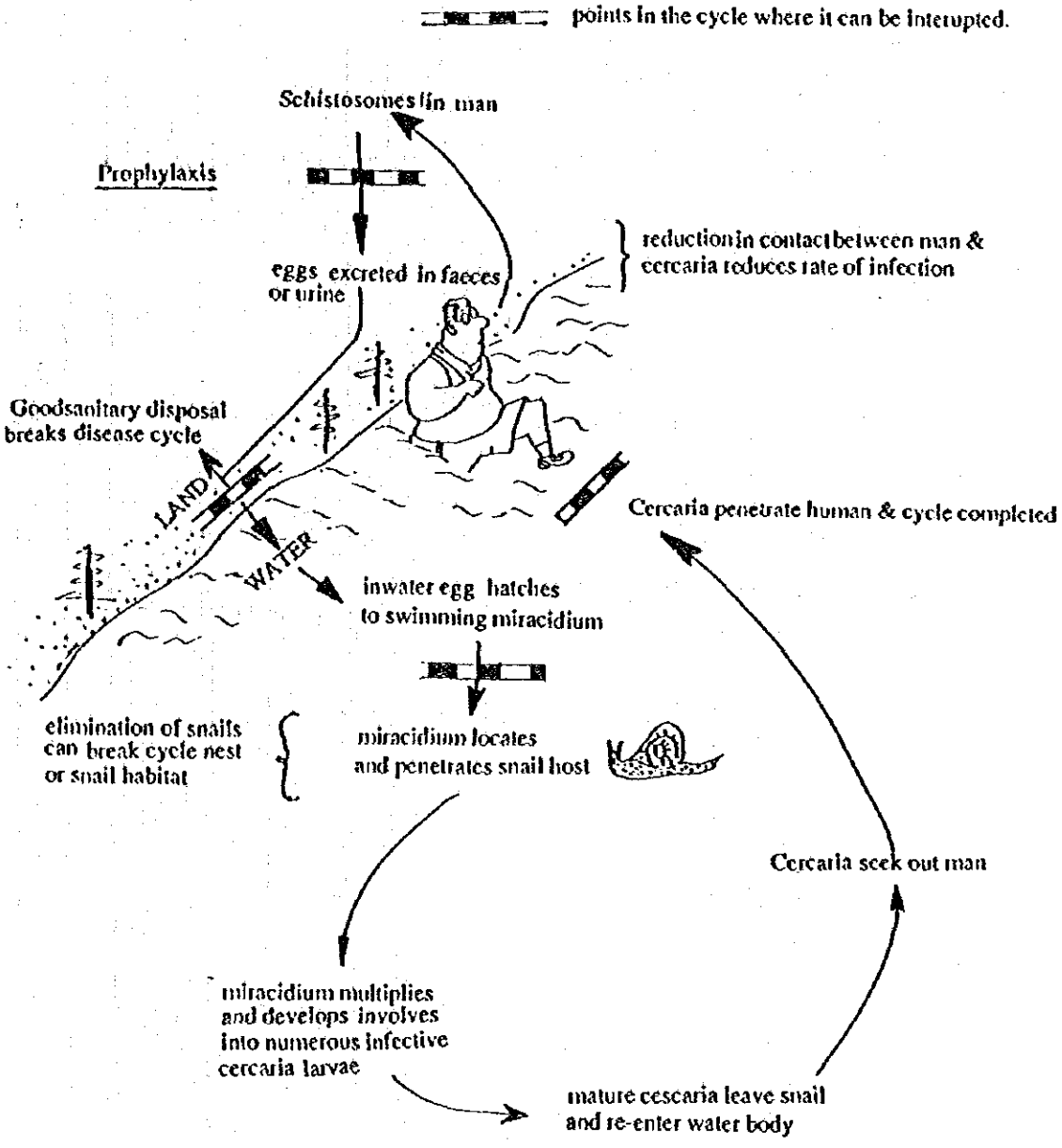


Figure N3.1 Environmental Impacts of Irrigation

Fig.



Source : Sondu-Miriu Environmental Assessment Report, July 1991

a) Chemotherapy
b) Contact reduction
c) Sanitation
d) Snail Control

Figure N3.2 Basic Life-cycle and Control Points of Schistosome Parasite

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Fig.

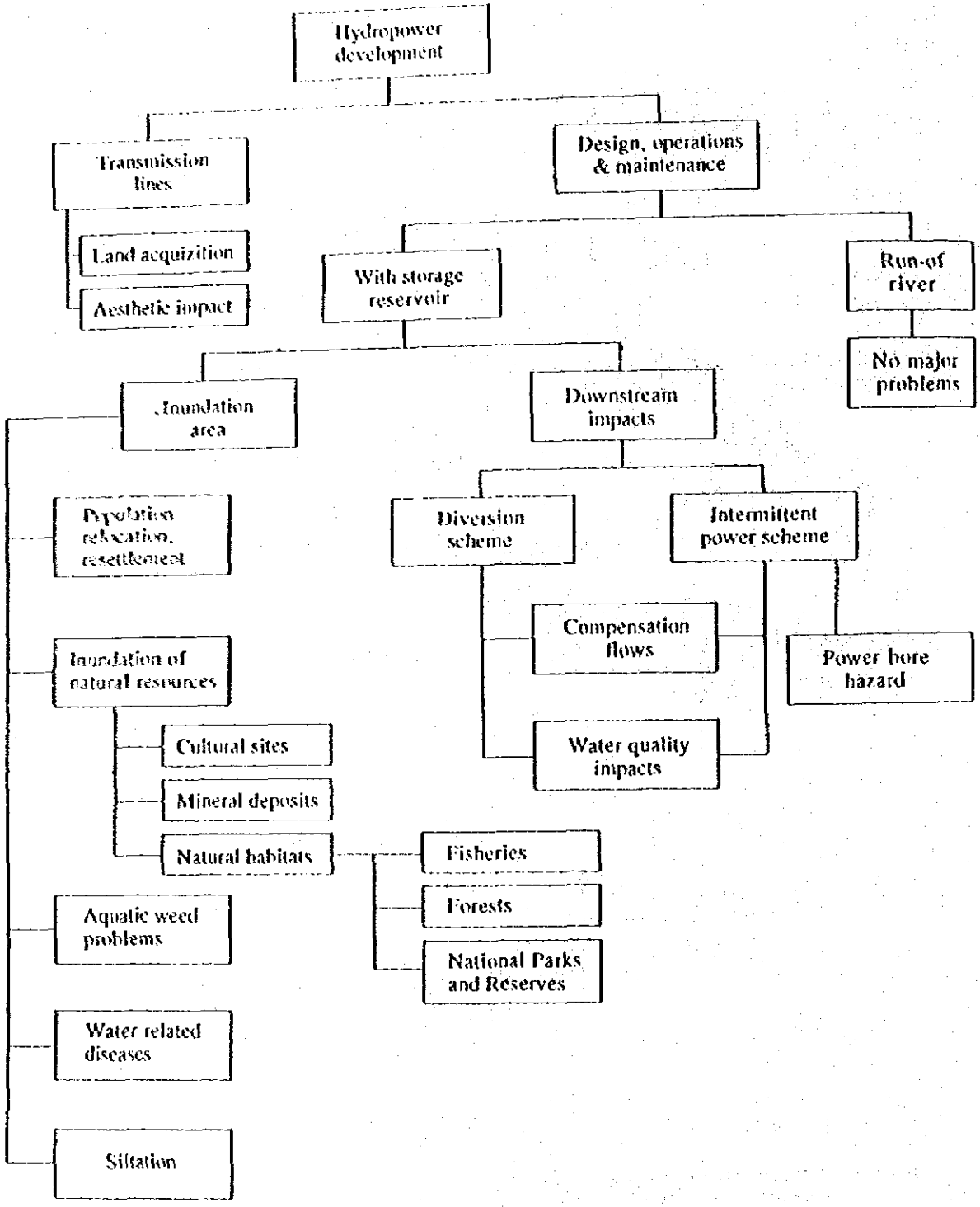

Figure N4.1 Adverse Environmental Impacts of Hydropower Development

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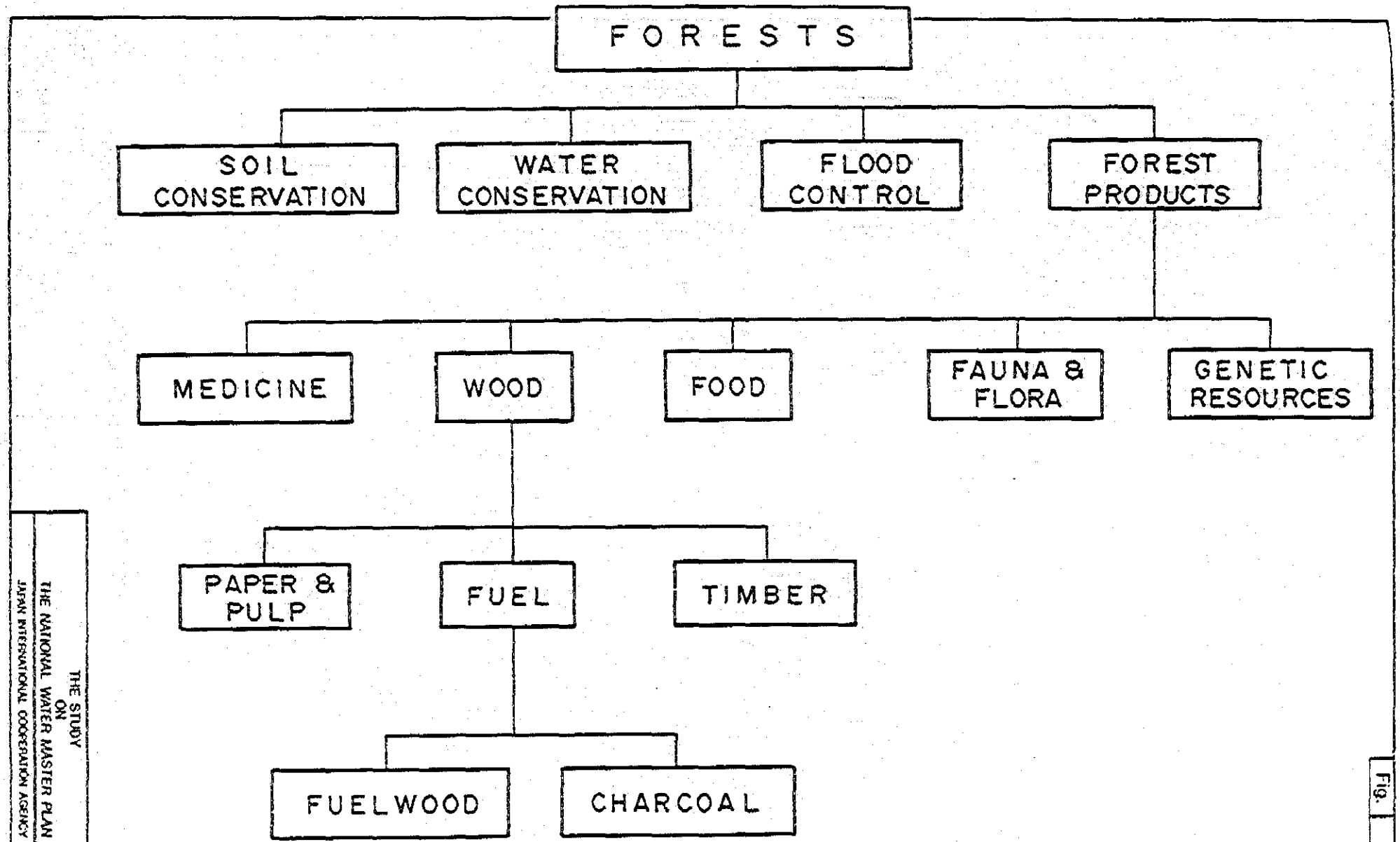

Figure N5.1 The Social, Ecological and Economic Benefits of Forests

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Fig.

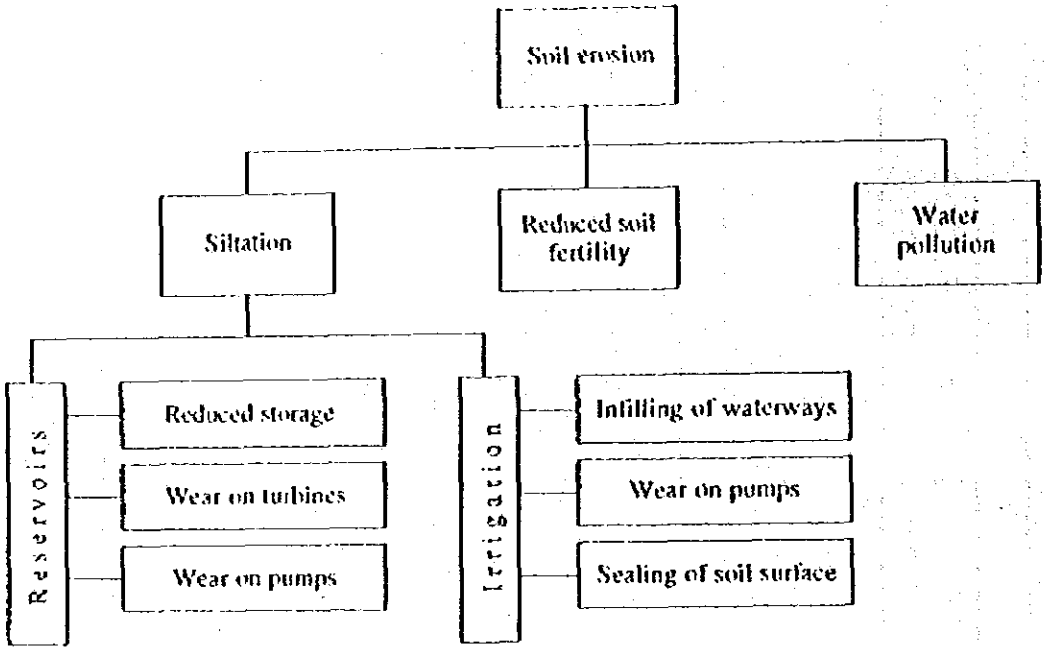

Figure N6.1 The Environmental Impacts of Soil Erosion

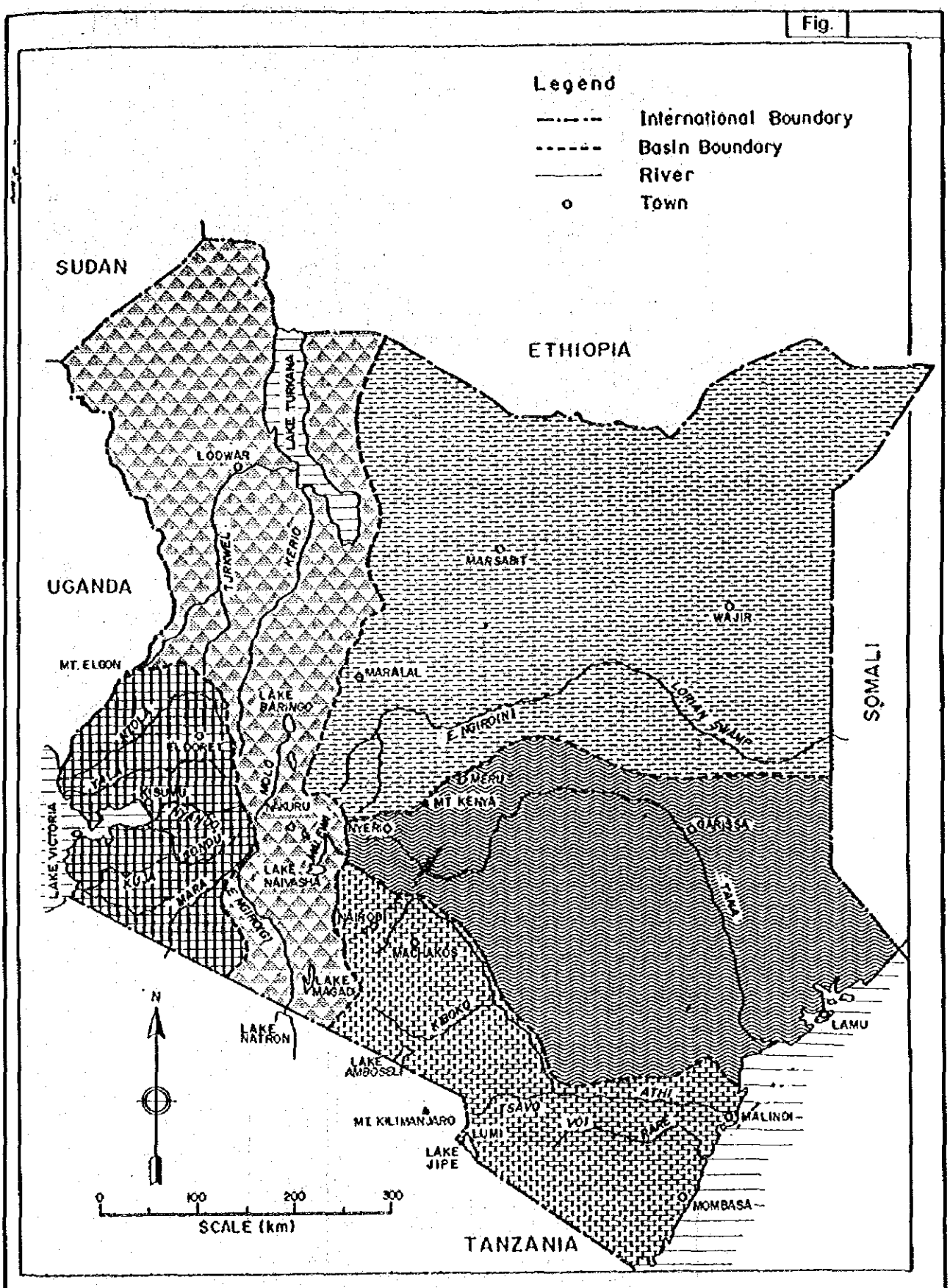

Figure N7.1 The Major River Basins of Kenya and Principal Rivers

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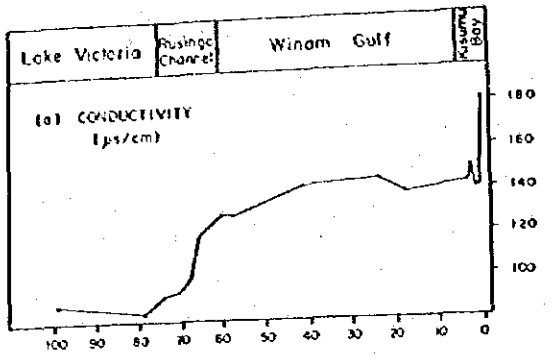

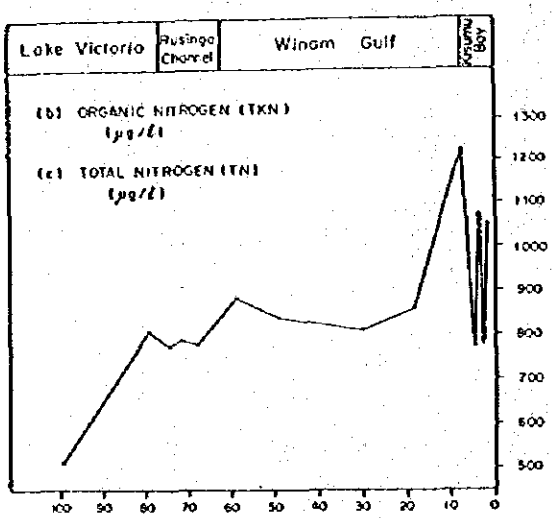

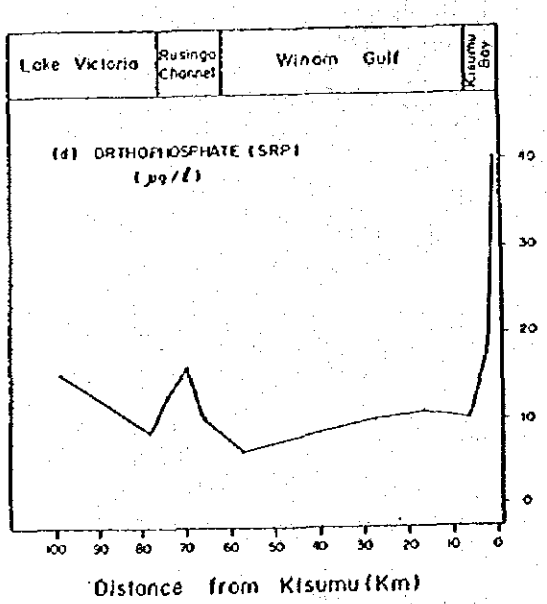

Fig.N8.1 (1) Water Quality Data of E-W Transect, Winum Gulf (1/3)

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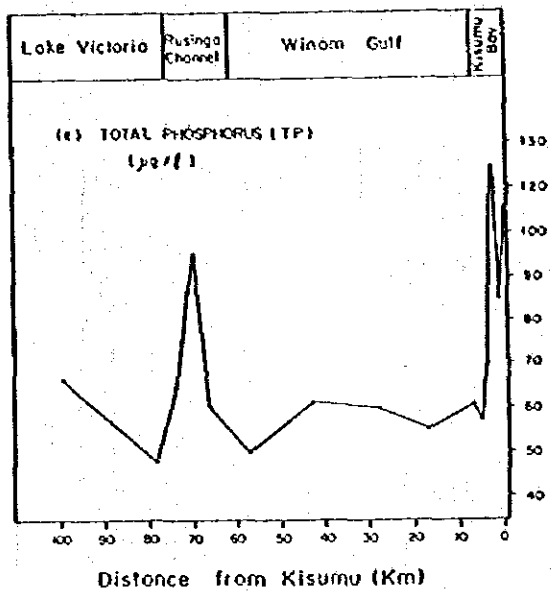
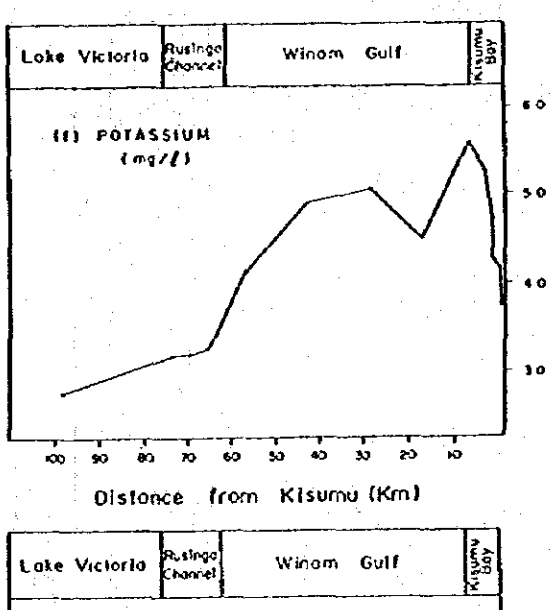
Fig.





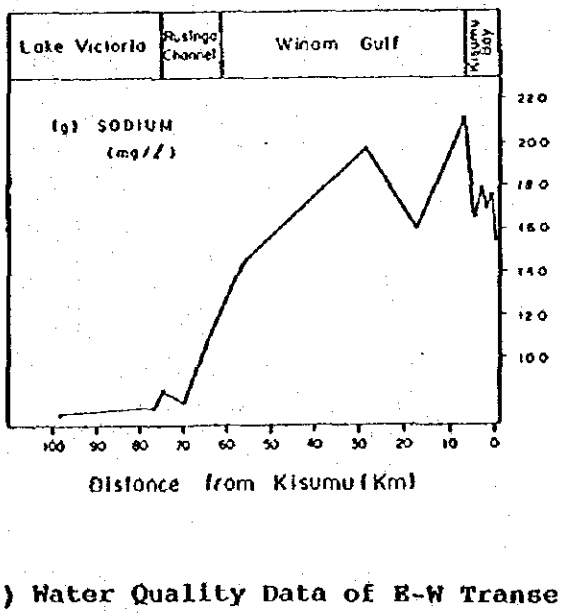


Fig.N8.1 (2) Water Quality Data of E-W Transect, Winum Gulf (2/3)

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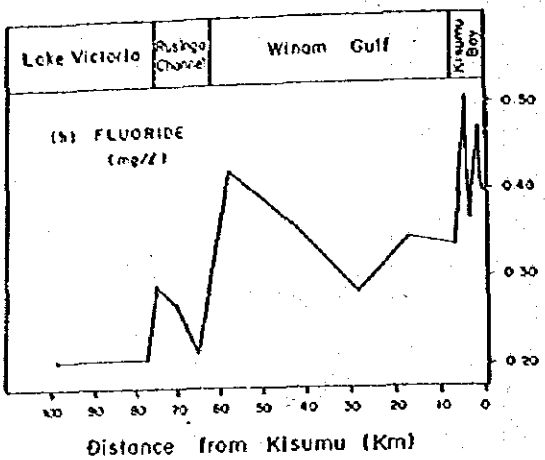

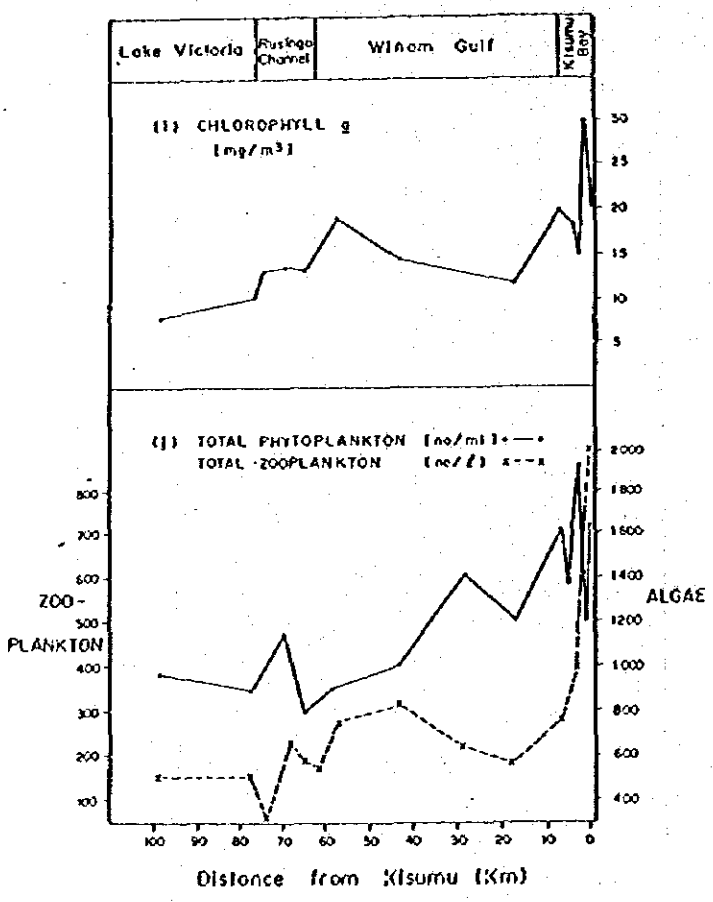

Fig.N8.1 (3) Water Quality Data of E-W Transect, Winum Gulf (3/3)

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Fig.

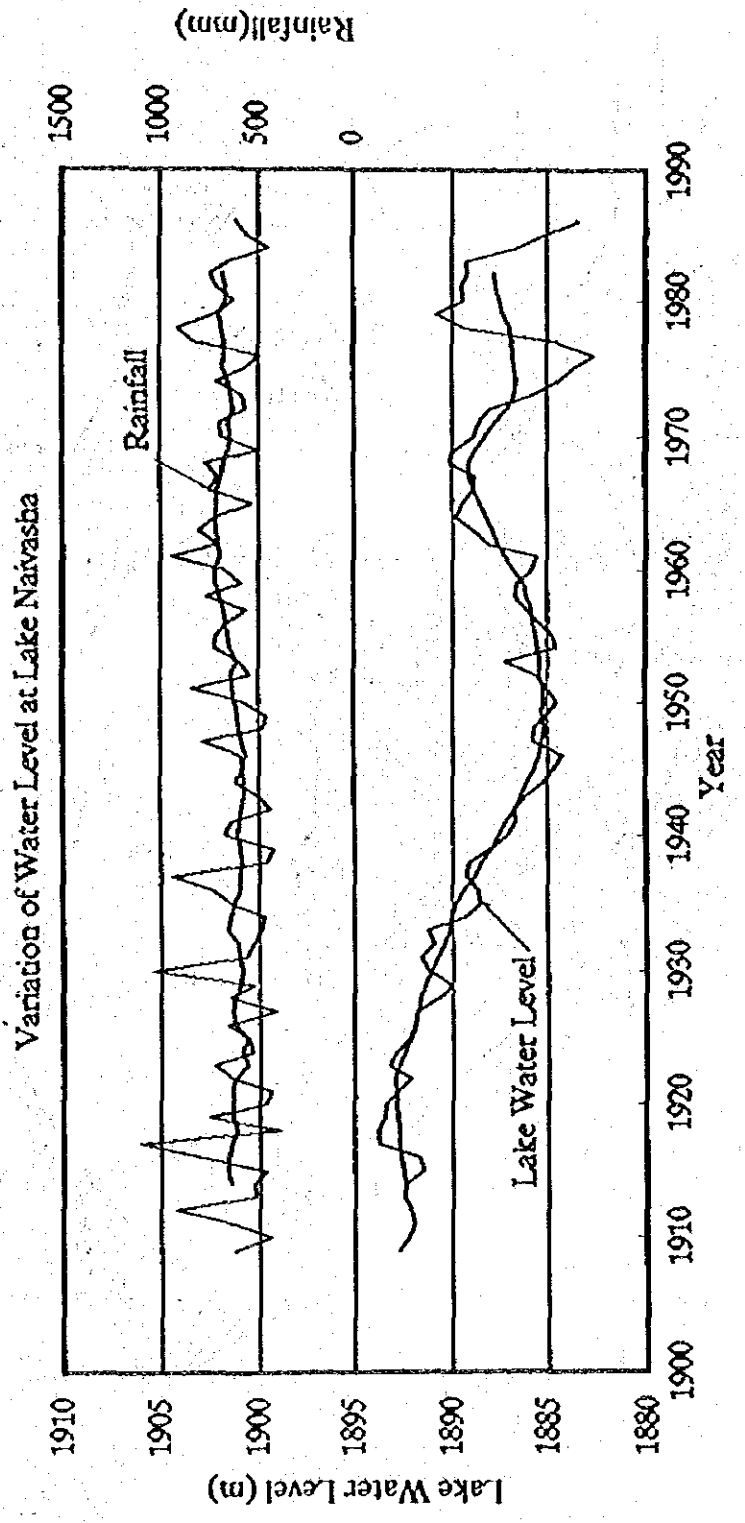

Figure N8.2 Variation of Water Level at Lake Naivasha

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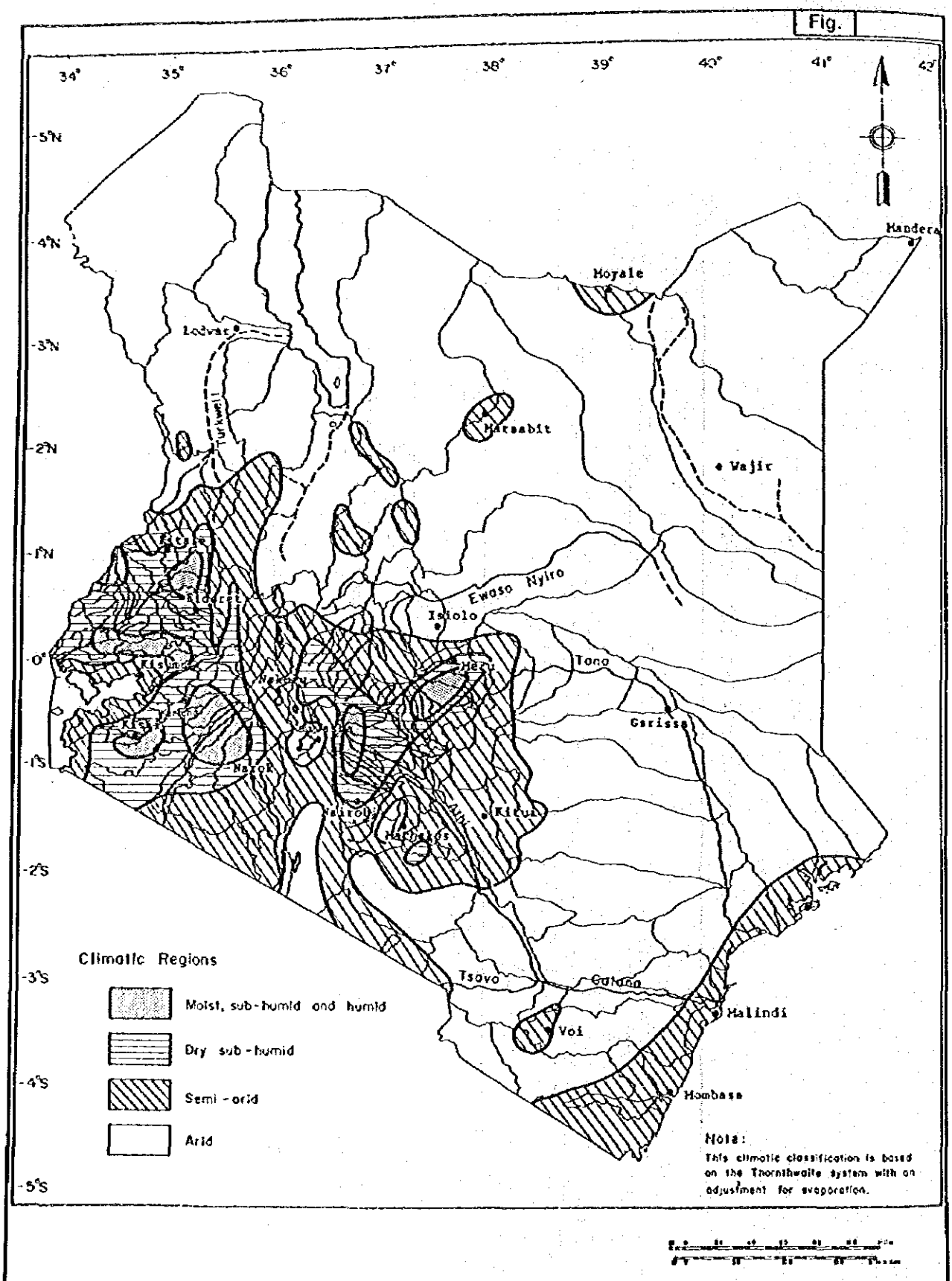

Figure N9.1 The Geographical Distribution of ASAL Areas in Kenya

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PART II

INITIAL ENVIRONMENTAL EXAMINATIONS

OF

SELECTED WATER DEVELOPMENT PROPOSALS

PART II INITIAL ENVIRONMENTAL EXAMINATIONS OF SELECTED WATER DEVELOPMENT PROPOSALS

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N11. DAMSITES AND RESERVOIRS

11.1 Introduction

(1) Procedure of the study

This chapter contains the results of preliminary environmental studies of dam schemes examined in this NWMP Study. Because of the simultaneous progress of this environmental study and the selection of proposed dam schemes (finally 28 dams selected), the both studies had to be carried out rather independently; the former not waiting for the final results of the latter.

Therefore, the environmental study was carried out adopting the following approaches;

(i) *Study on preliminarily selected schemes at interim stage (up to June 1991):*
During this stage, 24 schemes were studied at varying depths. The study was made at a depth of initial environmental examination (IEE) for eight damsites which were assessed to contain some noteworthy environmental issues. The other 16 schemes, for which insufficient information was available to complete an IEE, were evaluated separately at a preliminary study level.

(ii) Supplemental study on schemes selected in the proposed action plan but not included in (i) above:
Additionally, 13 schemes were taken up for examination after all the proposed dam schemes have been determined (March 1992).

Thus, a total of 37 dam schemes were examined. A copy of the checklist used as the basis of these studies is appended as Table N11.1.

(2) *Scope of initial environmental examination (IEE)*

The IEE reports prepared for the 8 damsites vary in scope and depth depending upon the extent of relevant information available to the consultant. For some sites where previous studies at pre-feasibility, feasibility or detailed design stages have been carried out the IEE is more advanced than for sites newly identified by this NWMP study. Of 37 schemes, some sites were examined by aerial and/or ground survey.

The qualitative results of the initial environmental examinations of the damsites selected during the final screening are summarized in Table N11.2; the principal physical features of the potential damsites are given in Table N11.3.

It is stressed here that these are ***initial examinations*** designed to identify the most obvious or most probable environmental impacts associated with each particular damsite; as such it is expected that all sites selected for development will receive further and more detailed environmental impact assessments in due course. It is also expected that these reports will be used in the comparative evaluation of alternative development options in the future studies.

11.2 Results of Initial Environmental Examinations

Discriptions are given for the eight schemes, which comprise (1) Magwagwa, (2) Nandi Forest, (3) Malewa, (4) Oldorko, (5) Mwachi, (6) Ndarugu, (7) Pemba and (8) Rare dams.

11.2.1 Magwagwa Damsite

(1) Purpose of the dam

The site at Magwagwa is to be developed for peak power electricity generation, river regulation and supply of water to the proposed Kano and Nyando plains irrigation schemes. It will operate in conjunction with the Sondu-Miriu hydropower development project.

(2) Basic details

The construction of a 100 m high dam will impound the Sondu-Miriu River to form a 26 km2 reservoir at dam crest elevation (1670 masl). From this reservoir water will be diverted through a tunnel to the power house 12.5 kilometres downstream. After passing through the twin generators the water will be returned to the Sondu-Miriu River approximately 20 km upstream of the Sondu-Miriu hydropower weir. At low water level the lake area will fall to around 4 km2 with a drawdown of 62 metres. It is not expected that the spillway will be operative on many occasions and a basic maintenance flow of 0.5 m3/sec will be released into the Sondu-Miriu River below the dam.

Power generation will not be continuous. The station will come on line twice per day to meet the morning-midday and evening peak power demands. During power production a total of 82 m3/sec will pass through the power house turbines.

(3) Water quality

Data on water quality are available in the Environmental Conservation Report, chapter 7; studies conducted by the JICA Magwagwa Study Team indicate few problems of water quality but predict that the reservoir will undergo a limited degree of eutrophication.

(4) Results of the IEE and aerial reconnaissance

The main findings of the JICA Study Team and the present study are summarized below; for full details refer to the JICA Environmental Impact Assessment Interim Report (March 1991).

(a) Relocation and resettlement of population:

This is identified as the single most important negative impact of this project; between 4500 and 5000 people in 700 households will have to be evacuated and resettled by the scheme. Consequent upon this need is a secondary problem of locating and acquiring suitable and acceptable land for resettlement. This also is a serious problem and a solution will be hard to come by. Compensation for land and infrastructure should be repaid in kind ie. land-for-land; while cash payment for crops and inconvenience will be needed.

(b) Safety hazard from generation power bores:

A problem not specifically identified by the JICA Study team is the creation of a power bore in the river below the power house tailrace twice per day as the station comes on line.

At the onset of each of the twice daily power generation cycles an additional 82 m3 of water will be introduced into the river per second from the tailrace outfall causing a rapid rise in both the speed and depth of the river. It is estimated that as the first generator comes on line the volume of water in the river will increase from 0.5 to around 16 m3/sec in about 1.5 minutes; a further 30 minutes will elapse until this generator is at full power and discharging 41 m3/sec. At this point the second turbine will come on line following the same pattern.

The bore developed in the 20 kilometres of river between the power house outfall and the Sondu-Miriu weir may be dangerous and potentially lethal to anyone or anything caught in its path. Presently it is not known what the velocity of the bore will be or how deep the water will rise: until this is known the magnitude of the risk cannot be adequately assessed. Further investigations and adequate remedial actions are necessary to safeguard public safety.

This power bore hazard will also probably interfere with trade and traffic across the river to some extent, especially if the river is fenced off for safety reasons. Fencing will also deny the local population access to the river for water supply and other uses, including washing and stock watering. It is not thought that fencing the river will be either effective, economical or socially acceptable and is not recommended as a mitigation option.

The use of audible sirens to warn of the hazard is a more practical method which if coupled with bores coming at regular times my reduce the hazard to acceptable levels. As with road traffic, a price will have to be paid for the benefits but all efforts should be utilized to reduce this price to a minimum though no obvious fool-proof practical solution are immediately apparent.

(c) Erosion of the Sondu-Miriu delta region:

The Sondu-Miriu River enters the Winam Gulf in Nyakach Bay and here silt deposition from the river has built up a large delta. The silt transported, mainly from the upper catchment, which has built and maintains this delta will now be retained in the reservoir. It thus seems inevitable that erosion processes will overcome the depositional accumulation of silt and the delta will, in time, cease to exist. The delta is presently well populated and cultivated; the extent and likelihood of the destruction of the delta needs full assessment and feasibility of remedial earthworks examined.

(d) Compensation flow:

It is proposed to release 0.5 m3/sec of water into the Sondu below the dam to maintain the utility of the river as a water supply to downstream users and to preserve the ecology of the river.

(e) Sangoro Riverine Research Laboratory:

This laboratory is located at Sangoro, about 10 kilometres upstream from the river mouth and the reduction in water volume in the river is likely to seriously affect the work and viability of the research station. This situation also requires further analysis. It should be pointed out that the impacts of Magwagwa may be partially mitigated by the auxiliary power station proposed as part of the Sondu-Miriu power development project since this would divert some additional flow back into the river above the research laboratory. Again, a more precise assessment of the magnitude of the impact is impossible until of details concerning the mode of operation of the three proposed power stations on the river and the water demand of the Kano and Nyando Plains irrigation schemes are fully defined.

11.2.2 Nandi Forest Damsite

Details given below applied to the original proposal for a large dam and reservoir to be constructed within the Nandi Forest. This proposal has subsequently been replaced by another involving a small weir and which consequently has far less adverse environmental impact than the large reservoir scheme. The original IEE is included here to indicate the extent of the impacts of the original proposal and to support the choice of the small more environmentally friendly weir scheme.

From the few details available on the weir scheme it would appear that all the major adverse environmental impacts associated with the original scheme will be either avoided or substantially reduced. Little if any forest will be inundated, construction impacts will be much reduced.

(1) Purpose of the dam

The original proposal of this dam was to supply hydropower and includes the transfer of water via a 15 km tunnel from the Yala River to the Kano Plains for irrigation. The tunnel facilitates the generation of 45MW using 183 million m3 of water which can be used for irrigation and possibly also water supply to Kisumu.

(2) Basic details of the dam

Elevation (m)	*Dam height (m)*	*Reservoir area (km2)*
1780	0	0
1800	20	3.7
1820	40	8.3

FSL = 1806 m.

(3) Water quality

Water quality in the Yala River at the damsite was analysed during the Kisumu Water and Sanitation Study in 1984-85. These studies concluded that water quality was excellent for the proposed use in power production and irrigation. Treatment would be required for potable water supply. Details of water quality are given in Chapter N7 (Part I) Table N7.11.

(4) Results of the IEE and aerial reconnaissance

(a) Land use

i) Vegetation and cultivation

The entire inundation area lies within the South Nandi Forest which is a gazetted national forest reserve with an area of 19.5 km2. It contains a dense cover of tall mature indigenous trees with thick undergrowth between the trees. No signs of habitation, cultivation or stock grazing were observed during the over-flight.

ii) Settlements and other structures
No settlements or isolated houses were seen in the forest. There is an existing small water treatment works near the damsite which will be covered by the proposed reservoir.

iii) National Park or Reserve or forest
As noted this reservoir will have an impact severely upon a major national gazetted forest which is in prime condition, not showing signs of encroachment as is often seen in other such forests.

(b) Compensation, relocation and resettlement

i) Land and crops
The South Nandi Forest is already government land and so compensation for land is unnecessary. There is no agriculture or habitation within the forest obviating the need for compensation.

ii) Relocation and resettlement
Similarly there are no people to relocate and resettle.

(c) Bush clearance

Approximately 8.3 km2 of dense indigenous forest and under-growth will have to be felled and cleared from the site if this project is implemented.

(d) Aquatic weeds

No significant aquatic weeds were seen at the reservoir site but their presence or absence in the Yala River tributaries upstream is unconfirmed.

(e) Downstream user conflicts

i) Water shortages
Since transfer of water from the Yala to the Kano Plains is an integral part of this proposal attention must be given to the maintenance of adequate water supply for downstream communities; thus compensation flows need to be quantified.

ii) Water quality reduction
There appear to be no over-riding reasons why unacceptable changes in water quality should occur in this reservoir; though some changes are to be expected as a consequence of storage.