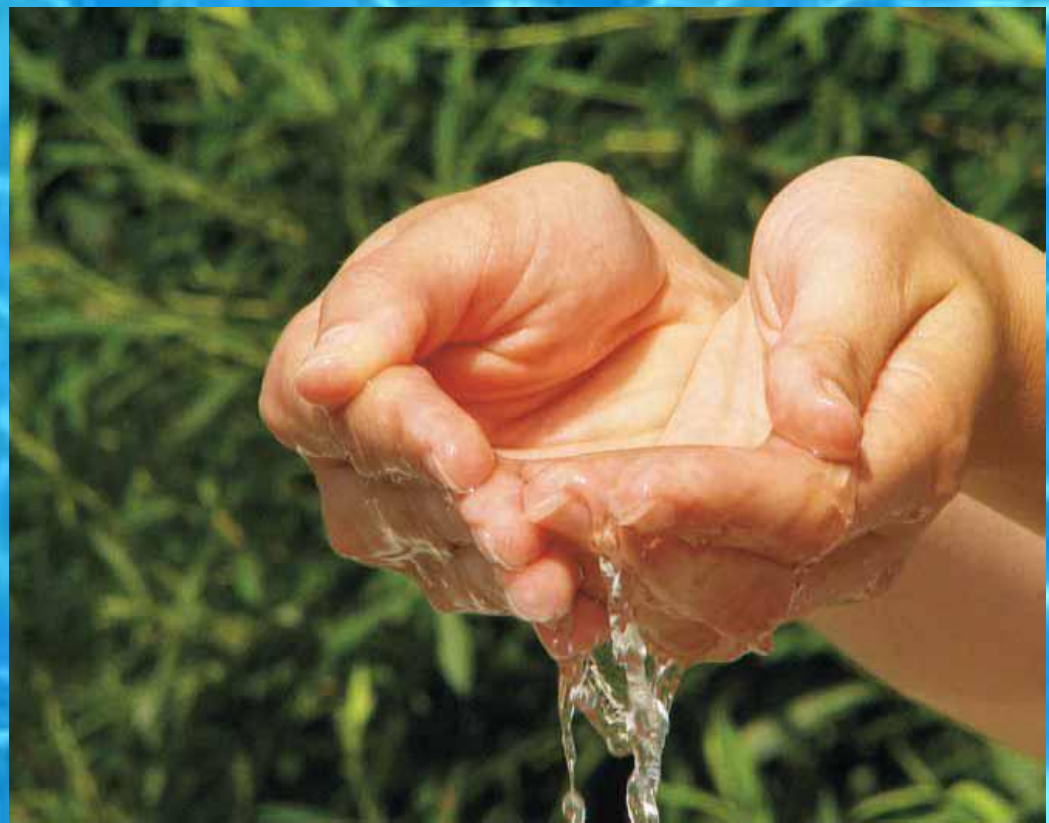
Challenges Faced by SIDS for an Ecosystem Approach to Sustainable Water Management

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Professor
Faculty of Agriculture
University of Mauritius
Réduit, Mauritius



Key Components of the Presentation

- Challenges faced by Small Island Developing States (SIDS) that constrain their quest to adopt an ecosystem approach to water resource management.
- The path taken by Mauritius to face these challenges and adopt at least a partial ecosystem approach.






The Ecosystem Approach

- A *strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.*
- SIDS have very fragile ecosystems, and this approach is an imperative for their very survival.

Characteristics of SIDS

- **Small size**, often made up of a number of smaller islands;
- **High population** densities, often concentrated in the coastal zones.
- Narrow range of **resources**;
- **Limited resources**, leading to overuse and premature depletion;
- Limited **institutional and human** capacities;

Characteristics of SIDS

- Excessive **dependence on external forces** and hence susceptible to global developments;
- Depend on **international trade** without the means of influencing the terms of this trade;
- **Vulnerable economies**;
- High **cost of production** (no economies of scale);
- Limited export volume from remote locations, leading to **high freight costs**;

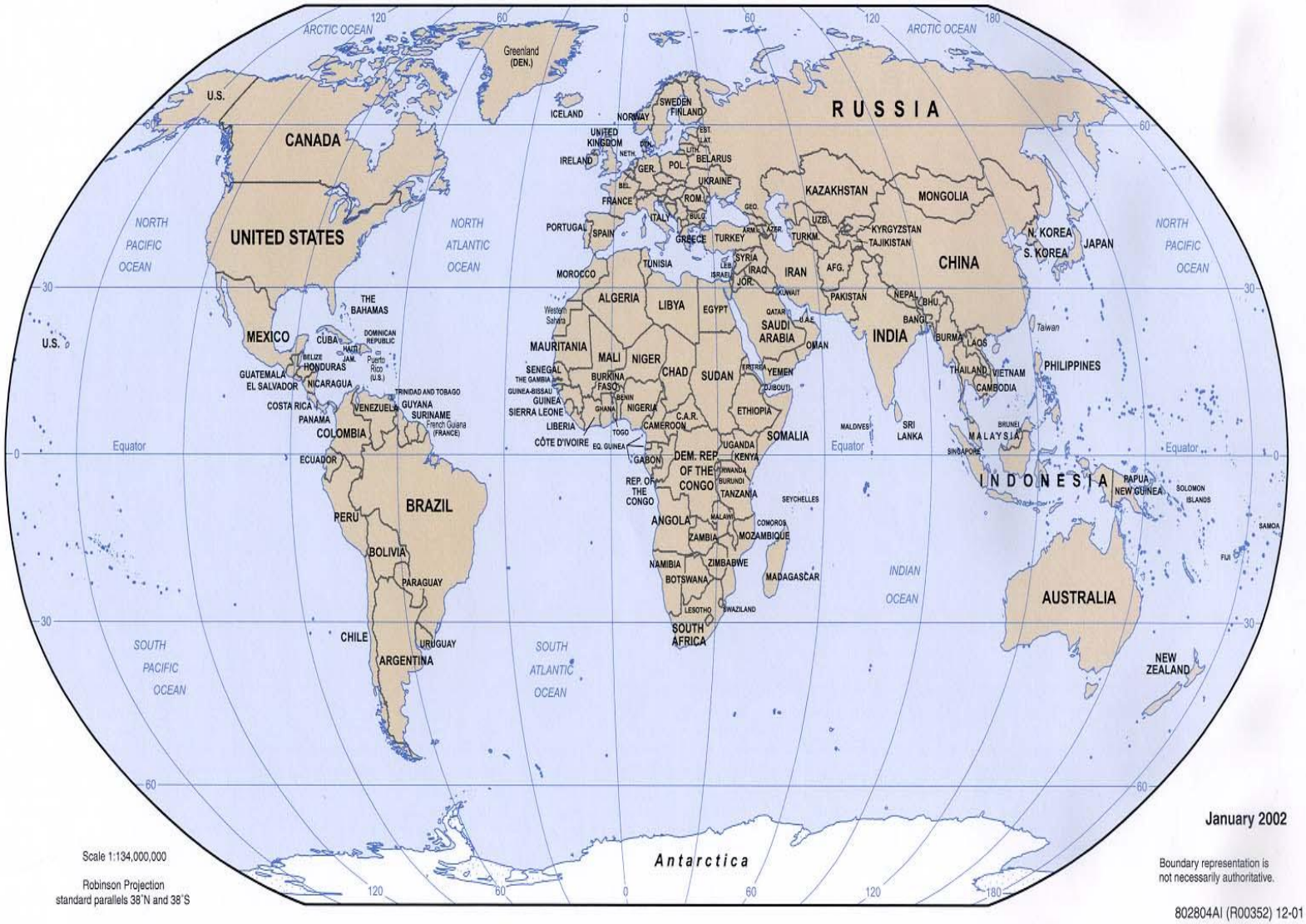
Characteristics of SIDS

- Highly **vulnerable to natural** (cyclone, tsunami, earthquake, etc.) as well as **environmental (**global warming, ozone depletion, sea level rise, etc.) **disasters** and have **limited capacity to respond** to, and recover from, such events;
- Contribute the least to **global climate change** and sea level rise and yet are among those that would **suffer the most** from the adverse effects of these phenomena.

The Bottom Line for SIDS

- SIDS have very limited room for manoeuver to meet the needs of their people, develop their economy, ensure growth and maintain a healthy environment at the same time.
- New emerging challenges such as globalisation and climate change further exacerbate these constraints.

The Case of Mauritius

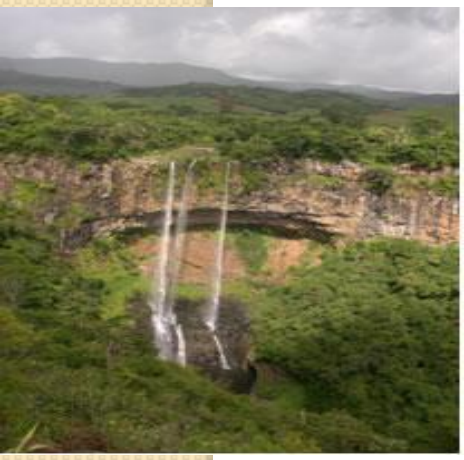

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SURINAME
French Guiana (FRANCE)
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VENEZUELA
COLOMBIA
C.A.R.
CAMEROON
TOGO
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EQ. GUINEA
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UGANDA
KENYA
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SRI LANKA
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SINGAPORE
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BURUNDI
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INDONESIA
PAPUA NEW GUINEA
SOLOMON ISLANDS
BRAZIL
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INDIAN OCEAN
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BOTSWANA
AUSTRALIA
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Guinea
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Benin
Ethiopia
Central African Republic
Liberia
Ghana
Ivory Coast
Togo
Cameroon
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Equatorial Guinea
Sierra Leone
Gabon
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Uganda
Kenya
Guinea-Bissau
Rwanda
Democratic Republic Of The Congo
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Gambia
Seychelles
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Zimbabwe
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Lesotho
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North Atlantic Ocean
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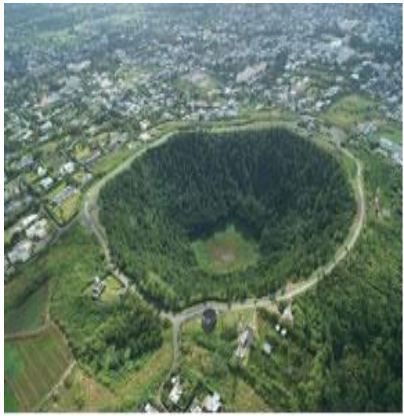







Île aux Serpents
Île Ronde
Île Plate
Îlot Gabriel
Coin de Mire
OCÉAN
INDIEN
Île Maurice
Île d'Ambre
Île de l'Est
Île aux Cerfs
Île aux Bénitiers
Île aux Aigrettes
Île Foureau









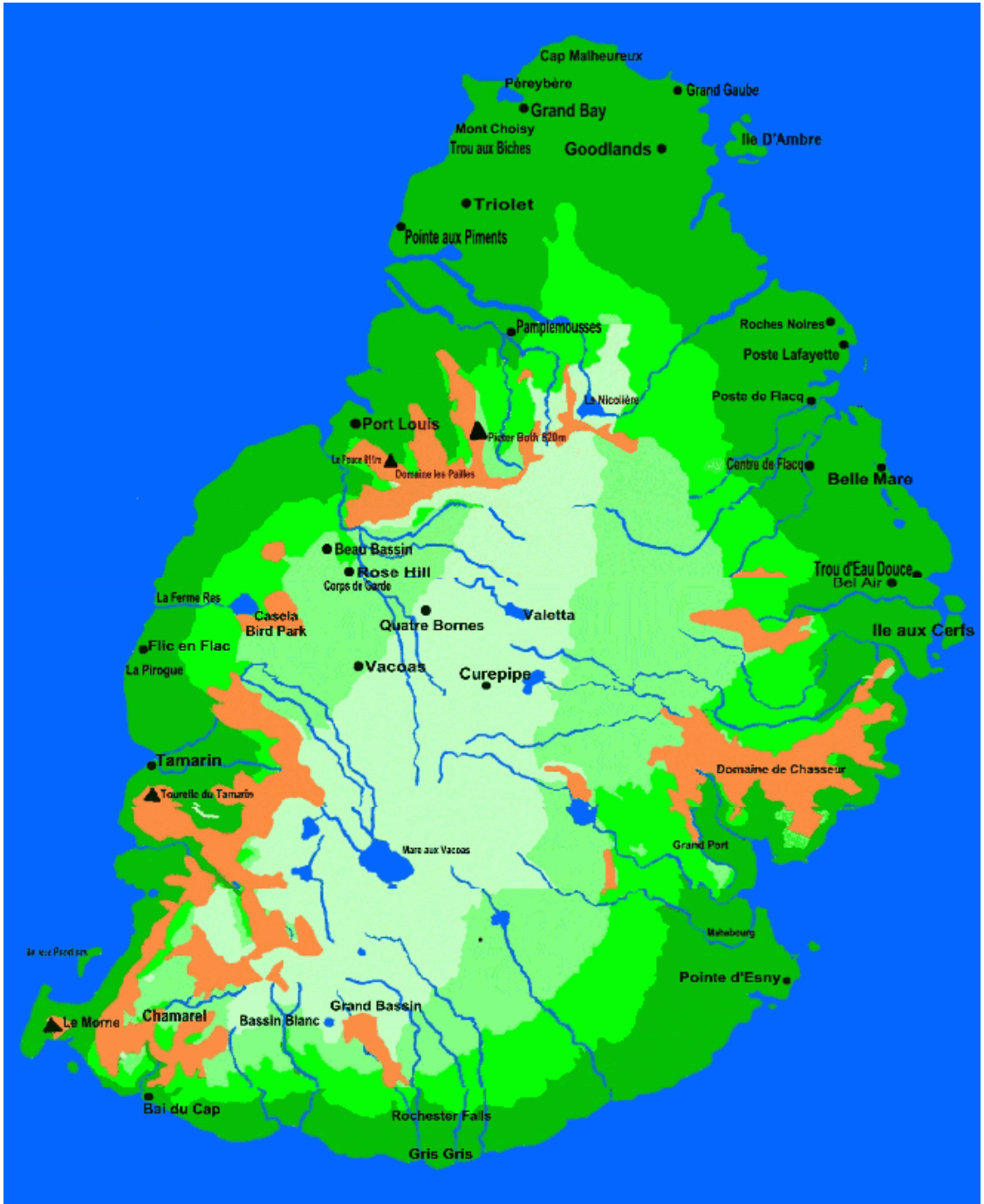











Cap Malheureux
Pereybère
Grand Gaube
Grand Bay
Mont Choisy
Trou aux Biches
Goodlands
Ile D'Ambre
Triolet
Pointe aux Piments
Pamplemousses
Roches Noires
Poste Lafayette
La Nicolière
Poste de Flacq
Port Louis
Pieter Both 820m
La Fouche 811m
Domaine les Pailles
Centre de Flacq
Belle Mare
Beau Bassin
Rose Hill
Corps de Garde
Trou d'Eau Douce
Bel Air
La Ferme Rés
Casela
Bird Park
Quatre Bornes
Valetta
Ile aux Cerfs
Flic en Flac
La Pirogue
Vacoas
Curepipe
Tamarin
Tourelle du Tamarin
Domaine de Chasseur
Mare aux Vacoas
Grand Port
Mahebourg
Pointe d'Esny
Le Morne
Chamarel
Bassin Blanc
Grand Bassin
Bai du Cap
Rochester Falls
Gris Gris

The Republic of Mauritius

- A multicultural, multilingual, democratic country, Mauritius has **1.3 million inhabitants**, and with a population density of ~ **600 persons/km^2**, is considered heavily populated.
- The country has gone up the scale from being a developing country to a **middle-income country** with a per capita GDP of ~ US$ 7,500.

Water Resources in Mauritius

- The only source of water is **rain.**
- 25 major river basins; 21 minor river basins.
- Perennial rivers, originating from the central plateau, and flowing radially to the sea.
- 5 main aquifers, 11 reservoirs and 350 boreholes.
- Average depth of boreholes = 40-60 m; maximum depth = 173 m.

Water Resources in Mauritius

- Discharge to the sea = 0.5 km^3/year.
- Total renewable water resources = 2.751 km^3/year.
- Total exploitable water resources = 1.083 km^3/year.
- North and west of the island are driest (annual precipitation 1,200 mm and 900 mm respectively).
- The Central Plateau (altitude 500 meters) receives an annual average of 4,000 mm.

Water Resources in Mauritius

- Owing to its topography, hydro-geological conditions and tropical location, Mauritius experiences **high levels of rapid run off**.
- Only 10 % of the precipitation goes as ground water recharge, while evapo-transpiration and surface runoff represent 30% and 60% respectively.
- Part of the surface runoff is conveyed to the impounding reservoirs, abstracted from rivers for domestic, agricultural and industrial uses and the remaining flows to the sea.

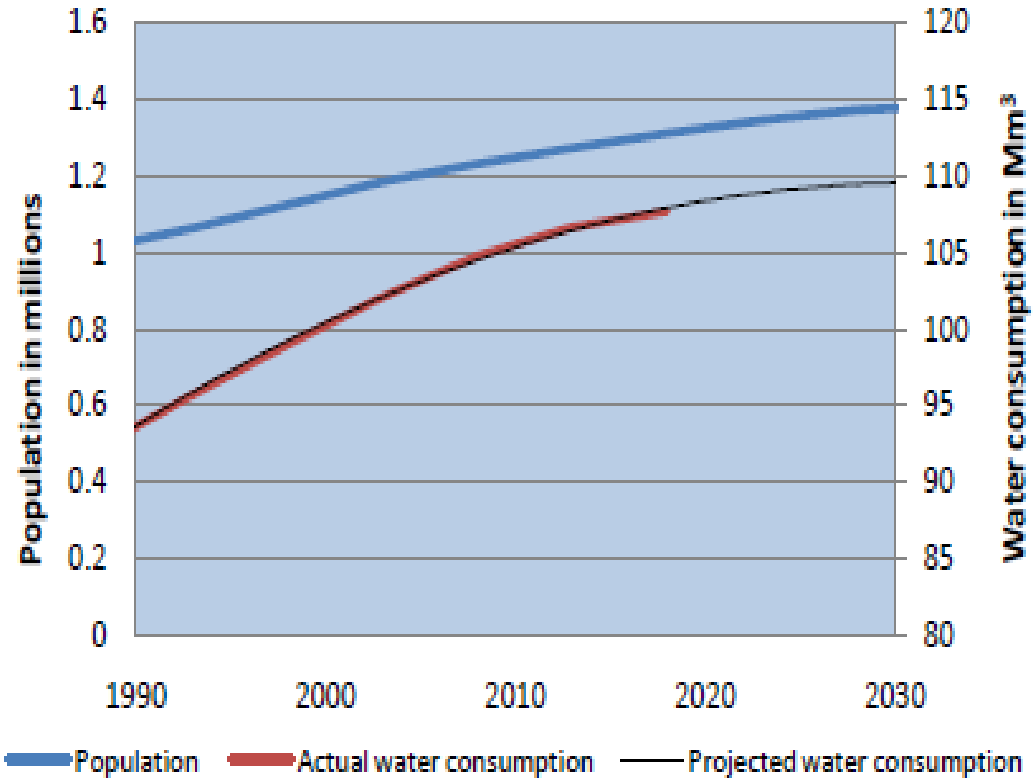
Water Resources in Mauritius

- **6** main storage reservoirs (Mare aux Vacoas, La Ferme, Mare Longue, La Nicoliere, Piton du Milieu) and the recently completed Midlands Dam.
- **3** Minor reservoirs for hydropower are Tamarin, Eau Bleue, and Diamamouve;
- **2** in-field minor storage reservoirs at Valetta and Dagotière, which regulate water for irrigation.
- Total dam capacity is **93 Mm^3**, of which Mare aux Vacoas alone has 26 Mm^3, and supplies 1/3rd of the population.

RESERVOIRS	CAPACITY (Mm^3)	MAXIMUM SURFACE AREA (Km^2)	PURPOSE
Mare aux Vacoas	25.89	5.60	Domestic
Midlands	25.50	2.98	Domestic, Irrigation
Mare Longue	6.28	1.05	Hydropower, Irrigation
La Ferme	11.52	2.28	Irrigation
Piton du Milieu	2.99	0.76	Domestic
Nicoliere	5.26	1.02	Domestic, Irrigation
Tamarind Falls	2.30	1.68	Hydropower, Irrigation
Eau Bleue	4.10	0.75	Hydropower
Cascade	4.30	0.43	Hydropower
Dagotiere	0.60	-	Mill, Irrigation
Valetta	2.00	-	Mill, Irrigation

Water Use in Mauritius

- Annual utilisation is about **1,030 Mm^3**, equivalent to about **26%** of average annual rainfall over the island.
- About **882 Mm^3** are from surface water and the remaining **148 Mm^3** from groundwater.
- Water is mainly used for :
  - Agriculture (~ 48%)
  - Hydropower (~30%)
  - Domestic, industrial and commercial (~ 21%)
  - Industrial (private boreholes) (~1%)
- **8** hydroelectric stations produce **59 MW**, and the water is thereafter available for irrigation.

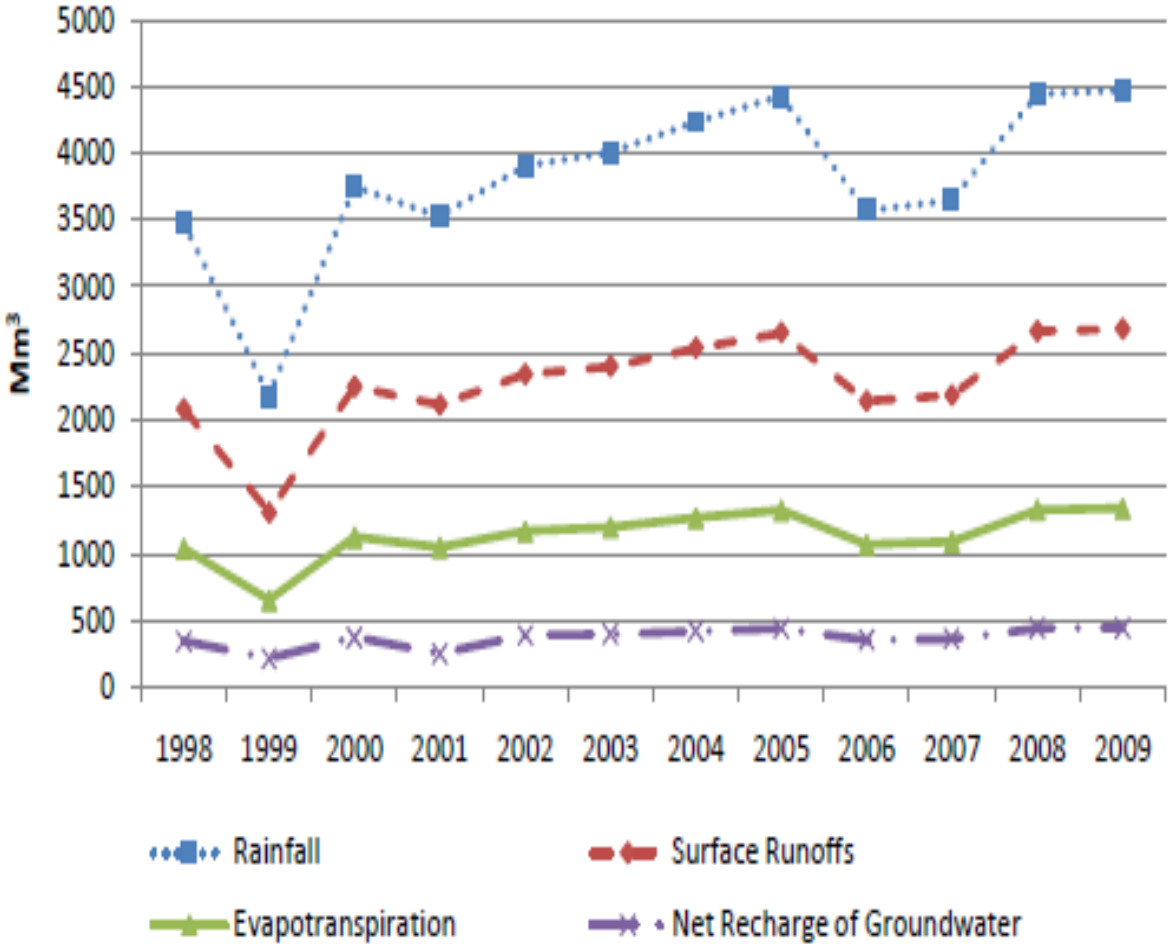


Source: CSO – Digest of Energy and Water Statistics, 2009

	Surface Water				
	Rivers	Reservoirs	Aquifers	Total Mm^3	%
Agricultural irrigation	320	74	5	399	39.9%
Hydropower[36]	199	169	-	368	36.8%
Domestic, industrial & Tourism	36	76	111	223	22.3%
Industrial (Private boreholes)	5	0	5	10	1%
Total Mm^3	**560**	**319**	**121**	**1,000**	
%	56%	31.9%	12.1%	100%	

Source: CSO – Digest of Energy and Water Statistics, 2009

Water Balance



Source: CSO – Digest of Energy and Water Statistics, 2009

- The present usable freshwater potential has been estimated at 1,233 Mm^3 per year, equivalent to **1,027 m^3/person/year,** which puts Mauritius within the water stressed category (UNDP Human Development Report, 2006).
- Mauritians use between **200 to 220 litres daily**.

Challenges facing the water sector in Mauritius

- **Small watersheds** and threatened supplies of freshwater.
- **High population densities** concentrated in area areas, increasing pressure on the already limited water resources in these regions, and increasing costs of getting the water there.
- **Unsustainable development** threatening the very livelihood of the people and their cultures.

Economic Development

Since the past twenty years, economic development and improvement in the standard of living have led to an increase in water demand.

Tourism

- Many **new hotels and industrial parks** are being built as the economy develops.
- The increase in the number of hotels, Integrated Resort Scheme (IRS) / Real Estate Scheme (RES) and bungalows along the coast have also led to **land clearing and loss of biodiversity, including loss of mangroves and wetlands.**
- This is exacerbated by the increased water demand by the **increasing tourist population.**
- This poses a challenge to the water sector in terms of the **additional water** required on one hand, and the **impact on the watershed**, on the other.

Deforestation, Soil Erosion and Siltation

- Significant **erosion of top soil** by rainfall following **deforestation** has occurred in most regions of Mauritius.
- This top soil gets deposited either in the lagoon or water reservoirs. Part of it is deposited in natural river basins or reservoirs which are now **filled with silt**, e.g. La Nicolière reservoir.
- Fresh water ecosystems have also been affected by this, with many species of fish, shrimps and aquatic plants having disappeared.



Destruction of Wetlands

- Wetlands play a very important role in ecosystem balance and regulation.
- They act as **buffers against floods**, storing rainwater and then slowly releasing it.
- Wetlands can be efficient, low cost, water **purification systems**.

Destruction of Wetlands

- Many wetlands have been **drained and built over,** especially the coastal wetlands for hotel development.
- Wetlands in Grand Baie and Flic en Flac have been to a great extent destroyed by tourism development projects.
- This has resulted in **serious imbalances in its ecology.** The wetlands now no longer act as a regulator of tides and floodwaters during heavy rains and so there is a grave risk of flooding during the rainy season.

Destruction of Wetlands

- The blockage of natural drains has led to a **rapid rise in the water table** during the wet season, and at Grand Baie where the water table is only one metre deep, **contamination with faecal coliforms** has been recorded.
- Similar problems are suspected in the regions of Flic en Flac, Baie du Tombeau and Pereybere due to hotel development on wetlands.

Sugar Mills

- Until recently, there were **19 sugar mills** , half of which were found close to the sea or to rivers.
- Until the early 90s, the **liquid waste** from cane crushing operations was discharged into rivers and streams **without prior treatment**, resulting in damage to the aquatic life.
- In the 90s, **decantation ponds** were built for the primary treatment of effluents before discharge into the environment.
- Presently the sugar milling has been concentrated into **5 mills,** with the others having been converted for **tourism** purposes and for **property development**.

Industrial Effluents

- Dye houses, soap, detergent and chemical manufacturers, galvanizing, food canning and ethanol distilleries, tanning, etc. are some of the main industries, and their **effluents undergo only pre-treatment.**
- For coastal industries, the effluent is discharged **600-800 metres** into the sea through a sewerage outfall.
- **Contamination** of aquifers by such discharge methods is a distinct possibility.
- The small size of the island mean that very quickly water sources can be adversely affected by **effluent pollution.**

Agriculture and Food Security

- Deforestation leading to soil erosion.
- Heavy irrigation in some areas.
- Discharge and leaching of fertilisers have promoted algal proliferation and **eutrophication** in many water bodies, and some coastal regions, while **pesticide leaching** has killed most of the aquatic organisms and unbalanced the aquatic ecosystems.
- 77% of the food is imported – **virtual water**.

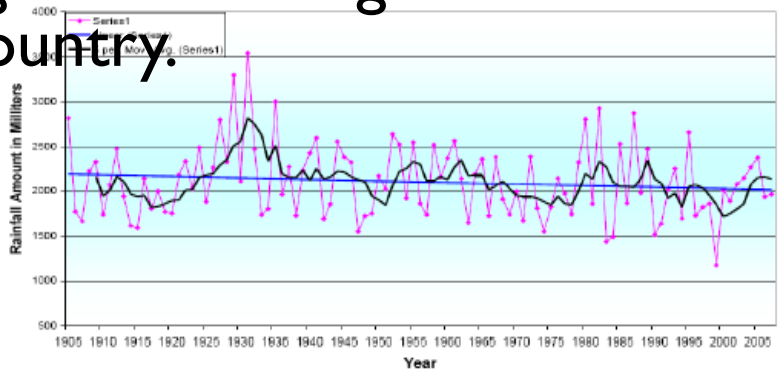
Exotics and Invasives

- Although the Rivers and Canals Act prohibits any planting in a 50 feet strip bordering a river, this regulation has not been implemented since several years, with the result that many of the **riparian borders** have become overgrown with **invasive** plant species.
- Exotics and invasives have heavier water demand than indigenous species, and have affected the ecohydrology in many regions, e.g. ***Ravenala madagascarensis***



Climate Change Impacts

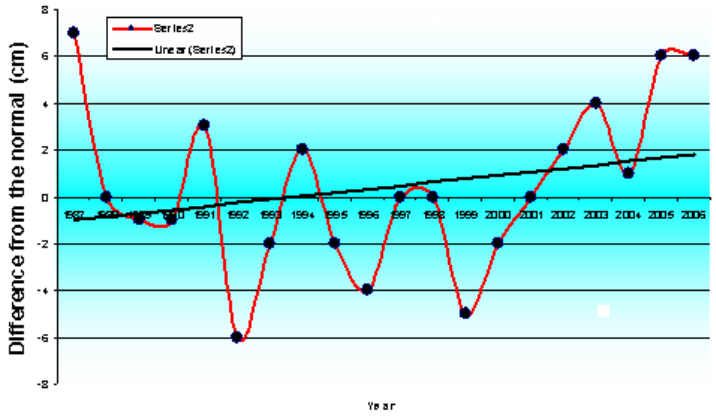
- Rainfall is decreasing (by 8% in last 50 years).
- While in the 60s and 70s summer rains used to start by November, they are now occurring in March.
- The number of rainy days has decreased but the frequency of heavy rainfall events has increased.
- All of which necessitates increasing storage capacity.
- Furthermore, the Central Plateau with the largest catchments in the common recharge zones has seen a significant decrease in rainfall.
- This is reflected in changes in ground water and river-flow regimes, making water management a major challenge for the country.

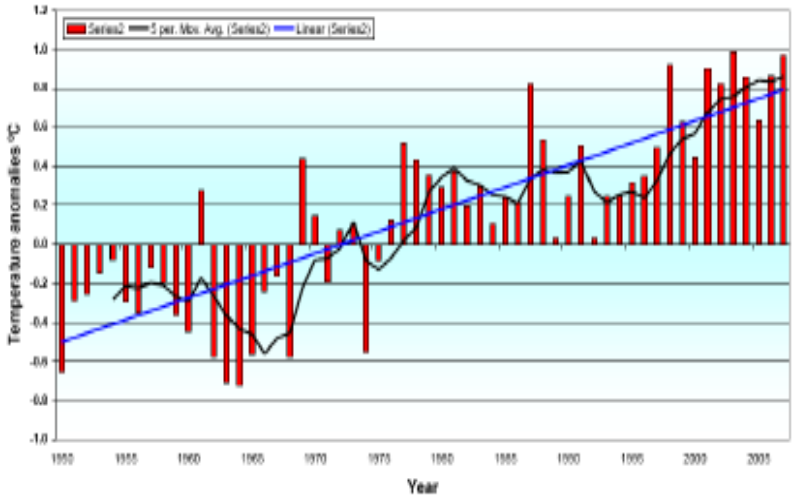


Source: Meteorological Services, March 2009

Climate Change Impacts

- Average temperatures increased by 0.74°C on high ground and by 1.1°C in coastal areas, compared to 1961 - 1990 long term mean.
- Rate of sea level rise in Port Louis has averaged 3.8 mm/year over the last five years.
- Overall, mean sea level rise during the past decade has been around 1.2 mm.

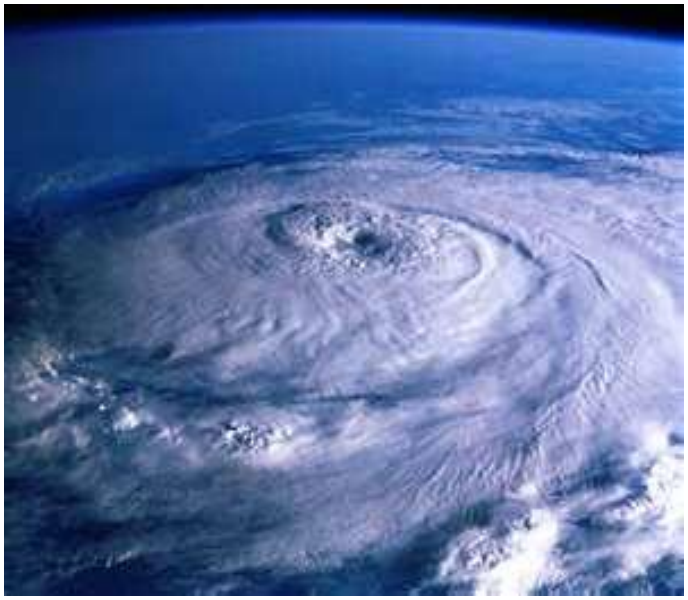




Source: Meteorological Services, March 2009

Climate Change Impacts

Sea level rise and excessive water abstraction from boreholes is beginning to lead to **saline intrusion** and **inundation** of certain low-lying coastal areas, affecting the watershed in these areas.



Since 1975, increasing trend in the number of intense cyclones.

Sea Level Rise

- Sea level rise is also resulting in :
  - flooding of low-lying areas;
  - Salinisation of coastal ecosystems;
  - Salinisation of soil;
  - Loss of beaches, which will affect tourism.
  - Reduction of tourism will affect foreign exchange earnings;
  - Costs of protecting beaches and other ecosystems is increasing.

Climate Change Impacts

- CC is increasing **evaporation** and **evapotranspiration.**
- CC related events may result in death of some tree species, make others more susceptible to insect infestation, increase the likelihood of fires, etc. , all of which can result in **large-scale die off** of forest stands.
- This can have significant repercussions on the **ecohydrology** of the area, although it is known that land use change in watershed area and streamflow response is **not linear**; **thresholds** exist for the minimum proportion of a watershed that must be altered to elicit a detectable change in streamflow.

Other issues

Fragmentation of Responsibilities

- Central Water Authority
- Water Resources Unit
- Irrigation Authority
- Forestry Service.

Non-Revenue Water

- Illegal abstraction
- Losses in distribution system due to leakages

The Path Taken by Mauritius

- In Mauritius, a specific, stated ecosystem approach to integrated water resource management has not yet been adopted (e.g. South Africa's 1998 Water Act which provides priority water allocation for the environment as an Environmental Reserve).
- However, a number of measures undertaken, or being undertaken, contribute directly and indirectly to watershed management and protection, and partially constitute an ecosystem approach to IWRM.

Summary of Key Actions

Scientific

- Better management of soil moisture, e.g. sustainable agricultural practices such as mulching, pit planting, shading, use of compost.
- Controlling soil erosion through terracing, planting specific plants and cover crops, mulching, planting trees as hedgerows and buffer strips.
- Rainwater harvesting
- Enhancing storage, building dams and reservoirs.
- Research on drought and pest resistant crop cultivars and animal breeds.
- Creation of vegetation corridors and strip lines.
- Making multiple use of water : aquaculture in irrigation reservoirs, aquaponics.
- Integrating crop- tree- livestock systems in dry ecosystems. (agroforestry, agrosilvopastoral).
- Reusing agricultural wastes, to increase the amount of food produced without increasing the amount of land and water resources required.
- Preventing and minimising pollution of freshwater ecosystems.
- Extending forest cover by reforestation of strategically selected areas.
- Replacing exotic plantations by native species up to 50%.
- Creation of ecotone buffering areas to prevent groundwater and surfacewater pollution.
- Creation of artificial wetlands (constructed wetlands).
- Interbasin transfers.

Social

- Engaging local communities for sustainable use and management of water, e.g. small-scale, individual and community-based water harvesting and storage.
- Providing free seedlings of indigenous species under the 'Plant a tree' campaign.

Policy

- Rescheduling quantum and timing of water supply.
- Water pricing
- Pricing for waste water management
- Providing incentives for rainwater harvesting
- Penalties for certain water use, washing cars, watering lawns.
- Upgrading of villages into towns to prevent migration.
- Watershed governance.

Capacity Building

- Developing institutions for integrated water resources management; enable coordination for IWRM and the multipurpose use of water.
- Education, training, public awareness campaigns.

New Sources of Water

- Freshwater from deep in the sea for drinking and in industries (e..g cold storage, air conditioning plants).

Better management of soil moisture, e.g. sustainable agricultural practices such as mulching, pit planting, shading, use of compost, insect traps













Controlling soil erosion through community-managed agroforestry, planting specific plants and cover crops, mulching, planting trees as hedgerows and buffer strips.



Agrosilvopastoral system



Agroforestry systems











Watershed management through an integrated crop-tree-livestock system, community water harvesting, mulching, terracing, buffer stripping, cloud water





Close up view of a community water harvesting device

Making multiple use of water

- Aquaculture in irrigation reservoirs
- Aquaponics (hydroponics + aquaculture)
- Constructed wetlands in hotels
- Constructed wetlands as ecotourism sites

Rainwater Harvesting

- Government provides upto 40% (upto a max of 3,000 USD) to each farmer to build rainwater harvesting mechanisms in their field.
- Taxes removed on household rainwater harvesting devices.
- Very well developed in the island of Rodrigues where every house has a rainwater harvesting device.

Wastewater reuse and desalinisation

- About 100,000 m^3 of waste water is treated daily and then mixed with raw water and used to irrigate sugar cane.
- In the island of Rodrigues, desalinisation plant has been set up for potable water.
- Hotels with a certain capacity are required to treat and reuse their waste water for toilets, and for irrigating lawns and golf courses.
- Some hotels have also invested in desalinisation plants.

Extending native forest cover

- Reforestation of watershed areas.
- Replacing exotic plantations by native species up to 50%.
- Creation of ecotone buffering areas to prevent groundwater and surface water pollution.
- Providing free seedlings of indigenous species under various tree planting schemes and campaigns.

UNEP/GEF WIO-LaB Project (2004-2010)

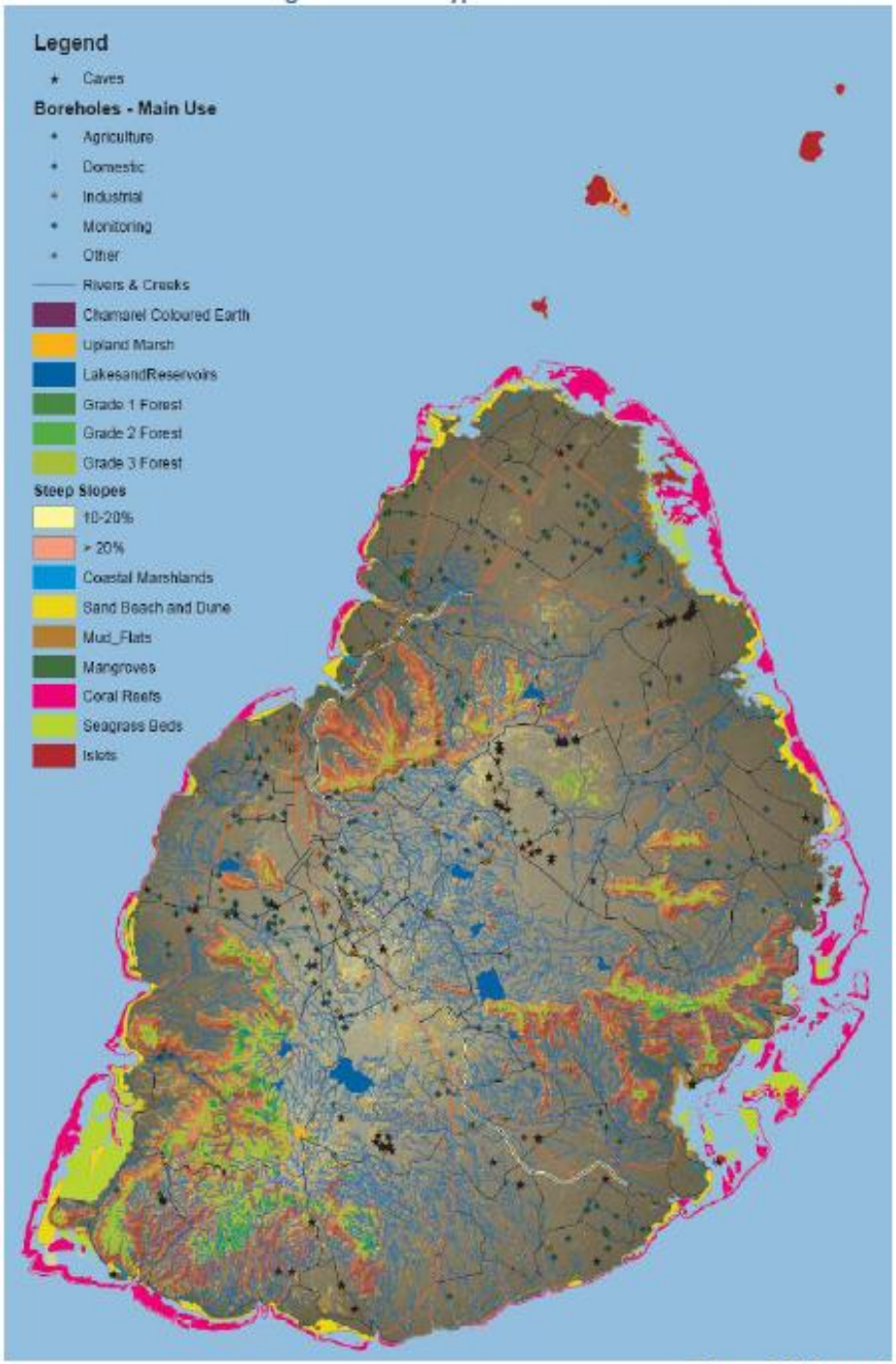
- Planting of native species in the Black River Gorges National Parks to control soil erosion and prevent downstream sedimentation of the Le Morne lagoon through the Black River.

R & D

- Drought and pest resistant crops and heat tolerant animal breeds.

Identification of ESAs

Recommendations of the ESA Study to be implemented soon



Source: ESA Strategic Plan, 2009



Reducing leakages in pipes



Adjusting timing and quantum of water supply





Provision of water in bowsers in some areas

Exploring new sources of water

- Bringing up very cold water (1-4°C) from within deep in the ocean for coastal industries, e.g. for large scale air conditioning.
- Tapping freshwater streams deep in the ocean.

Social instruments

- Engaging local communities for sustainable use and management of water, e.g. small-scale, individual and community-based water harvesting and storage, planting indigenous trees, education, training and public awareness.

Policy Instruments

Water pricing :

- Cost of wastewater management is included in the water bill (1:1 ratio).

Policy Instruments

- Adhoc pricing measures : e.g. as at Feb 2012, Mare aux Vacoas was filled only to 23%.
- Anyone using a hosepipe to wash their car or water their lawns was liable to a fine of Rs 50,000 and imprisonment not exceeding two years.
- This was rescinded in April 2012, when the rains came, and reservoirs filled up.

Protected Areas

- The Rivulet Terre Rouge Estuary Bird Sanctuary (RTREBS) was declared as a Nature Reserve in 1999 and designated as a Ramsar Site in 2001.
- Around 1000-1200 migratory birds representing 11 regular species and 4-5 vagrant species visit RTREBS each year.

Interbasin transfer

- A pipeline was built to transfer 25,000 m^3 /day from Mare Longue reservoir to Mare aux Vacoas reservoir since Oct 2011.

Water Rights & Watershed Governance

- Govt has given some areas to individuals on long term lease and the water rights to any borehole or water body therein belong to the leasee, who is then also responsible for maintaining it with the help of designated Govt authorities.
- Even on freehold land, Govt retains management rights of any water body therein.
- In cases of acute water shortage, Govt has the right to take over the borehole/water body in the land concerned.

Reduce rural-urban migration

Declare 5 of the largest villages as towns

(has been discussed in Parliament, but not yet implemented).

Policy Plans

- An Integrated Water Resources Management Plan has been developed to improve water management.
- Integrated Watershed Management Plan is being recommended to conserve water catchment areas to ensure long term sustainable water availability.

Conclusion

- SIDS are more vulnerable than other countries to economic, water, food, and environmental issues, and must imperatively find ways to reconcile these essentials.
- Mauritius is attempting to reach the ecosystem approach to IWRM through a series of scientific, policy, legal, social, and institutional measures.
- In the near future, these are expected to be formalised as part of the proposed Integrated Watershed Management Strategy and Action Plan.

Thank You

Obrigada

Gracias

Merci



