

## Water Use in Kenya: A brief overview of Water use issues in a developing nation

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## Kenya Experience



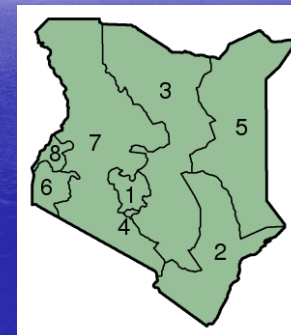
- 2003
  - Worked with Kenyan NGO in Kitale, Kenya on capacity building, environmental, agriculture and microlending issues.
  - Graduate Research Fellow with the World Agroforestry Centre (ICRAF) in Nairobi and Kisumu, Kenya.
- 2006/2007
  - Graduate Research Fellow ICRAF
  - Nairobi, Kenya

## Where is Kenya?



## Kenya Provinces

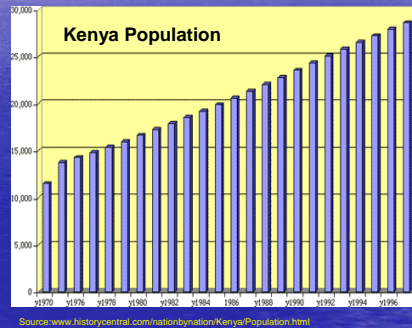
1. Central
2. Coast
3. Eastern
4. Nairobi
5. North Eastern
6. Nyanza
7. Rift Valley
8. Western



## Kenya's Population Explosion

1948 - 5.4million  
2006 - 34.7million  
(about that of California)

1988 - highest population  
growth rate ever  
recorded @ 4.2%



## Kenya Information:

- 580,367 Km<sup>2</sup>
- Nairobi is Capital
  - 1o 16' S and 36o 48' E
  - ~1/7 of population lives in Nairobi (>5 million)
  - of that 1 million live in Kibera (1,600 p/ha)
- 10 million live in urban centers (~1/3)
- Only 2.3% is water (mostly Lake Victoria)
- <10% of the land area is arable
- > 90 % is arid to semi-arid: i.e. desert
- Rural pop densities < 1,600 per/sq.km
  - (roughly 2.6x that of Birmingham, Alabama)

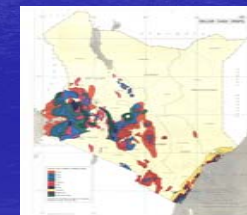
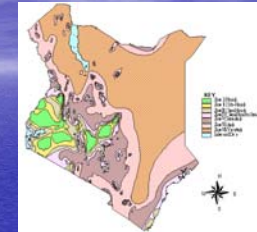
## Kenya Info (continued)

- GDP = 48 billion
- Per Capita = \$1,200
  - However >50% live on less than \$1/day
- Life expectancy ~ 45 yrs
- Slightly more than half of the pop are women.



## Kenya and Agriculture

- Depends heavily on Ag
  - 20% of GDP produced by agriculture
  - 80% of population involved in agriculture
  - Most are subsistence farmers
- Primary crops are maize, tea, coffee, rice, sisal
- Productivity declining
- Food imports increasing



## Kenya and Agriculture (cont)



## Climate

- Precipitation varies greatly depending on location:
  - Arid <10 in/yr
  - Semi-arid ~ 13 in/yr
  - Coastal zones ~ 31 in/yr
  - Humid ~ 80 in/yr
- Temperature:
  - Hottest Feb/March Coolest July/August
  - 60's – >100 F arid/semi-arid
  - 50 – 95 F Highland and coastal areas.

## Recurring food security disasters

- 2006 – 3.5+ million starved
- 2004 – 1.8 mil/ton of food needed
- 2000 – 1.4 mil/ton food needed
- 1961-1998 imports/food aid = 21% of total consumption.



## Kenya Surface Drainage System

- Drainage is determined by the Great Rift Valley, (generally north-south), and from its flanks, water flows:
  - west to Lake Victoria and,
  - east to Indian Ocean.
- Kenya's has 5 drainage basins and 192 sub-basins (Cege, 1968). The 5 basins are:
  - 1) Lake Victoria basin (46,229 km<sup>2</sup>) comprises the whole of the area west of the Rift Valley that drains into Lake Victoria.
  - 2) The Rift Valley area (130,452 Km<sup>2</sup>) is an area of internal drainage discharging into Lake Turkana in the north and Lake Natron to the south.
  - 3) The Athi/Sabaki River area (66,837 Km<sup>2</sup>) comprises the southern part of the country east of the Rift Valley. It drains the southern slopes of the Aberdare ranges and flanks of the Rift Valley south of the Athi River.
  - 4) The Tana River area (126,026 km<sup>2</sup>) drains the eastern slopes of the Aberdare ranges, the southern slopes of Mt. Kenya and the Nyambene ranges and discharges into the Indian Ocean. The Tana is largest river in Kenya.
  - 5) The Ewaso Nyiro North River area (210,226 Km<sup>2</sup>) comprises the northern part of Kenya and drains the northern slopes of the Aberdare ranges and Mt. Kenya, into the Indian Ocean.

## Water Supply



- Dams: uses include: Gov't, Agriculture, SHG's, Industry, & Institutions
  - Large Dams – 39
  - Small Dams - >800
- Water supply systems (gov't) - 401 (107 urban/294 rural).
- Arid and Semi-arid Land (ASAL) – water supply is the most serious problem- inadequate and unreliable.

## Kenya average water use rate

- Kenya uses 46 l/p/d
- US uses 575 l/p/d
- World water poverty threshold = 50l/p/d
- data obtained from UNDP, 2006

([http://www.data360.org/dsg.aspx?Data\\_Set\\_Group\\_Id=757](http://www.data360.org/dsg.aspx?Data_Set_Group_Id=757))

## Water supply (continued)

- SSA 35% of rural water supply systems are inoperative
- Kenya – 680 piped systems – 740,000 connections. Many don't work due to:
  - maintenance
  - Poor management
- Gov't starts many "new" projects but others fail – this one step forward and one back is a high cost / low return policy.
- ~1/3 rural pop (20+ million) have access to improved water supply through piped or pt source systems. 1/3 (6-7 million) of those are served by shg's
- Seems to be much interest in living sustainably



## Ground water Supply

There are 3 main ground water regions

1. Volcanic regions: GW occurs at varying depths and several quifers may exist on top of each other. The aquifers in these areas are confined and the depths to the aquifers and piezometric levels within them vary widely. The average yields are about 7.5 m<sup>3</sup>/hr. The depth to the aquifers on average is 94 m.
2. Basement areas: GW aguifers are mainly semi-confined. Yield depth to aquifers and static water levels vary within the rocks. Sample statistics for the country give an average yield of 4.5 m<sup>3</sup>/hr, an average depth to main aquifer of 55 m.
3. The sedimentary rocks cover approximately 55% of the surface area of Kenya. The yields in these aquifers range from 8.0 m<sup>3</sup>/hr to 3 m<sup>3</sup>/hr. Depth of aquifers vary widely.

## Ground Water supply

- Ground water wells are:
  - Machine installed (usually ,200 ft deep)
    - Usually big/privatized organization
  - Hand dug (usually < 70 ft deep)
    - Usually NGO, SHG or personally installed



## Maintenance on local wells

- Common problems with the pumps include:
  - worn out brushes ;
  - worn out pivot bolts;
  - broken handles;
  - worn out rubber flaps;
  - broken pedestal stand;
  - stolen bolts;
  - disconnected piston rods;
  - broken piston rods;
  - disconnected rising mains;
  - broken fork bolt joint; and
  - scratched rising mains.
- Sixty percent of the problems encountered were rectified by the villagers themselves. The rest were handled with assistance from field workers, while only two cases required the attention of the researchers.

(data from International development Research Center (IDRC), Nairobi, Kenya  
[http://www.idrc.ca/en/ev-83049-201\\_870085-1-IDRC\\_ADM\\_INFO.html](http://www.idrc.ca/en/ev-83049-201_870085-1-IDRC_ADM_INFO.html))

## Groundwater supply

Borehole	No. of boreholes	Percentage (%)
Public Water Supply	2124	22.7
Agricultural	944	10.1
Domestic	435	4.6
Industrial/Commercial	244	2.4
Livestock	176	1.9
Observation	62	0.7
Exploratory	51	0.5
Others	910	9.7
Unknown	4,438	47.4
<b>Total</b>	<b>9,364</b>	<b>100.0</b>

\* Water supply wells are less that 400 ft deep

## Contamination of GW supply

- Shallow wells (<100 ft)
- High permeability medium (deep soil/soft rock)
- High water table
- Latrines
  - poor siting
    - gw flow direction
    - distance to water table
    - distance from latrine to well
  - poor maintenance
- Agriculture (hogs, pesticides, Herbicides)
- Poor hygiene

### Methods of reducing the risk of contamination

- Increase horizontal separation distances between latrine and water point
- Move water point higher than latrines
- Change to a drier form of latrine
- Increase vertical separation between bottom of pit and water table by using shallower pits or vaults latrines
- If a borehole is being used, site the screens lower in the water table
- Treat water supplies or encourage use of home water treatment

### Other Considerations:

- Alternative sources of water if water gets contaminated. If the alternative is even more heavily contaminated, closing the water point may not be the most sensible option.
- Alternatives if pit latrines has to be closed.
- Is sewer an option? Expensive.
- Can the water be tested?

### Irrigation and Drainage

- Irrigation:
  - Generally new but traditional practices hundreds of yrs
  - 52,000 Ha w/ >600K potential
  - Large scale schemes for coffee, pineapple, rice, etc.
  - Small scale schemes used for local ag
- 600,000 ha need drainage/flood protection

Category	Existing/On-going Scheme in ha	Proposed Scheme in ha
Private	23,000	25,000
Smallholder	18,000	105,000
GoK agencies	11,000	
<b>Total</b>	<b>52,000</b>	<b>130,000</b>

### Major constraints to irrigation are:

- Inadequate (unreliable/polluted) source of water
- High cost of irrigation inputs
- Lack of proper technical knowledge
- High relief intensity (steep slopes)
- Sodic and saline soils
- Salt affected water

## Other Water Problems

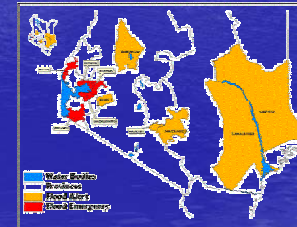


- Flooding
- Sanitation
- Industrial pollution
- Urban Wastewater
- Erosion



## Flooding

- Rivers in Kenya are classified into two main types: Perennial (mostly found in the Central, Western and Coastal areas and seasonal mainly found in semi-arid and arid areas.
- Flooding occurs regularly. The 1961 floods were the severest in the last 33 years. Other severe floods occurred in 1963/64, 1968, 1977/78, 1982, 1985, 1988, 1990, 1992, 1993, 1994, 1997, 2000, 2002, 2003, and 2006.
- 2006 affected 700,000 people
- This occurs mainly near Lake Victoria and Coastal areas but can occur any where including arid regions.



## Sanitation (waste water)

- Globally 2.6 billion don't have improved sanitation
- Africa it is about 40% of the population
- Why do we care?
  - Public health – disease
  - general well being and quality of life



## Diseases include:

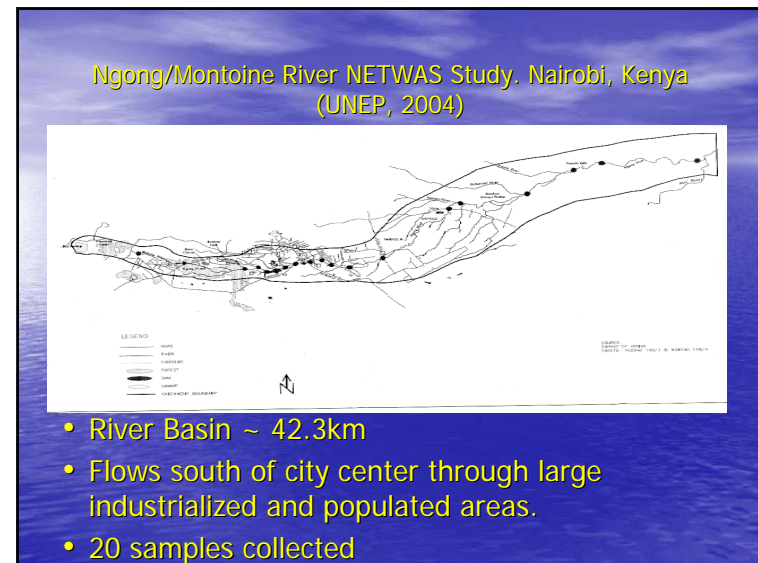
- Fecal – oral
  - Diarrhea = #1 killer >1.6 mill children/yr
- Soil diseases
  - Helminths – hookworm, roundworm, whipworm, etc.
- Meat diseases – tapeworms
- Water diseases – schistosomiasis/bilharzia
- Insect vectors – mosquitos, flies, cockroachs, rats – trachoma, filariasis, malaria



Parameter	Country			
	Uganda	Nigeria	Kenya	Tanzania
Population estimate (1998)	20.3 m	121 m	28 m	31 m
Rural population	86%	61%	75%	72-78%
<b>Poverty related (1)</b>				
Infant mortality rate /1000	141-203	191	NR	144-159
Life expectancy	42yrs	50yrs	42yrs	51yrs
UNDP poverty ranking /175	160	141	148	150
<b>Water supply: per cent of population with access to safe water</b>				
Water supply (Total)	43%	43%	43%	30%
Water supply (Rural)	35- 42%	37-40%	34-45%	22-26%(2)
Water supply (Urban)	60%	52-84%	70-76%(3)	64%(3)
<b>Sanitation: per cent of population with access to safe sanitation</b>				
Sanitation: total	45-47%	39-58%	48%	
Sanitation: rural	30-48%	30%		
Sanitation: urban	52-84%	70%		

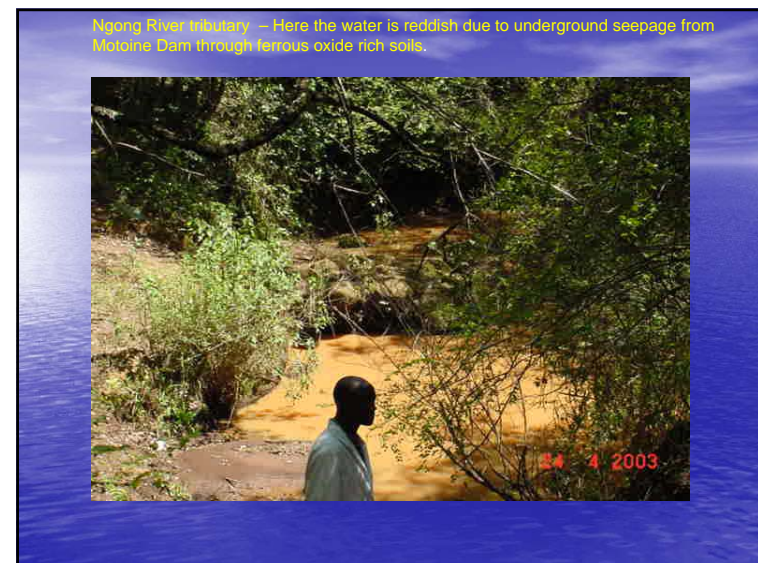
Notes:

- 1) One useful indicator of poverty not referred to in the sector studies is malnutrition.
- 2) In this case, only piped water supplies seem to have been considered as safe, hence the low figure of 22 per cent. Apparently, about 40 per cent of rural piped water supplies were not functional (Howard Humphries, 1998).



## Kibera area

- The rivers flow through Kibera
- Nairobi dam (upstream)
- Area deforested in 1950's/60's
- Area slopes (ave ~ 10%)
- Area bisected by numerous tributaries
- Pop density ~ 300,000 km<sup>2</sup> or ~ 3,000 per/ha
- Major contributor to water pollution







Nairobi Dam



Station within Industrial Area. Dark blue textile and paper dye/ink effluents are discharged directly into the river.





## Water pollution includes:

- Coliform
- Temperature stratification
- Heavy Metals
- Industrial organics

Characterization of sources of pollutants near Nairobi, Kenya (Krhoda 2002)

Source	Bacteria	Nutrients	Trace Elements	Pest/Herb	Industrial Pollution	Oil and Grease
Air		X	XXX	XXX	XXX	
Sewer	XXX	XXX	XXX	X	XXX	
Industrial		X	XXX		XXX	XX
Agriculture	XX	XXX	X	XXX		
Urban, RO & waste disposal	XX	XX	XXX	XX	XX	XX
Geological			XX			

X = Low, XX = Medium, XXX = High

## General Water quality of Ngong River in Nairobi:

- TSS (no value provided – just “high” and increasing downstream)
- Turbidity – same as TSS
- BOD – increases downstream WS high 10 -50 mg/l and DS = 100 -600 mg/l
- COD – increasing downstream with a high of 1,400 mg/l (DS) and 300mg/l (WS)
  - Due to oxides of Iron, Manganese and other metals that consume O<sup>2</sup>.
- PH = 6.7 – 8.3
- Nitrate = 0 - 3 (low)
- Ammonia = .4 ppm (upstream) to 40 ppm (downstream)
  - Anoxic conditions due to large amounts of decomposing organic matter (sewage, ind. waste and natural organics)
- Phosphate = 3.2 ppm (highest) 27 ppm (after Kibera)
- Heavy metals - including Copper (electroplating, textile dyeing), Chromium (metal plating), Lead (gasoline, batteries, paint, and plastics), and Zinc (galvanized steel, batteries, etc.)
- Chlorides – Natural background 10 - 20 ppm
  - SW Measured at 19 – 1,242 ppm – by product of human waste

## The Study concluded that:

- Water quality decreases dramatically as it enters slums and industrial areas, particularly after Mater Hospital, which recorded the highest concentrations of most pollutants. (TheNRBP-Phase I data (2001))
  - As the river flows through the industrial area, it becomes heavily polluted mainly due to the industrial effluent flowing directly into the river from burst sewers

## Solid Waste Disposal



## Solid Waste Disposal (continued)

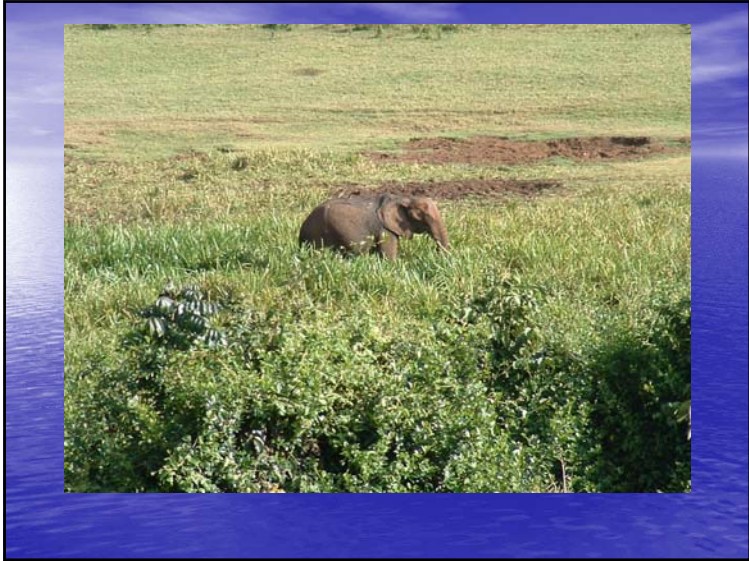
- In large portions of urban areas there is no to little SW collection and disposal.
- SW generation is <1 kg/pp/day
- No recycling or composting.
- No organized effort of waste reduction
- No RRR programs for sure!
- Raw Sewerage is a added bonus for QW!



## The end (almost)

Kenya is not all bad. There are some wonderful and beautiful people and places. I hope you have a chance to visit. You probably would enjoy it!





The End

Thank you for your time and attention

A photograph of a waterfall cascading down a rocky cliff. The waterfall is the central focus, surrounded by lush green vegetation. The background shows a hilly landscape under a clear sky. The entire image is framed by a blue border with a subtle wave pattern.