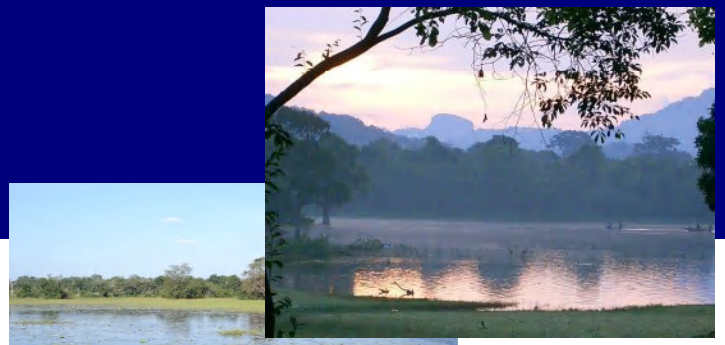
Water Management in Sri Lanka



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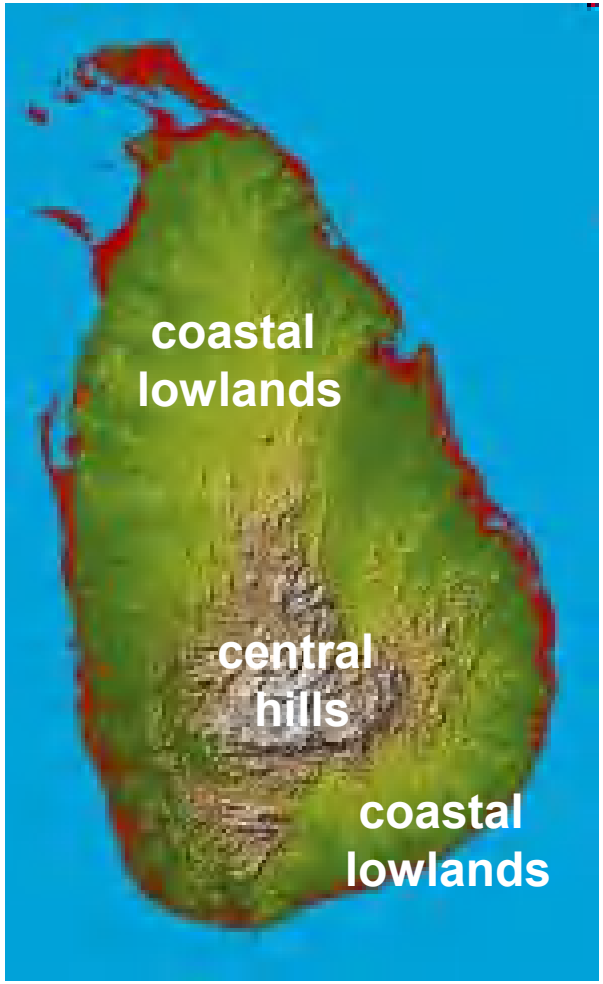
Geographical Setting of Sri Lanka

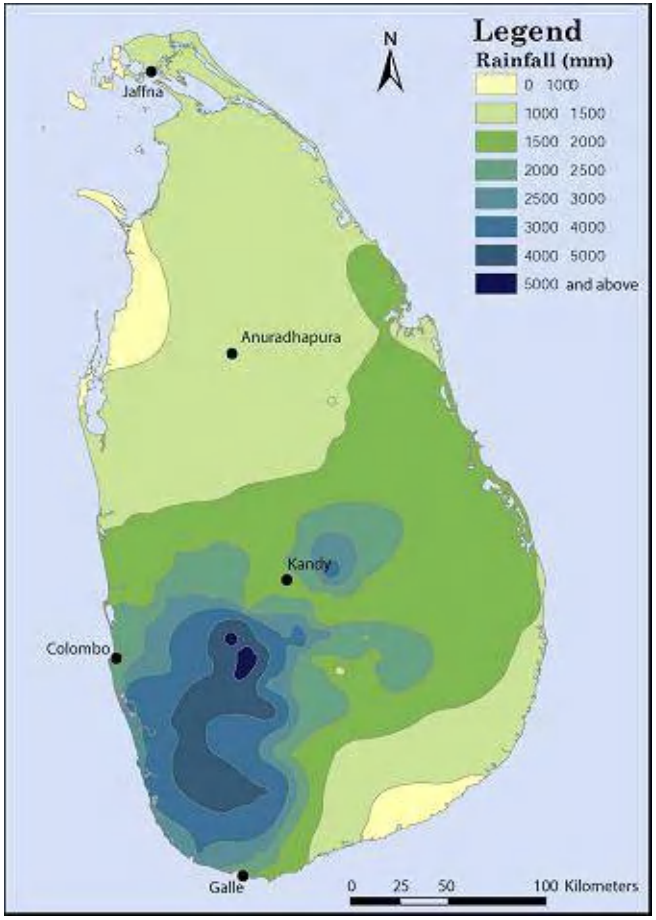
- Is a Tropical Island with total land area of 65,525 Sq. km
- Location;
  - Latitude 5^0-10^0 N
  - Longitude 79^0-82^0 E
- Max. length 432 km & width 224 km
- Topography; vast coastal plain with central mountains (peak 2,524m)
- Mean annual temp. 27^0C in coastal lowlands, 15^0C in central hills.



Freshwater Resource

1. Rainfall

- Annual Average rainfall varies between 900 mm to 5,000 mm
- Sri Lanka is divided into three different climatic zones based on the amount and pattern of rainfall received.
  - Wet zone (over 1900 mm rainfall/year)
  - Intermediate zone
  - Dry zone (less than 1500 mm rainfall/year)
- Cumulative rainfall on average 121km^3/yr
- Rainfall runoff 50 km^3/yr



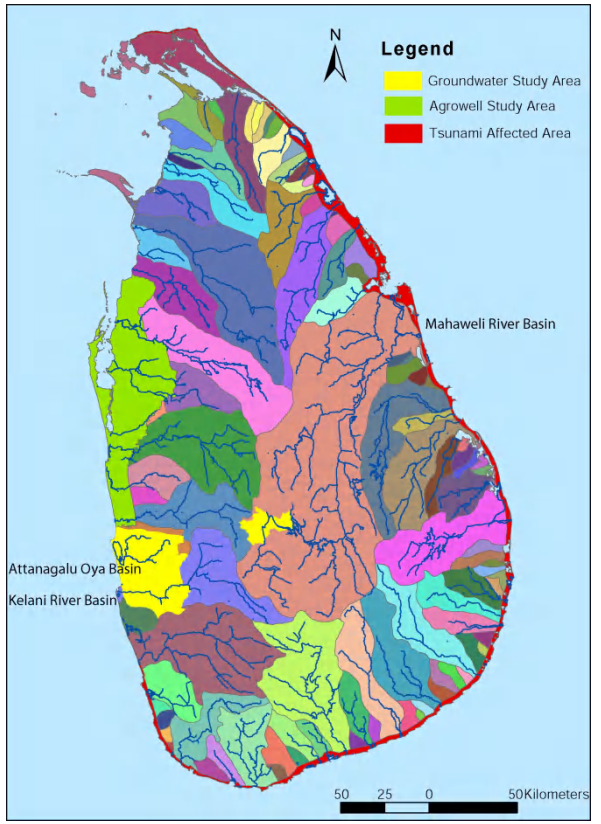
Rainfall distribution

Freshwater Resource

2. Surface water

Inland water bodies cover 2,905 sq.km
They include;

- in total 103 river basins
  - Largest catchment being *Mahaweli* River with 10,600 km^2 draining 4,009 mcm/yr
  - Largest discharge being *Kaluganga* River draining 4,032 mcm/yr, with a catchment area of 2,688 km^2
  - 16 rivers in wet zone draining nearly a third of country's land area carry nearly 50% of total surface runoff of the country
- Man-made reservoirs, lakes & tanks

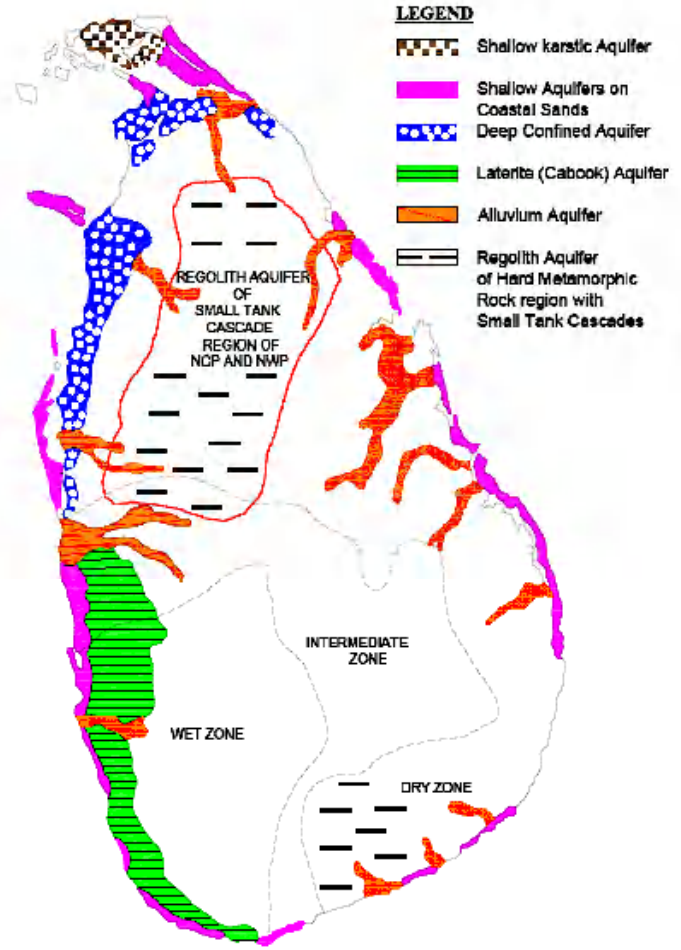


River Basins in Sri Lanka

Freshwater Resource

3. Groundwater

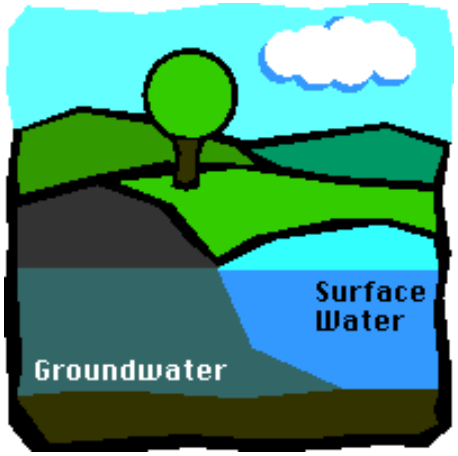
- Six Major Aquifer types;
  - Shallow Karstic Aquifer
  - Coastal Sand Aquifers
  - Deep Confined Aquifers
  - Lateritic (Cabook) Aquifer
  - Alluvial Aquifers
  - Shallow Regolith Aquifer of the Hard Rock Region
- Total renewable groundwater resource is estimated at approx. 8,000 km^3/Yr



Distribution of the Major Aquifer Types in Sri Lanka

(Modified from Panabokke and Perera 2005)

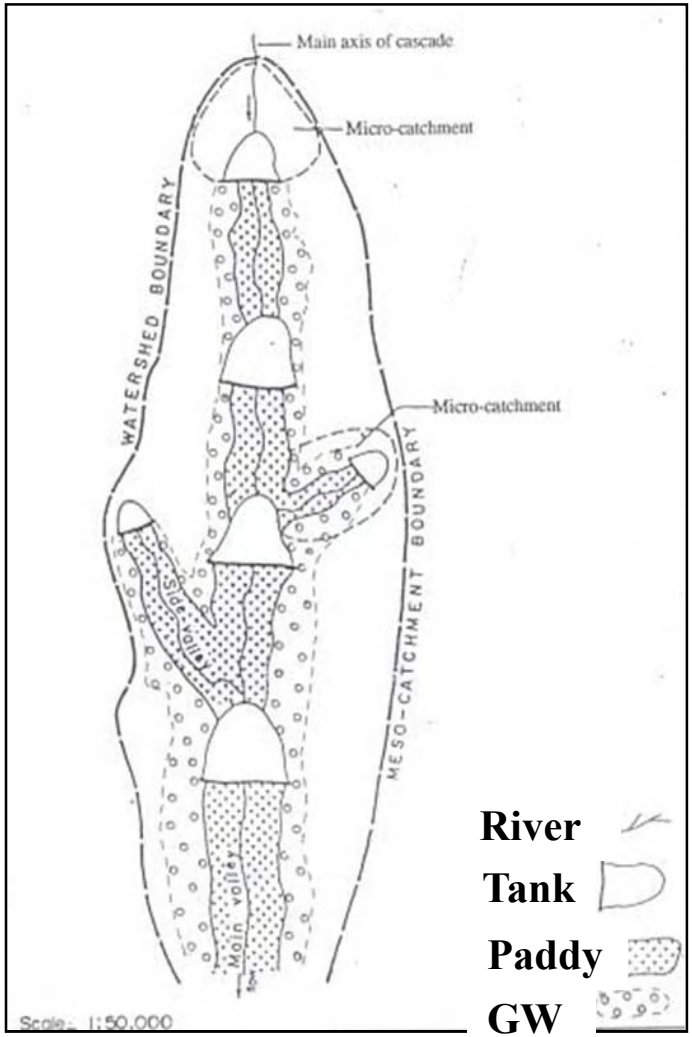
Water availability



- Country per-capita averages;
  (based on 2001 population census records);
  - Groundwater : 420 m^3/per person
  - Surface water : 2,400 m^3/per person
  - Rainwater runoff : 1,850 m^3/per person
- However, when one considers the total water available, details show a reasonable water resource but, the variations over space and time demand proper management strategies
- Total renewable water resource available estimated at 43,000mcm/yr.

Historical Water Resources Development

- Practice of construction of storage reservoirs for irrigation and domestic water requirements had been in practice since early as 500BC
- Thousands of reservoirs varying in size from few million m^3 to several thousand million m^3 was constructed in cascading arrangement for the purpose.
- Cascades of village tanks system is a salient feature of water and soil management system in ancient SL
- These ancient irrigation systems was in operation for over 17 centuries in the past but was abandoned due to foreign invasions
- However today, still these tank systems are widely used for irrigation works throughout the country



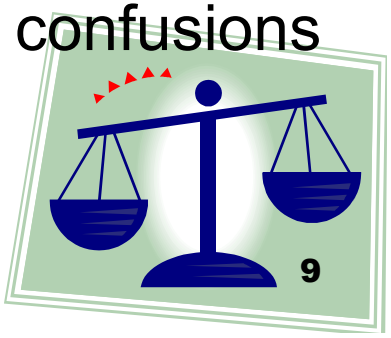
A typical cascade system

Current water supply and use

- Of the 43,000 mcm renewable water resource, just over 25% or 11,000 mcm is used for productive purposes.
- Water use (approx. for 2005) ;
  - Irrigation water 85-95%
  - Domestic supply 5-8%
  - Industrial supply 2-4%
- 80% rural domestic water requirement is from groundwater while surface water supports majority of the urban water supply requirements
- Future demands
  - 8-10% increase per annum in safe water supplies for domestic use
  - Industrial water demand to double every 5-10 years (8-10% annual)
  - Current (2007) safe water coverage only 69% (by population)

Current Management Setup

- Water is managed as an input to major development sectors such as irrigation, hydropower, and human and industrial water supply.
- There are about 30 government institutions involved with water related activities
- Over 43 Acts of parliament related to water sector.
- These laws have been enacted over years to meet specific needs, often with little consideration for existing legislation or future needs.
- Laws are administered by numerous agencies with a wide range of responsibilities, and there overlaps, gaps and conflicting jurisdictions have made lot of confusions and conflicts



Institutional Setup

- **The Department of Irrigation (DI),** established in 1900, is primariiy responsible for water resources planning, project formulation, construction, maintenance and informally responsible allocations of water for irrigation.
- **The Mahaweli Authority of Sri Lanka (MASL)**, established in 1979, is responsible for water resources development in many large river basins in the country.
- **The Water Resources Board (WRB)** was established in 1968. It coordinates governmental water resources functions and formulates national policies relating to the control and use of water resources.
- **The National Water Supply and Drainage Board (NWSDB)** established in 1974 is the main agency for domestic and industrial water supply, sewage, and surface drainage.
- **The Ceylon Electricity Board (CEB)** is responsible for the generation, transmission, and distribution of electric power, including hydropower.
- **The Department of Meteorology (DM)** is responsible for gathering information needed for estimating available water supplies nationwide.

Water Management Issues;

Competition and water shortages are increasing because of;

- Rapid economic growth
- High variability in rainfall
- Pollution

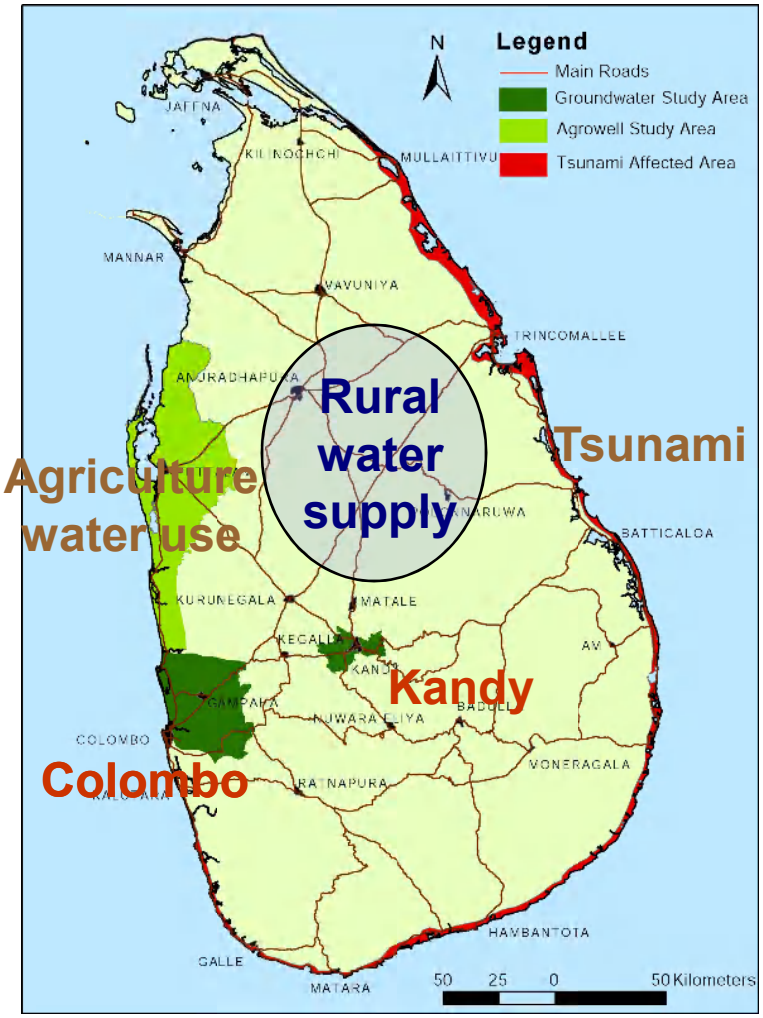
As a result;

- Shortages in surface water
- Lack of piped water supply (by 2005 only 26.9% had access to pipe water supply)
- Groundwater has become more vulnerable than ever
  - By end 2005, nearly 70% population relied on groundwater
  - Over 25% of piped water supplies are from groundwater
  - Groundwater is becoming a popular source for irrigation

Investigated through several case studies

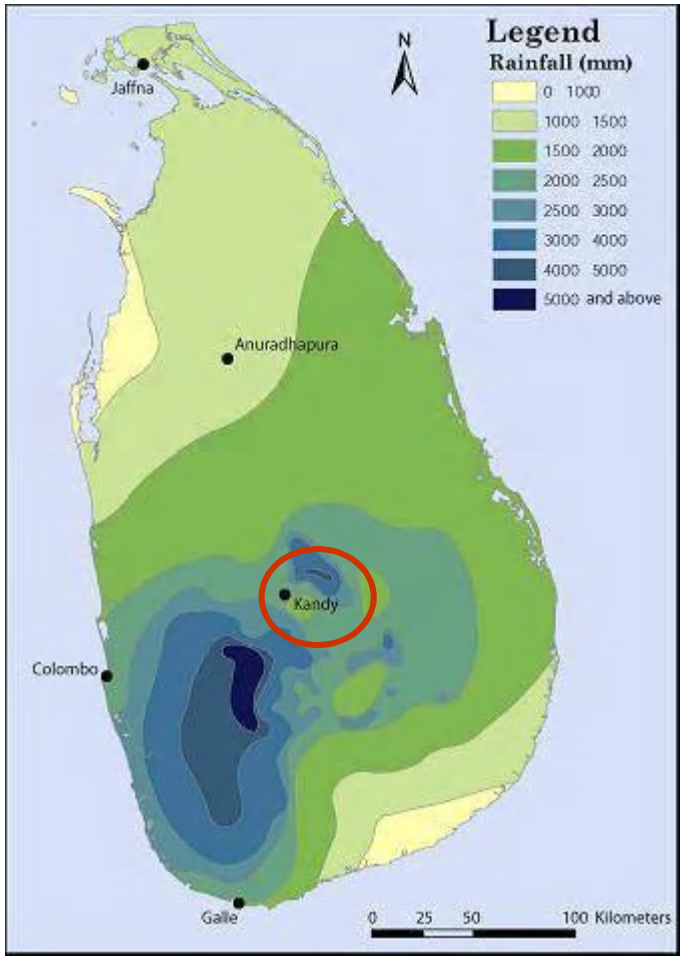
Management Case Studies

1. Variations in rainfall pattern
   - Whole country
2. Case Studies
   1. Urban Water use and Management in the areas of Colombo and Kandy
   2. Water use for Agriculture in dry zone of Sri Lanka
   3. Water supply in rural Sri Lanka

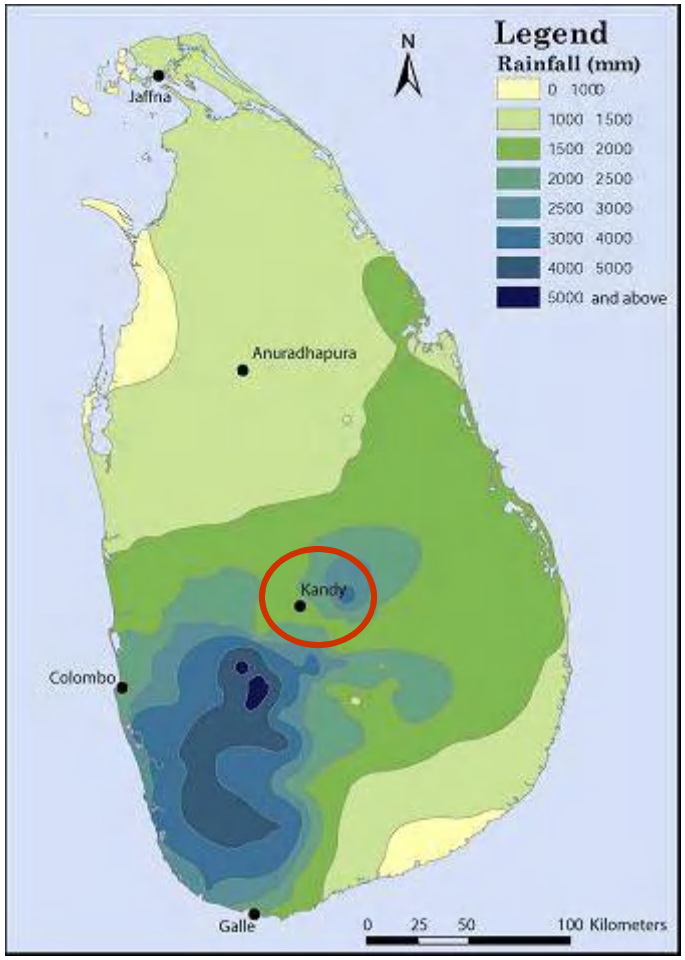


Case Study Locations

Rainfall Variations



1911-1961

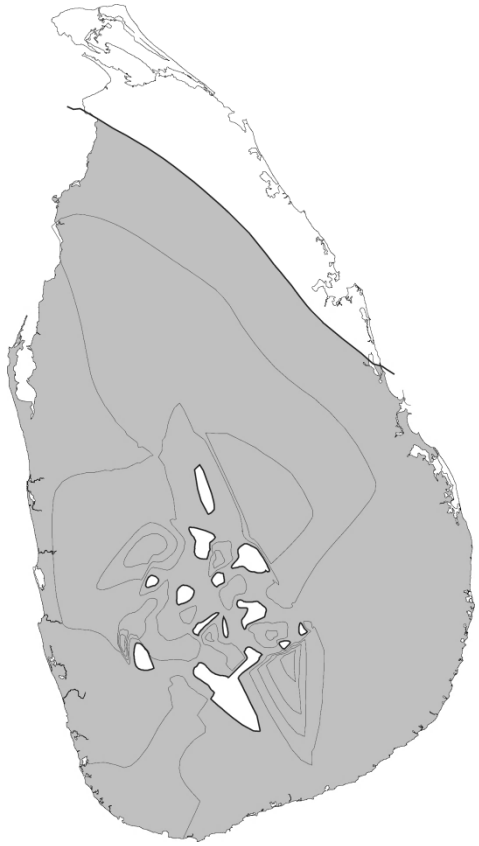


1961-1990

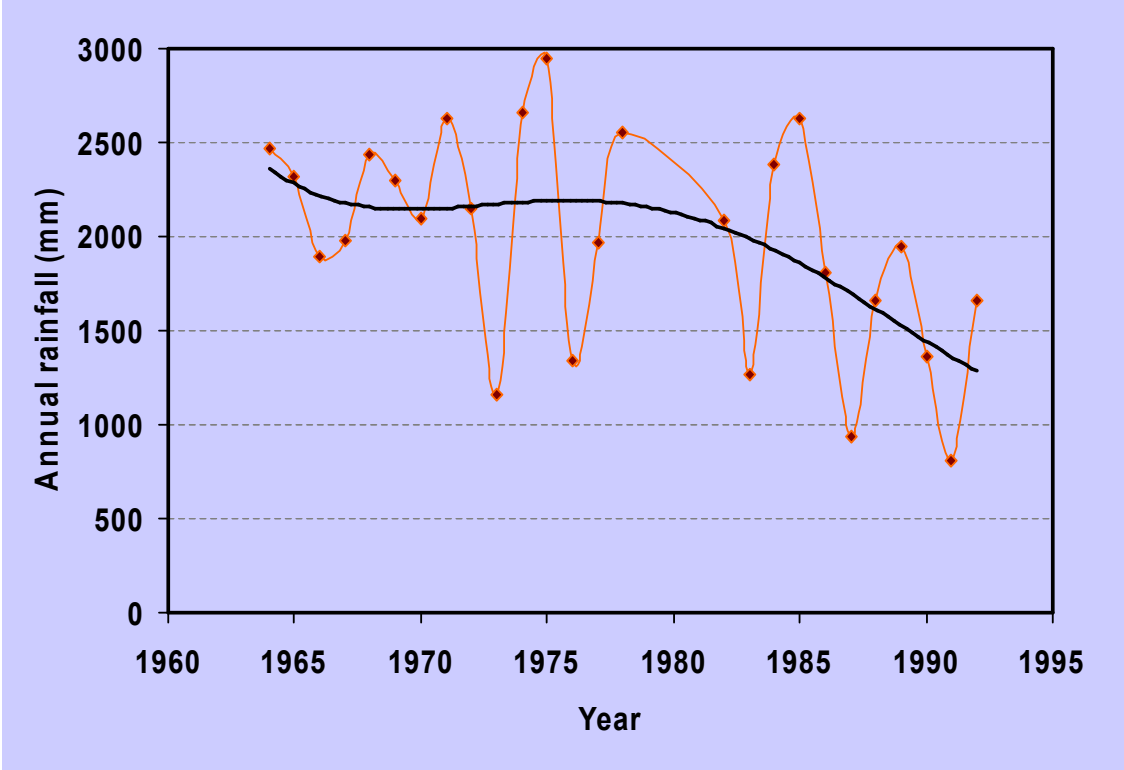
Changes in Wet/Dry spells

Increasing wet spells

Increasing dry spells



Rainfall Changes in Kandy



Urban water use

Available Water Resources (estimations in mcm/yr)

Study area	Ground Water	Surface Water	Rainfall
Colombo - average	815 (193)	5,300 (1,250)	3,745(885)
Kandy - average	176 (217)	2,049 (2,530)	592 (730)

() per-capita water availability, * Kelani Ganga basin detailed basin assessment

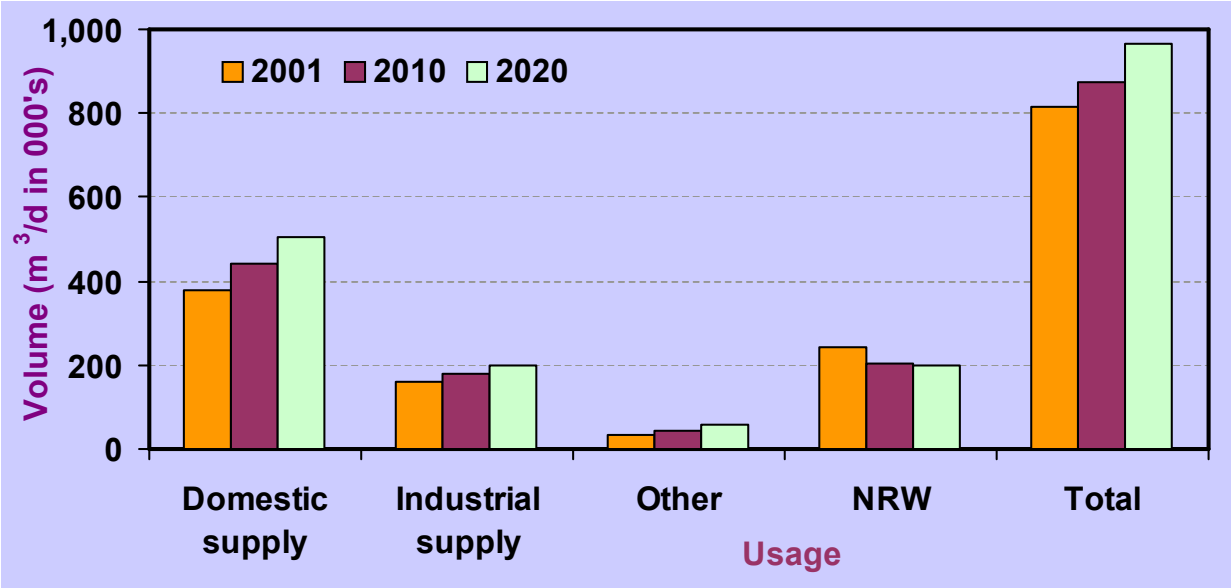
Water Supply (estimations in m^3/day)

	Surface water		Groundwater			NRW
			Deep		Shallow	
	Domestic	Industrial	Domestic	Industrial	Domestic	
Colombo (2001)	380,248	158,445	11,151	6,970	234,000	243,956
Kandy (2000)	36,679	5,972	5,546	804	41,000	22,928

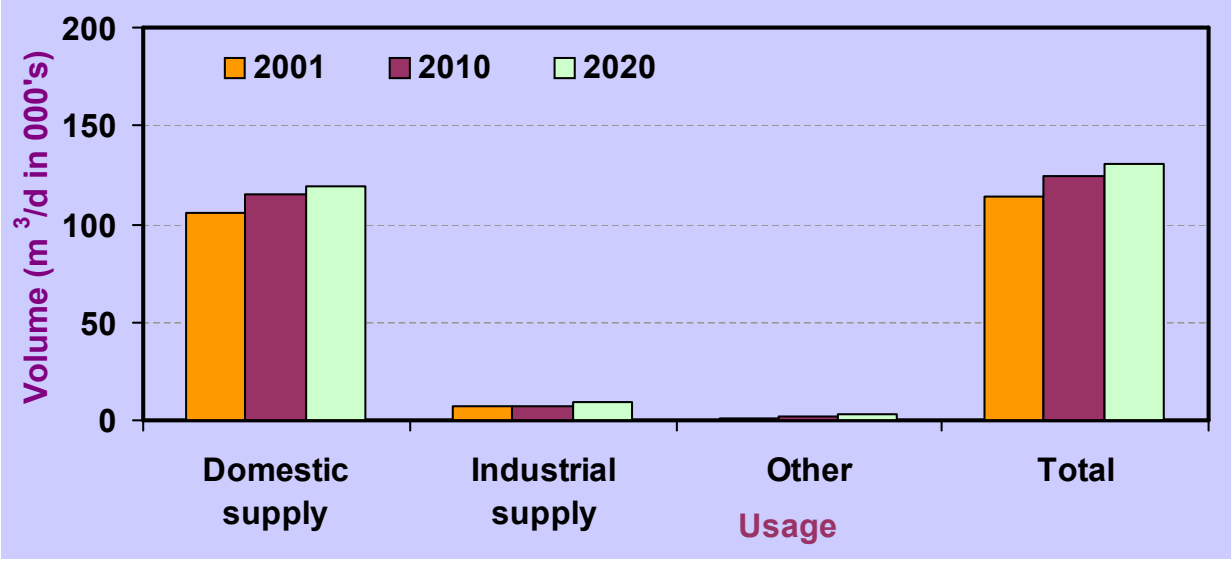
Sources for Drinking Water (Source – NWS&DB)

Colombo

Surface Water Demand

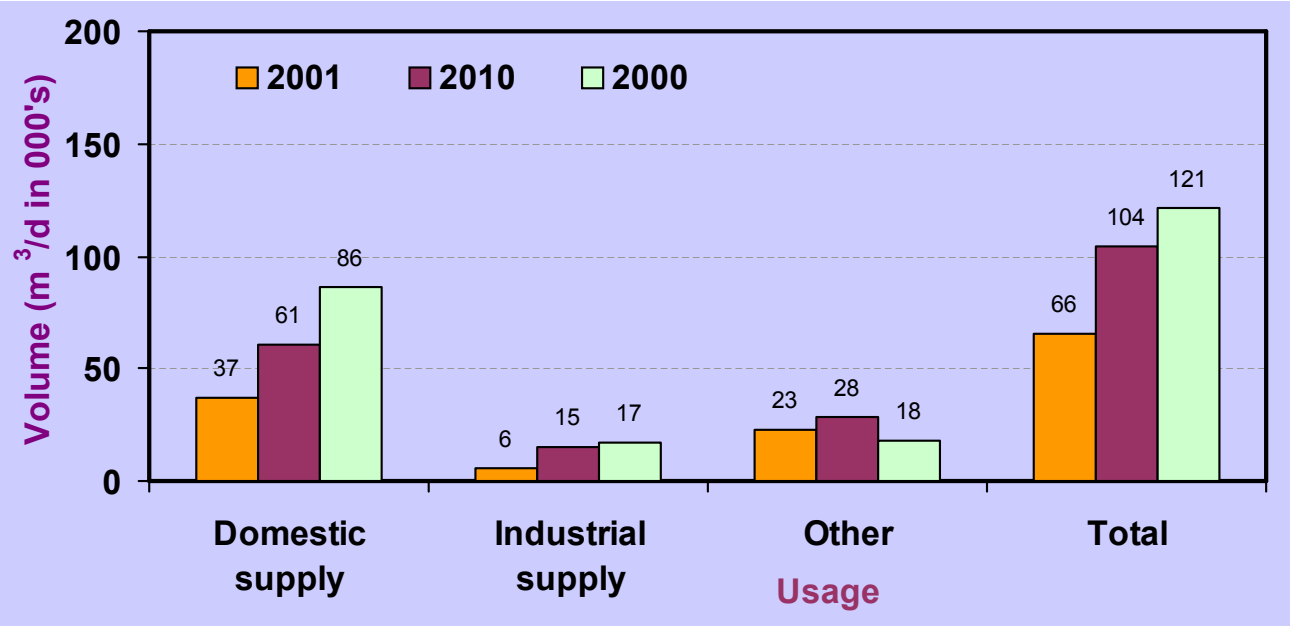


Groundwater Demand

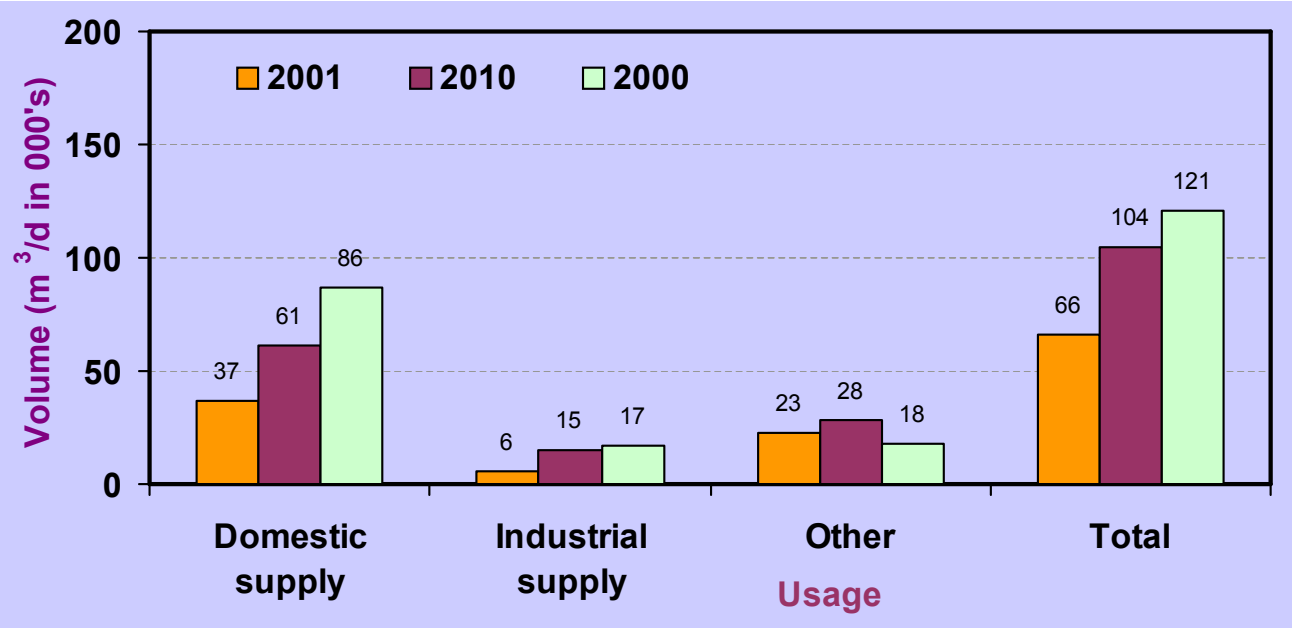


Kandy

Surface Water Demand



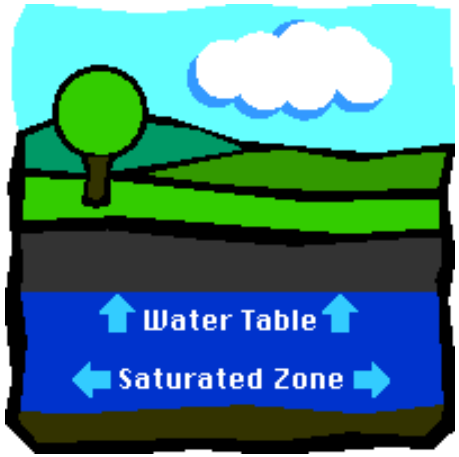
Groundwater Demand



Groundwater

Main Sources of Groundwater

1. Semi-confined hard rock aquifers
2. Shallow groundwater
3. River alluvial aquifers in unconfined deposits



Low Yield and Lower Success Rates

Success rates hard rock based sources;

Success rate at well construction = 80%

(limit; production well 20 l/min and hand operated well 4 l/min – NWD&DB sources)

After about 5 to 6 years of operation success rate = 65%*

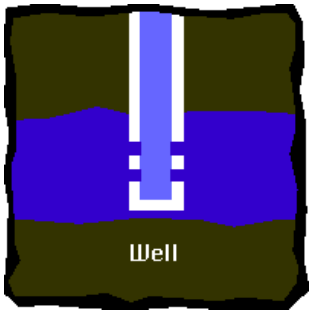
Wells maintain by local authorities = 50-55%*

Our estimations in Kandy = 50%

Lowered success rate is mainly attributed to **poor maintenance and over extraction**.

Yields;

Not promising for large scale use as average for Kandy is 331 m^3/d



Problems with Groundwater Exploitation
Some examples

Coastal Aquifers;

Over extractions during dry season causing saline water intrusions
Eg. Coastal belt– Specially by Hotel Sector

Shallow Aquifers;

Shallow well water draw-down as a result of deep well over-pumping

Semi Confined Hard-rock Aquifers

Rapid water level draw-downs (over 40 m)

Decreasing yields (Many Abandoned Schemes)

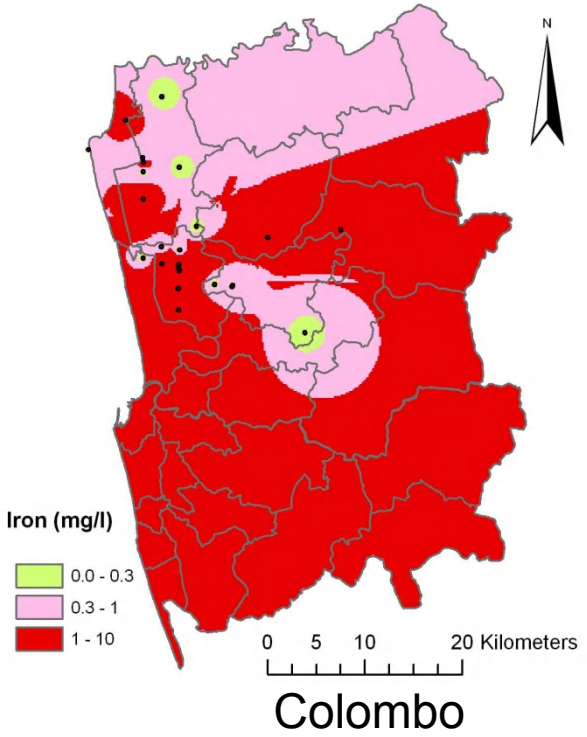
Overall no monitoring to observe any changes

Groundwater Quality

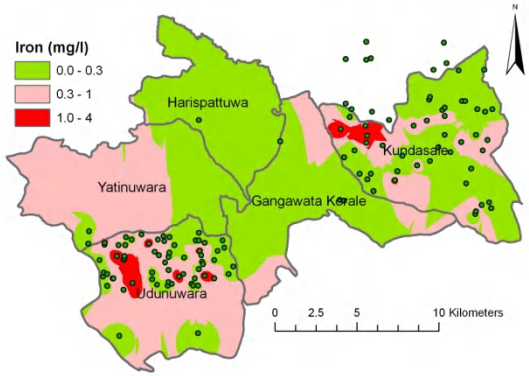
Deep Aquifers

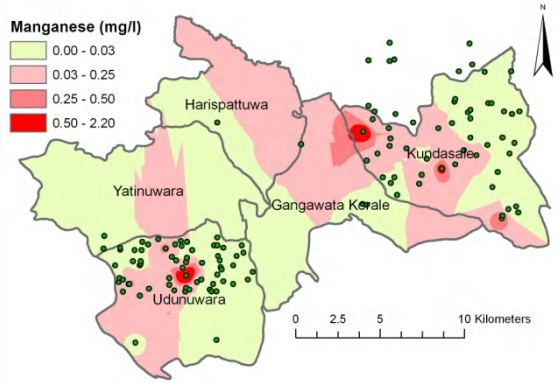
No major widespread quality concerns expect for;

- Nitrates (128 mg/l Kandy –East),
- Iron (13-18 mg/l Kandy and Colombo) and
- Hardness (1,100 mg/l Kandy East and South)



Colombo





Kandy

Groundwater Quality Problems

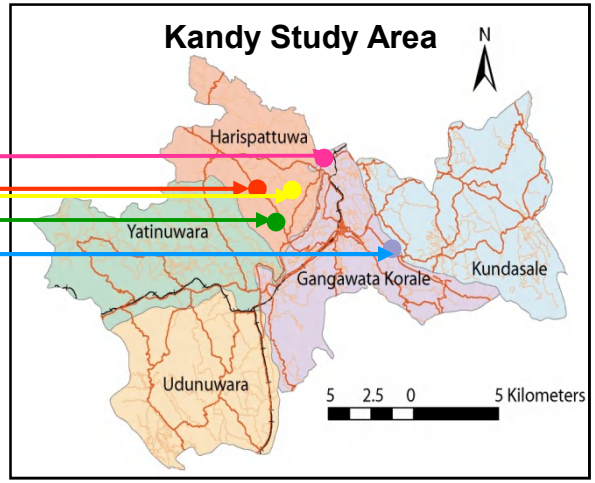
Shallow Aquifers

contamination from;

- From fertilizer,
- Bacteriological (Fecal – over 50% tested positive, total over 80% tested positive) contamination from domestic waste
- Untreated industrial discharge (Colombo)
- Solid waste dumping

Eg. Shallow GW total coliform (pfu per 100ml)

- Polgolla 2-44
- Hedeniya 150-300
- Akurana 24-144
- Kulugammana 0-56
- Ampitiya 24-84

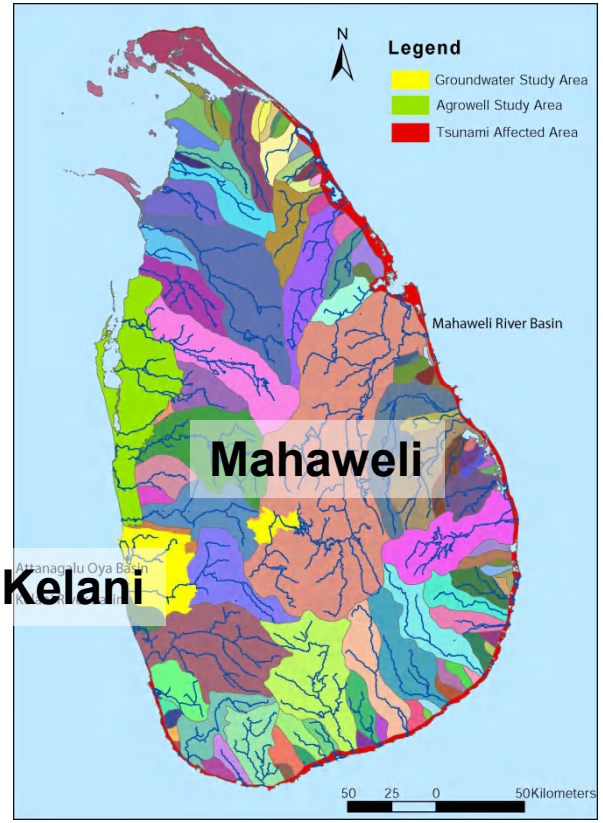


Urban Groundwater Management Issues

- Poor yield estimations and thus drying up of wells
- Lack of information to take timely and adequate measures
- Pollution control very poor

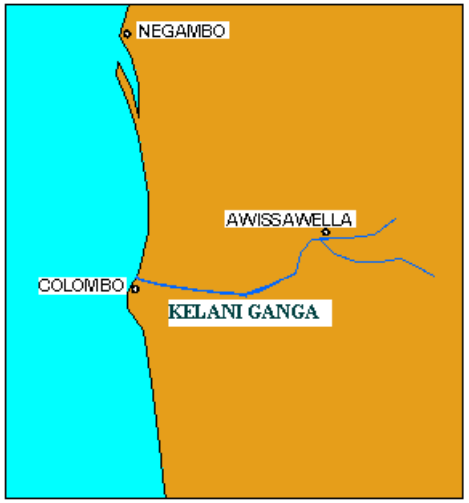
Surface water

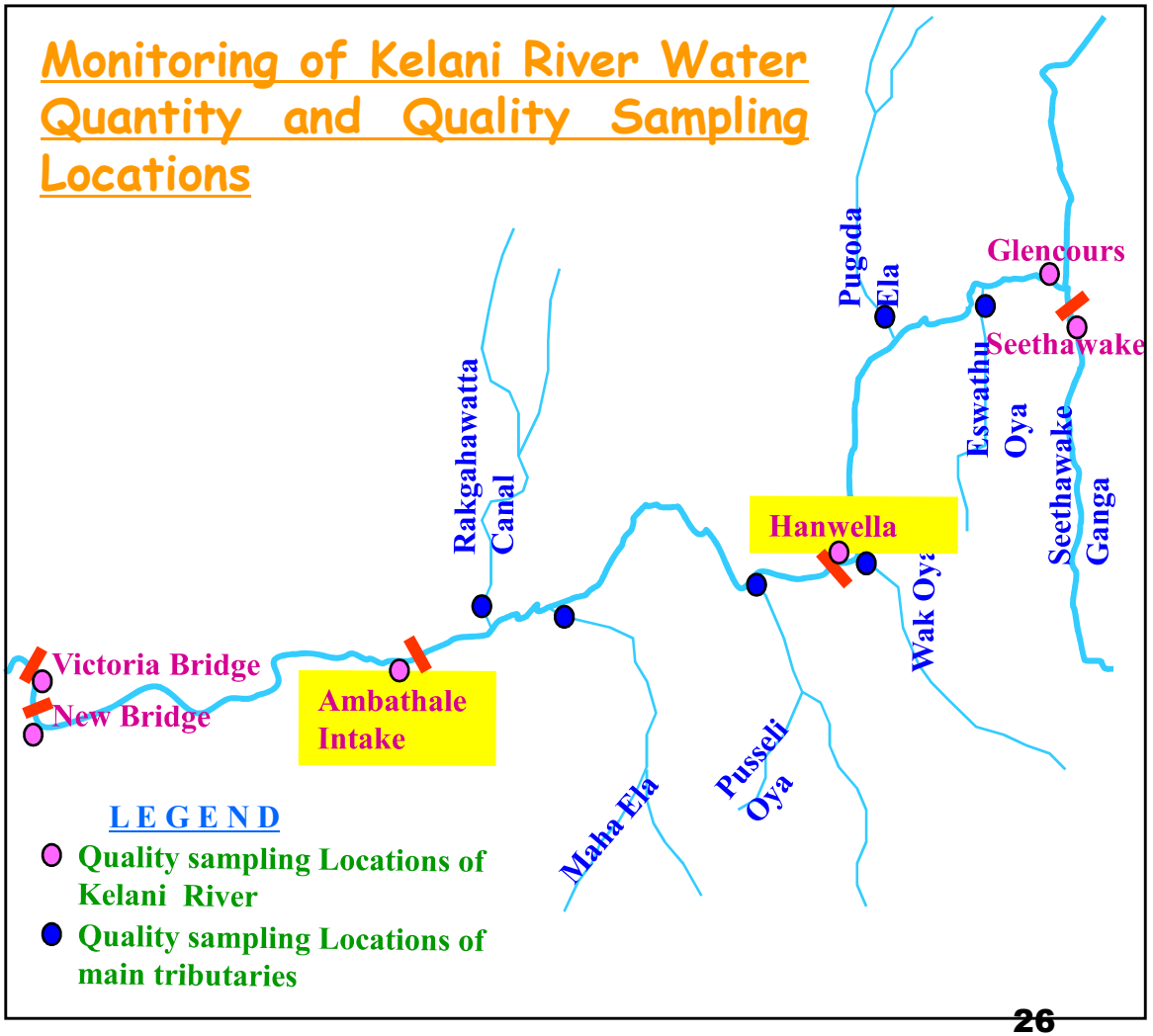
- Surface water availability analyzed using two river *Kelani* for Colombo and *Malaweli* for Kandy
- Surface water requirement for water supply considered
- Water demand for planned and full development level estimated
- Environmental Flow requirements for salinity control estimated
- Values compared with river discharges
- River Water quality investigated



River Basins
under consideration

Kelani river Colombo



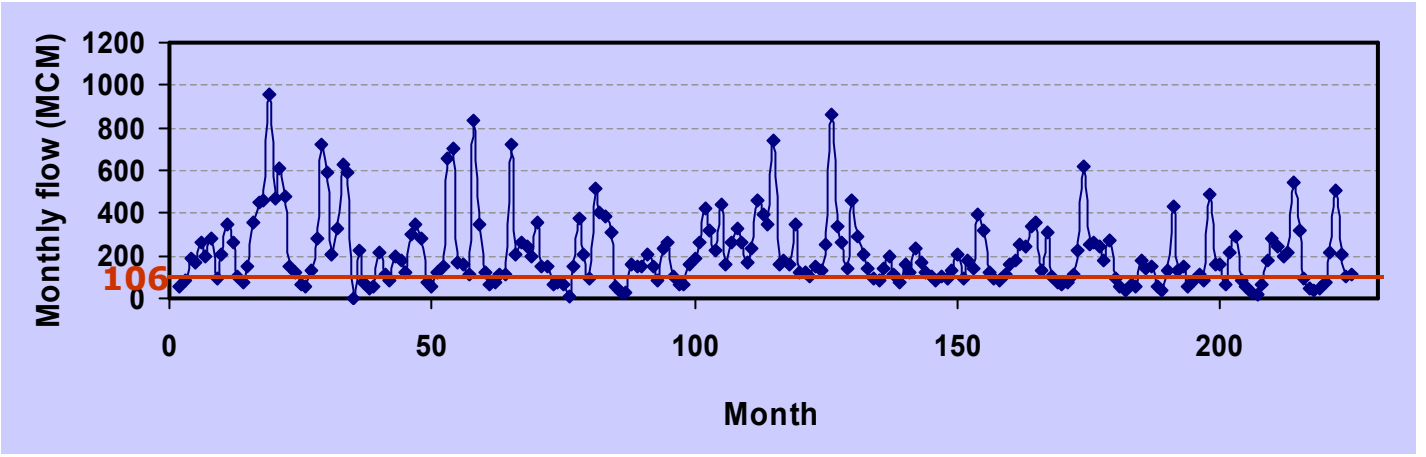


Surface water

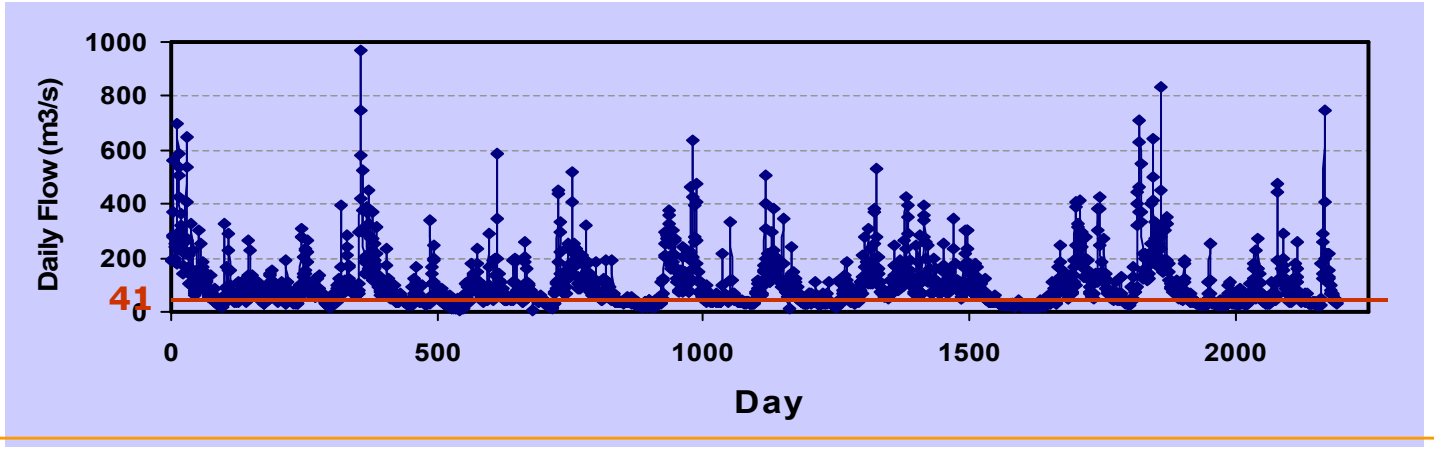
Availability Colombo:

Main source is Kelani River - Discharge at Hanwella

1973 to 1993



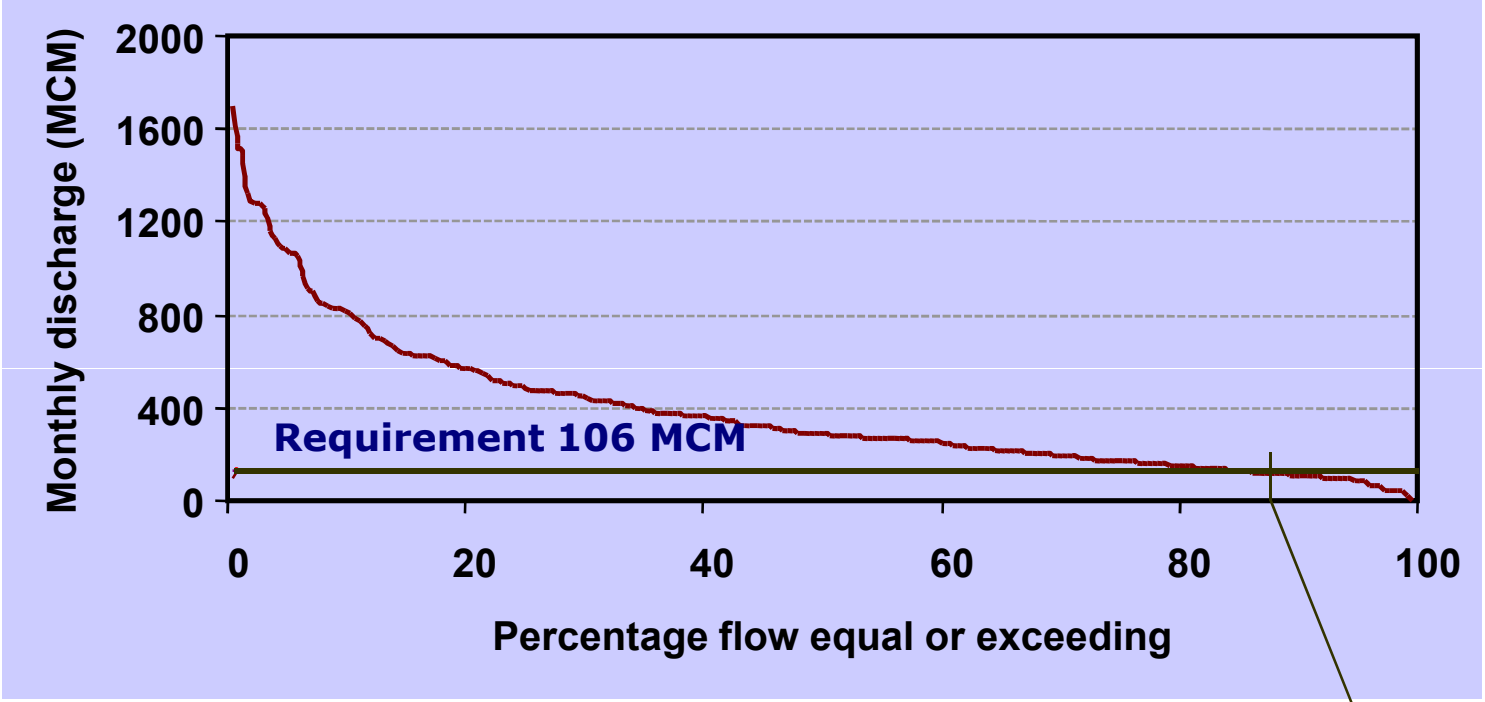
1998 to 2005



106 mcm; Minimum requirement for satisfying the year 2020 planned supply demand with salinity control, **41 mcm** planned supply demand with no salinity control

Surface water reliability

Kelani River at Hanwella (Colombo)



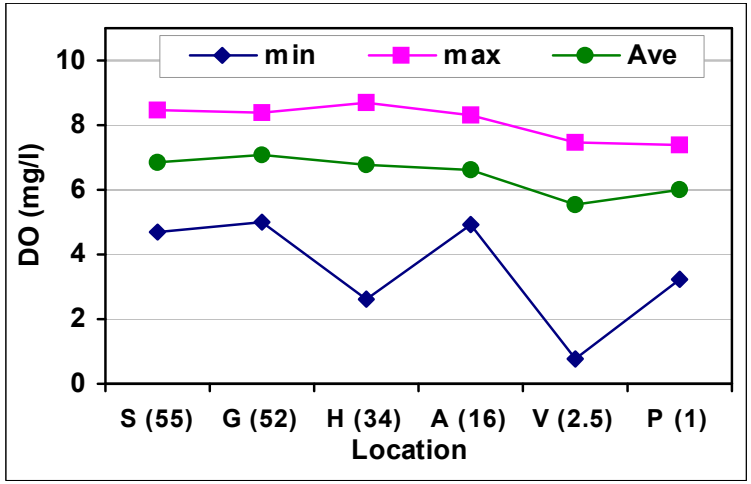
Demand	2001	2005	2015	2025
Planned Supply Demand	85.8	84.9	82.4	79.7
	2000	**2010**		**2020**
Full Development Demand	91.8	91.1		90.8

90%

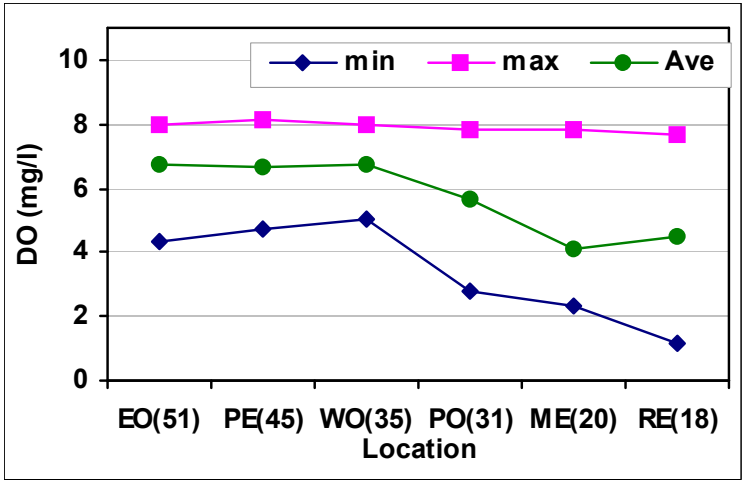
Surface water quality

Dissolved Oxygen (DO)

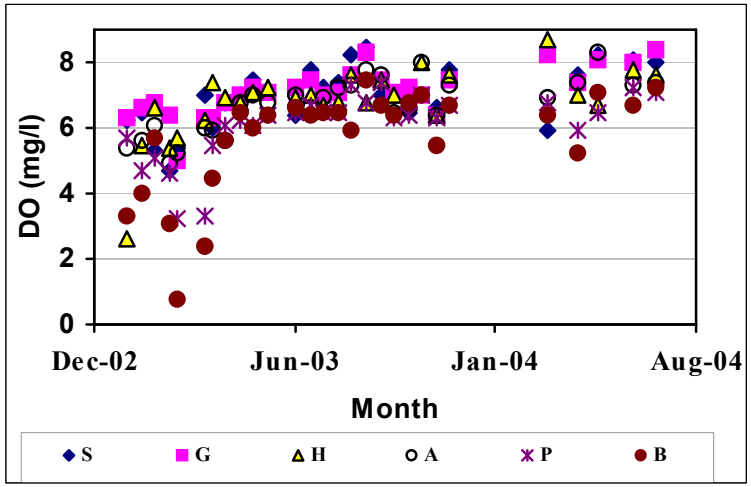
Main stream



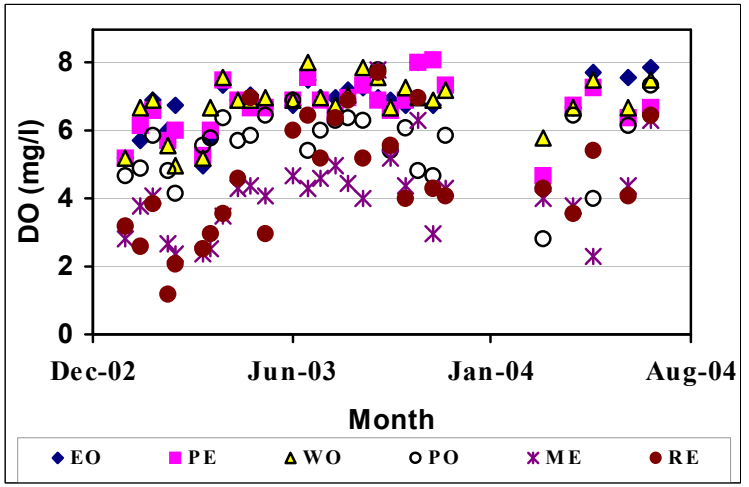
Tributaries



Up stream to Downstream

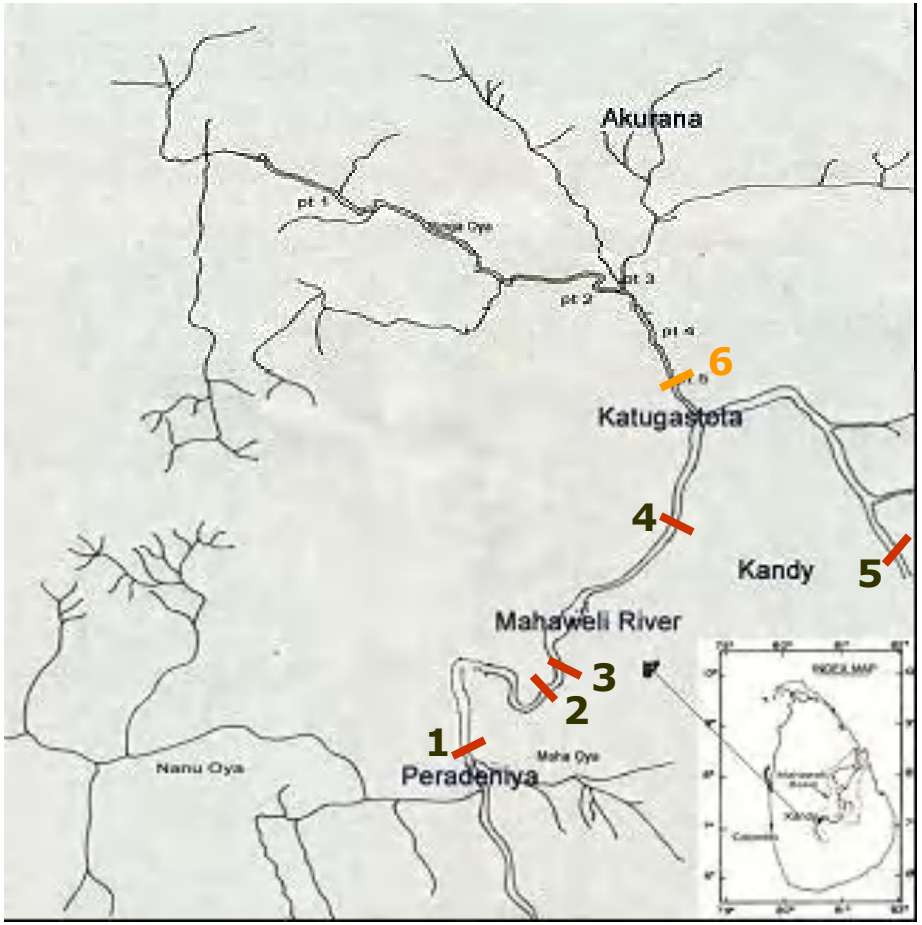


Up stream to Downstream



Surface water Kandy

Quality concerns Mahaweli River Kandy;



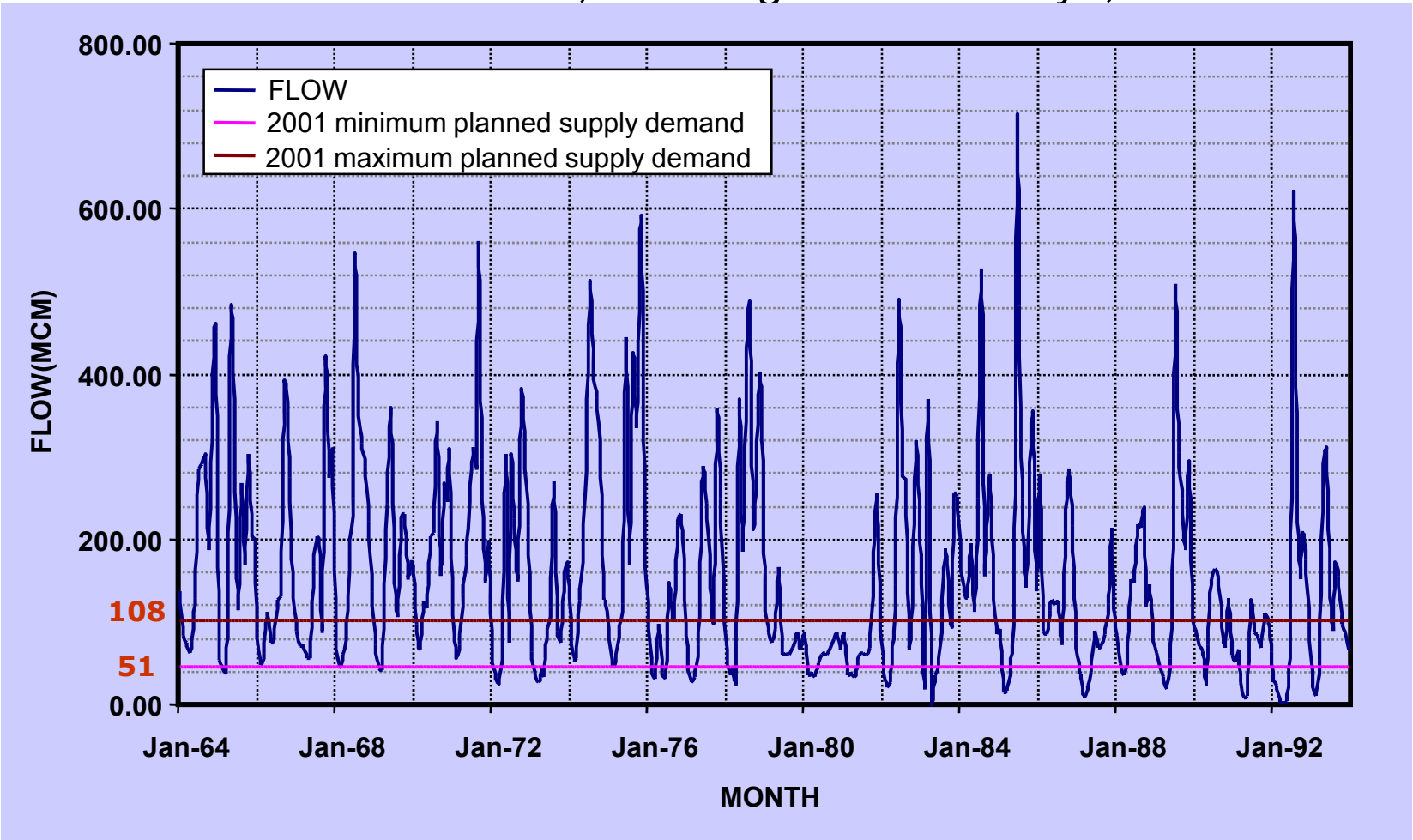
Quality Measurement Locations

1. Peradeniya (0 km)
2. Gatambe 1 (4.4 km)
3. Gatambe 2 (4.8 km)
4. Gohagoda (9.9 km)
5. Pollgolla (13.9 km)
6. Pinga-oya (10.9 km)

Kandy

Surface water

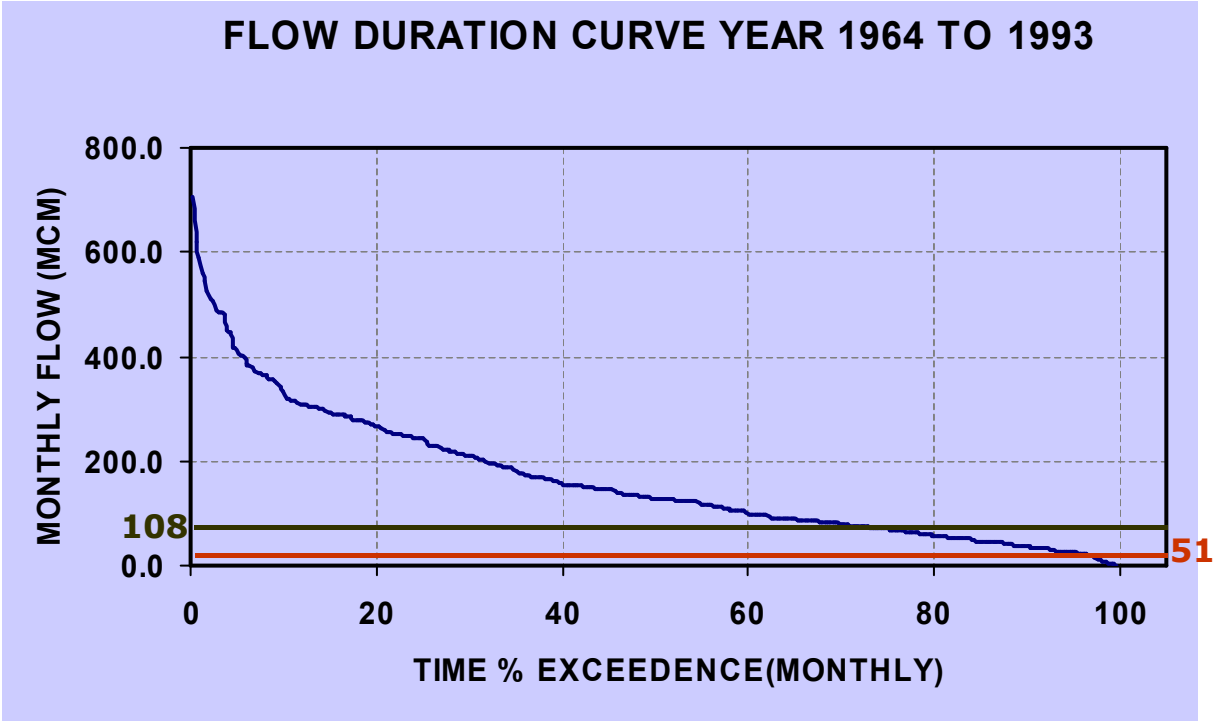
Main source - Mahaweli River, Discharge at Peradeniya,



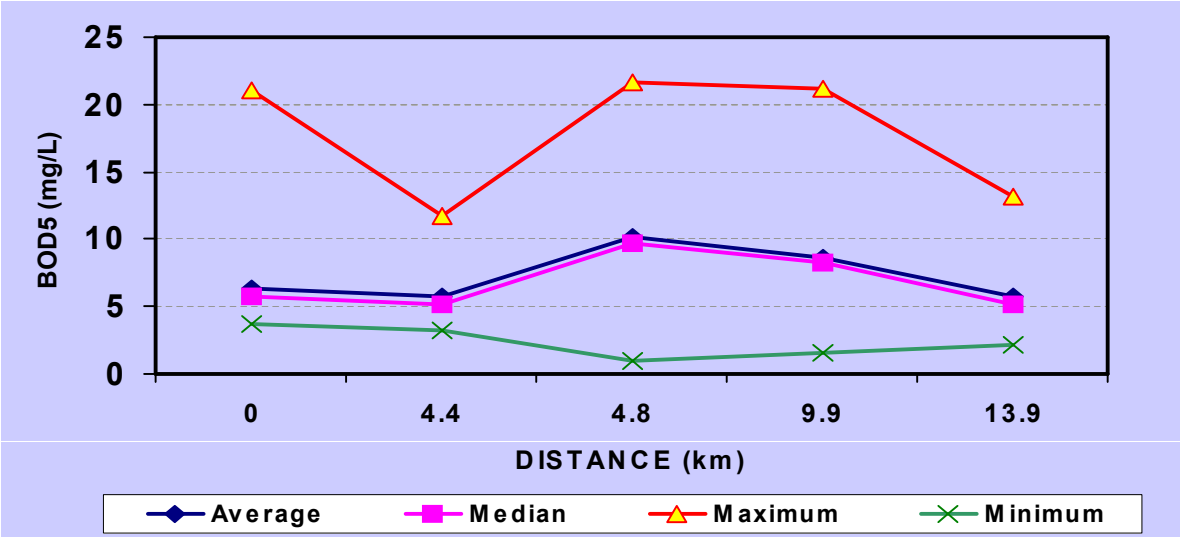
108 mcm; Requirement for satisfying the year 2020 planned supply demand with maximum irrigation requirement, **51 mcm** planned supply demand with minimum irrigation requirement

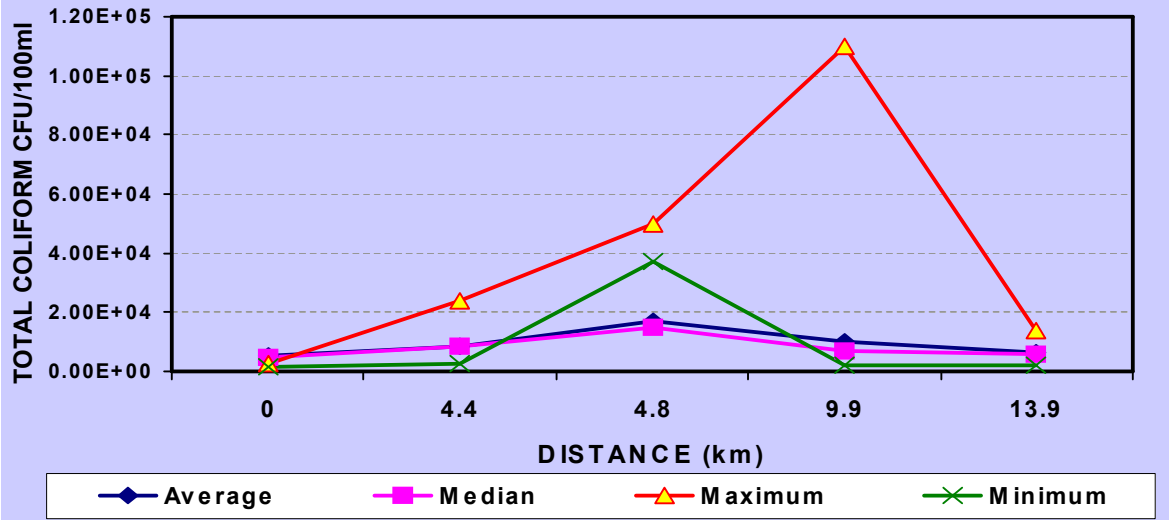
Surface water reliability

Mahaweli river at Peradeniya;



Water Quality from Peradeniya to Polgolla





Surface Water Issues

1. Reliability is low during dry months from February to April
2. Quality deterioration due to;
   - Industrial discharges in Colombo
   - Domestic discharges in Kandy/Colombo
   - Salinity intrusion in Colombo
3. Conflicting water allocation priorities between
   - hydropower generation and water supply -Colombo
   - Irrigation and water supply - Kandy
4. No proper implementation of effluent standards

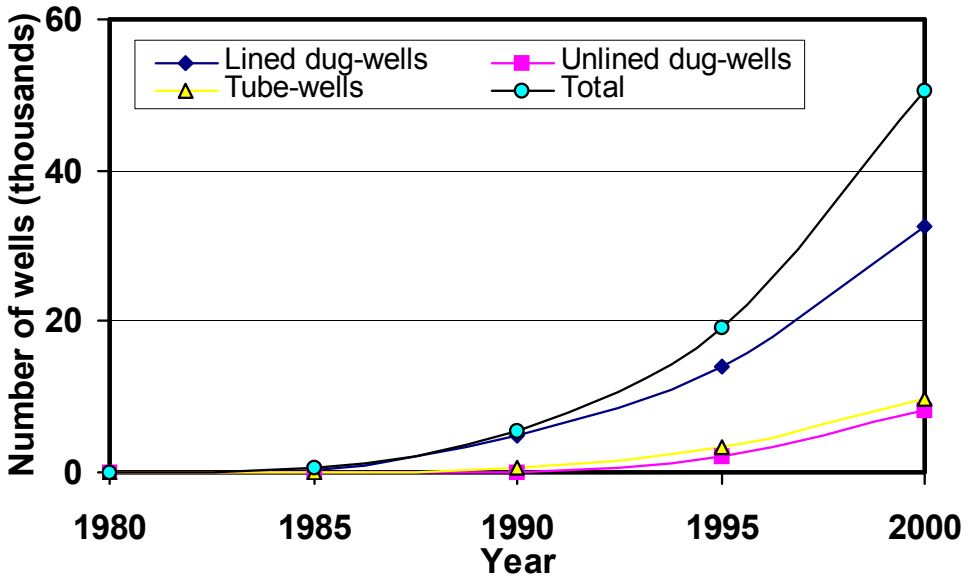
Water use in agriculture – surface water

- Main Sources – surface water diversion and rainwater collection
  - Diversions from Wet Zone of Sri Lanka
  - Rainwater harvesting through tank systems
- For the purpose of irrigation water allocation an established system exist (through water panels)
- Water Panel meets before each cultivation season for consultations and consensus (all stakeholders involved meet before and during cultivation season that include the officials from operational agencies such as power, irrigation and water supply) to monitor, plan and to take timely action if needed.
- Particularly in a Drought season they decide how to share available water quantity in the each system and adopt a method called “Bethma” system for cultivation (Part of the whole cultivation area will be shared among all farmers and manage the season. This is traditional to Sri Lanka.

Ground water - Agrowell Program

- Widely used in the dry zone of Sri Lanka
- Initially intended to irrigate during dry season using groundwater for off-seasonal cash crops
- Program was funded by both the state and by the NGOs
- Now even used to supply water for paddy cultivation
- Resulted in rapid increase of agrowells specially in the northwestern regions where surface water is lacking

Typical Agrowell



Issues

- Though initial intension was to cultivate the homesteads using agrowells, at present they are used even to irrigate paddy causing concerns of GW over exploitation
- Though this rapid diffusion of agrowells so far has had no adverse effects, few complains of water shortages reported.
- Income of farmers increased up to tenfold there by reducing migration to urban areas
- Over use of water in some area raises nutrient (Nitrate) pollution of its GW.

Irrigate using argowells
in Kalpitiya


Water supply – rural areas in the dry zone of Sri Lanka

Government Strategy – improving rural water supply

Status

- At present (2007) less that 10% of rural people (78% rural) have piped water supplies and nearly 70% have access to **so called safe water**

Strategy

- Launch as many as new large to medium scale water supply projects
- Projects to construct new water sources in addition to rehabilitation of the existing sources such as;
  - Water supply systems
  - private dug wells,
  - community wells,
  - Small water supply schemes operated and maintained by CBO's

Introduction – safe water coverage

But,

The current actual safe drinking water coverage in rural areas is estimated to be less than 40 %

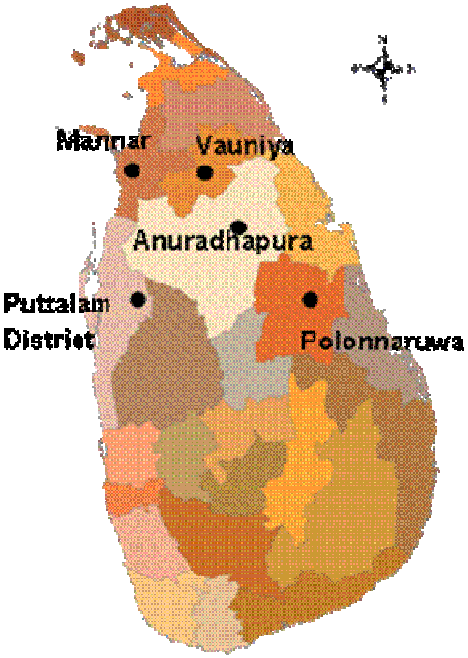
WHY???

Hence in this investigation, the groundwater quality of drinking water sources in dry-zone rural areas is analyzed to identify the possible quality issues in those regions

Profile of the study area

Population and pipe water coverage

District	Population (2001)	Supply coverage (%)	% relying on groundwater
Anuradhapura	746,000	25.5	65
Mannar	151,600	3.3	90
Polonnaruwa	359,200	19.4	70
Puttalam	705,300	11.2	90
Vauniya	149,800	4.7	90

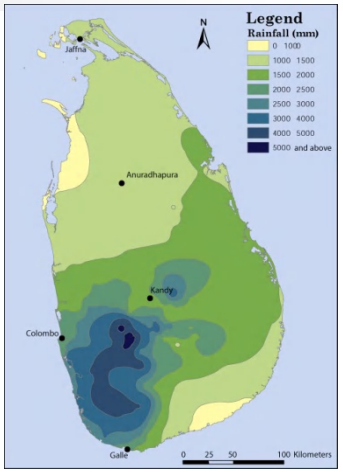


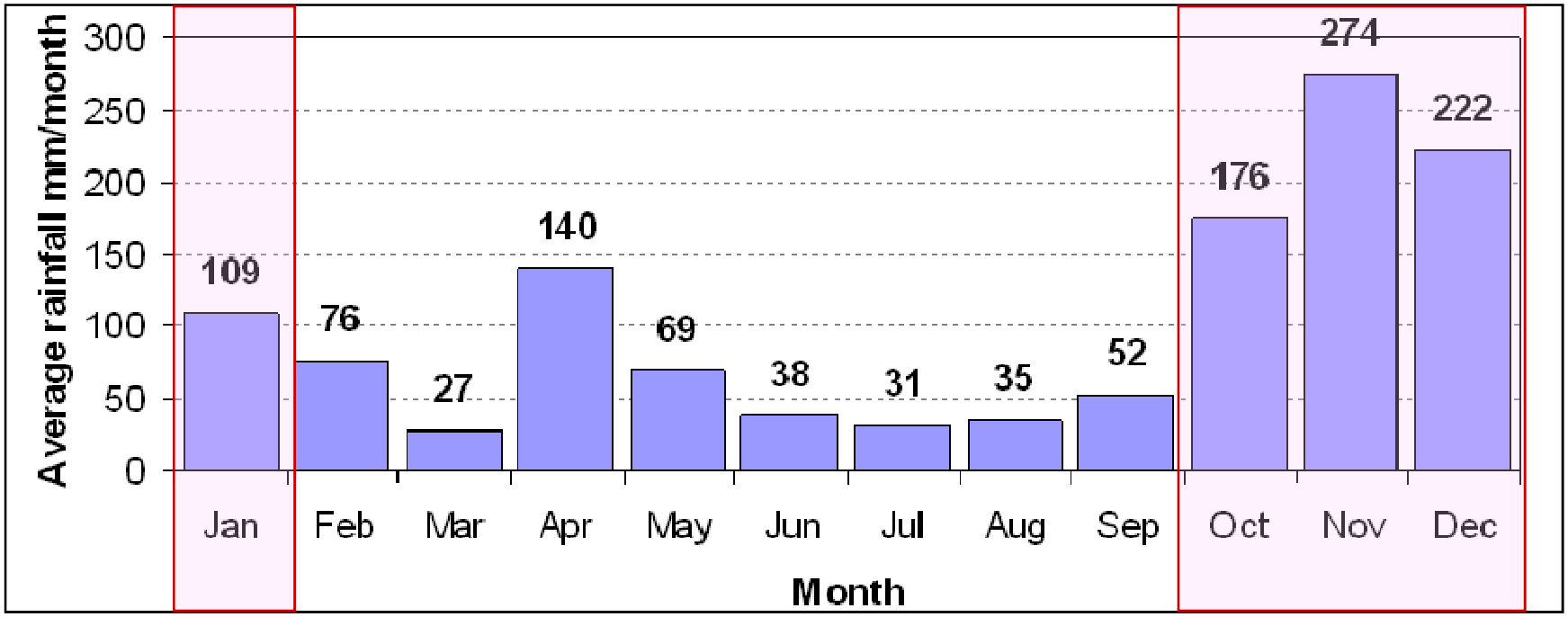
Most people rely on groundwater

Rainfall in study areas

Sri Lanka divided into three different climatic zones based on amount and pattern of rainfall received.

- Wet zone (more than 1900 mm rainfall/year)
- Intermediate zone
- Dry zone (usually less than 1500mm rainfall/year)





Monthly rainfall variation in Anuradhapura

Groundwater Quality

- Analysis done taking into account over 840 samples in the districts of Anuradhapura, Polonnaruwa, Puttalam and Vauniya
- Main parameters analyzed are; fluoride, total iron and total hardness

Fluoride levels

- It was observed that 27.8%, 30.8%, 11.1% and 34.5% of wells in Anuradhapura, Polonnaruwa, Puttalam and Vauniya districts had fluoride content in excess of the maximum permissible limit of 1.5 mg/l.
- Maximum fluoride level observed in Anuradhapura, Polonnaruwa, Puttalam & Vauniya districts are 159 mg/l, 64 mg/l, 3,132 mg/l and 3.0 mg/l respectively.

Groundwater Quality Contd.

Total Iron Content

- It was observed that 34%, 15%, 64% and 10% of wells in Anuradhapura, Polonnaruwa, Puttalam and Vauniya districts had iron content in excess of the maximum permissible limit of 1.0 mg/l
- Maximum total iron levels observed in Anuradhapura, Polonnaruwa, Puttalam & Vauniya districts are 54 mg/l, 3.9 mg/l, 79.5 mg/l and 3.5 mg/l respectively.

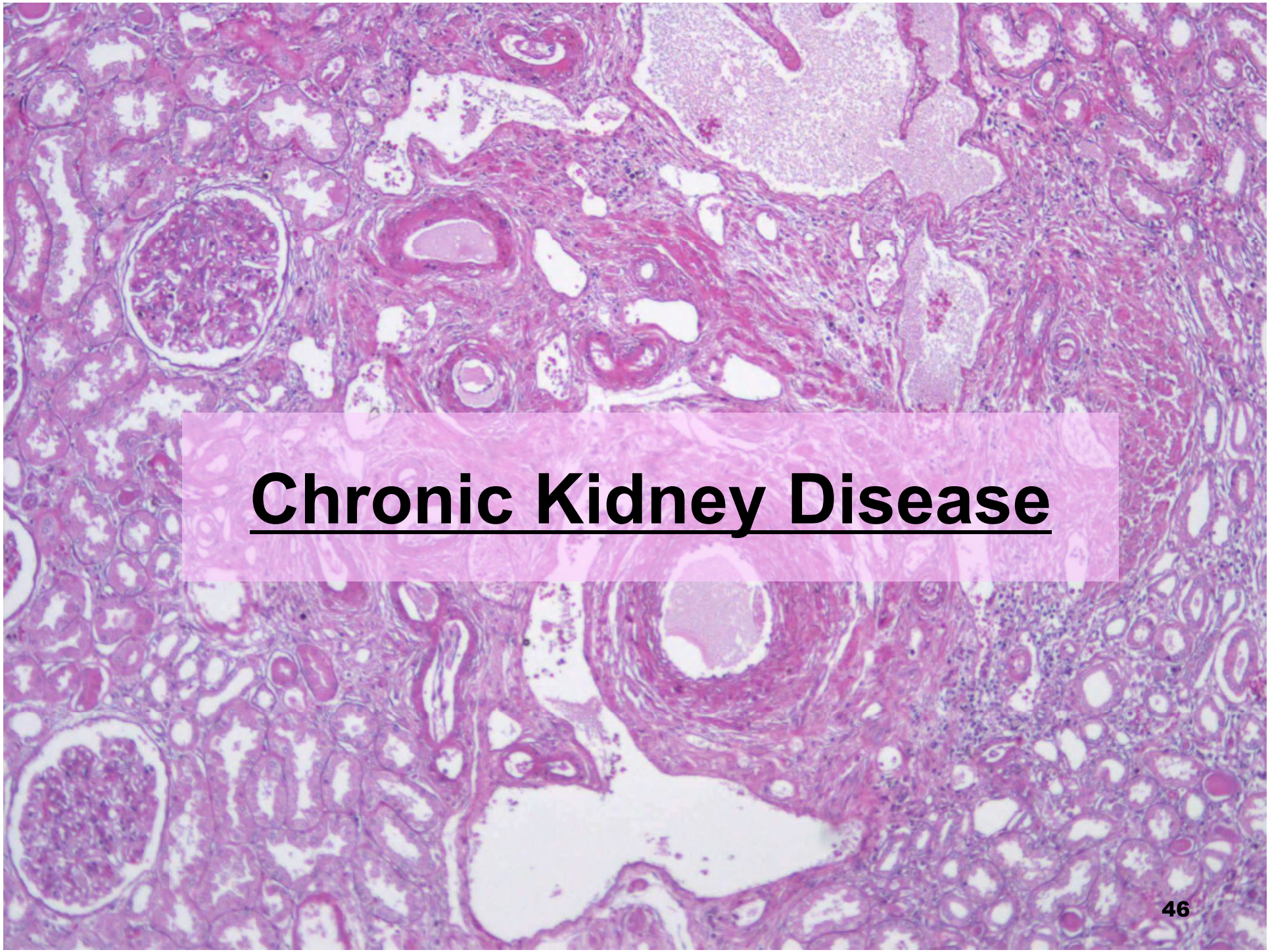
Total Hardness Content

- It was observed that 7%, 15%, 25% and 10% of wells in Anuradhapura, Polonnaruwa, Puttalam and Vauniya districts had total hardness content in excess of the maximum permissible limit of 600 mg/l
- Maximum total iron levels in Anuradhapura, Polonnaruwa, Puttalam & Vauniya districts are 1,390 mg/l, 347 mg/l, 15,800 mg/l and 1,280 mg/l respectively.

Major issues

- **Most of these wells are used by poor less educated rural population to satisfy their daily water requirements as;**
  - **They have no other alternate source available.**
  - **Authorities consider these wells as safe enough for drinking?**
  - **There is no alternate mechanism in place to prevent from using these wells**

- **The situation has given rise to many social and health issues**



Chronic Kidney Disease

Chronical Kidney Disease (CKD)

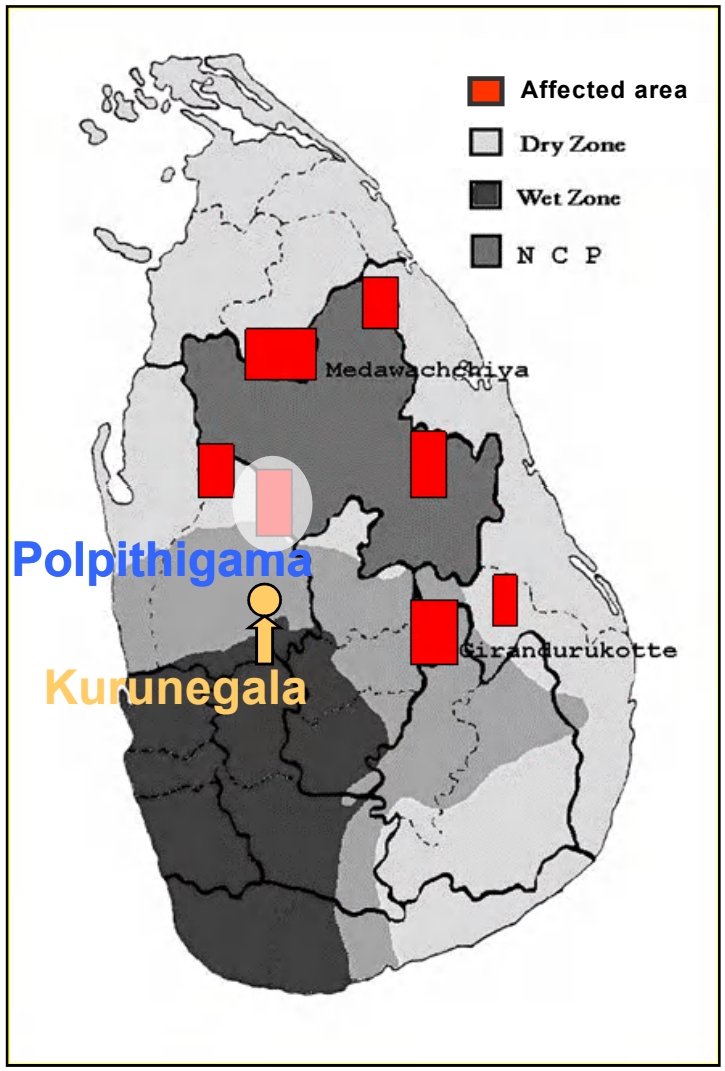
- CKD, is a disease suspected to be due to nephro-toxic heavy metals in susceptible individuals
- The source for these toxins most likely are from drinking water
- Patients affected show symptoms of Kidney problems

Chronical Kidney Disease (CKD)

Why finding the causes for CKD problem is difficult?

- Chronic toxicity is more difficult to diagnose because they often remain latent for years (especially if no specific clinical features are present)
- Cause – effect relationship is difficult to demonstrate
- Many susceptibility factors

Affected Pockets



Study area;

Polpithigama District Secretariat Division

This area is located in the Boarder of Anuradhapura District but in the Kurunegala District

A screening in the area between 2007 November and 2008 July, 621 new patients with Kidney problems identified

This amount is 7.3% of the population

68 recorded CKD deaths since 2005

Possible susceptible factors contributing to the CKD problem in Sri Lanka

- Chronic exposure to heavy metals specially from the low quality aluminium cooking utensils,
- Chronic exposure to pesticides used in agriculture activities
- Use of low quality fertilizer, where excess fertilizer leaching into the groundwater
- Interaction of chemicals in groundwater, where fluoride is suspected to be making a facilitative role
- Factors such as dehydration, poor nutrition etc.

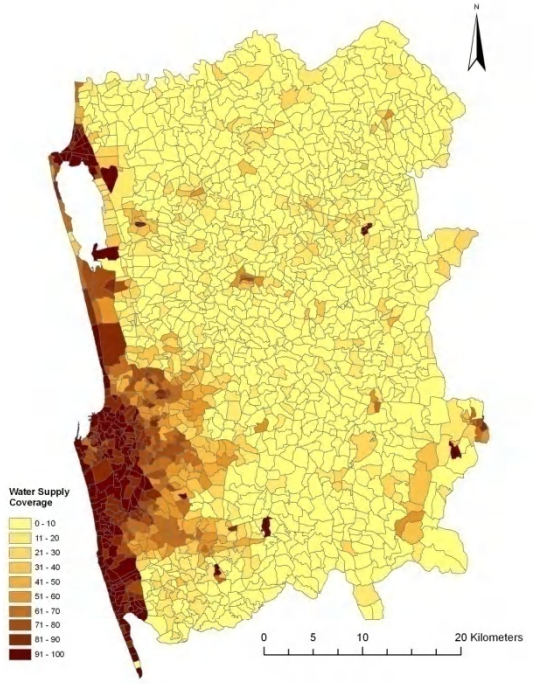
Cause for the CKD problem can be a single factor or a combination of many

Summary - Present Management Issues (main)

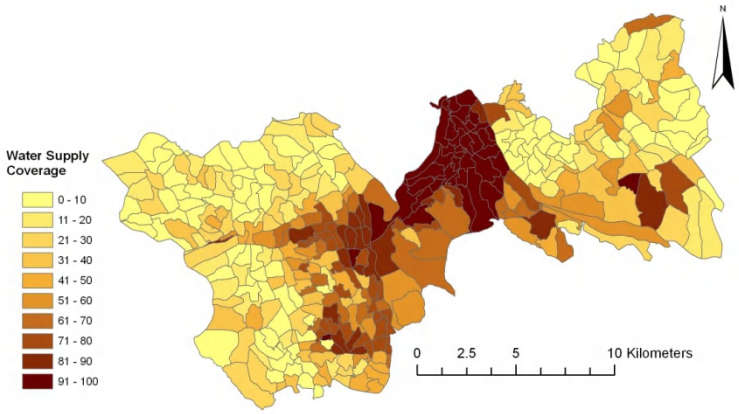
- The main issue is to meet the growing sectoral water demands for domestic, industrial, irrigation, agriculture, and hydro-power)
- Opportunities for further development of water resources are very limited because of the high cost involvements and socio economic problems.
- The existing legislation is not adequate to meet and address the country's current water issues.
- The legal provisions are scattered across a number of enactments implemented through various organizations available in the country.
- There is no single responsible authority to regulate allocation, conservation and protection of water resources.
- Poor Monitoring and water allocation procedures has made problem solving difficult
- No fixed priority system for water allocation


Thank you

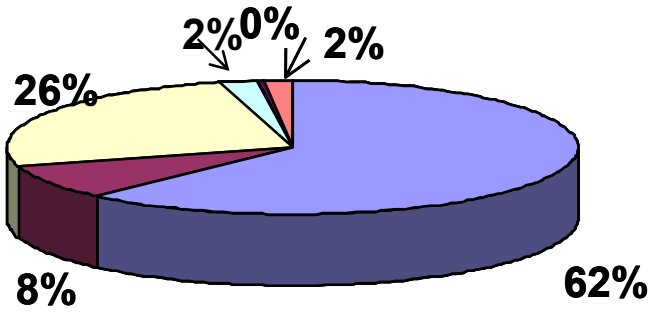
Water Coverage



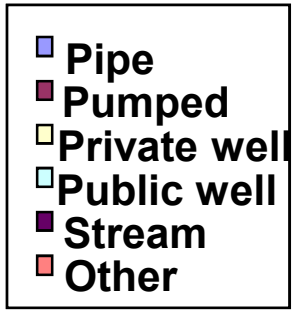
Piped water Colombo

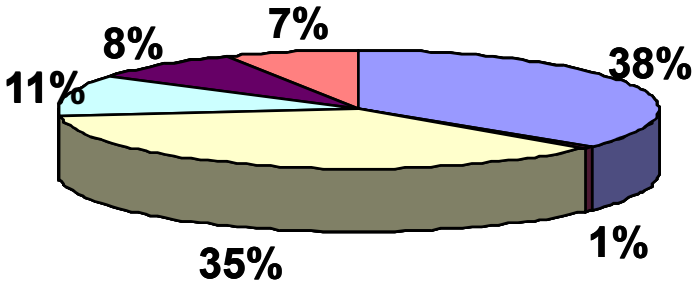


Kandy



Colombo study area





Kandy Study area