Wateropleiding “Integraal Waterbeheer”

17 July – 11 August 2023

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Module 2: Water Supply and Water Use

Theme: Suriname water resources and global sustainability, status and treats

Part 1: 19 July 2023 (fysiek)

Part 2: 26 July 2023 (on-line)

ZUILEN L.

19 JULI 2023

Suriname water resources and global sustainability, status and threats:
Part 1 - Subjects

- Overview of how much surface and groundwater is available in Suriname and where the aquifers occur
- Water use for various purposes such as consumption, agriculture, industrial purposes, transportation, recreation, conservation of ecosystems, etc.
- Basic information about the history of global water resource development.
- Basic principles of water resources planning and management.
- Tools and techniques in water resources management.
- River basin planning, modeling and analysis.

Suriname water resources and global sustainability, status and threats:
Part 2 – Subjects

- Basic information and applying processes of flood and drought management
- Need to balance ecological sustainability with developing water resources for human use
- Identify human activities that can affect water quantity and quality
- Strategies to minimize the negative impacts of human activities on water resources.
- Natural state of water resources and the threats to these resources
- Need for integration of different actors in water resources management.

Introduction

- Demand for freshwater resources has rapidly increased due to ever-increasing human populations and economic development.
- For this reason, managing our water resources to meet domestic and industrial water needs, sustainable agriculture, and a productive environment for all living organisms is vital.
- What are water resources ?
- Which water resources we have?
- How much water is available?
- How the water resources are / can be managed?

Water resources

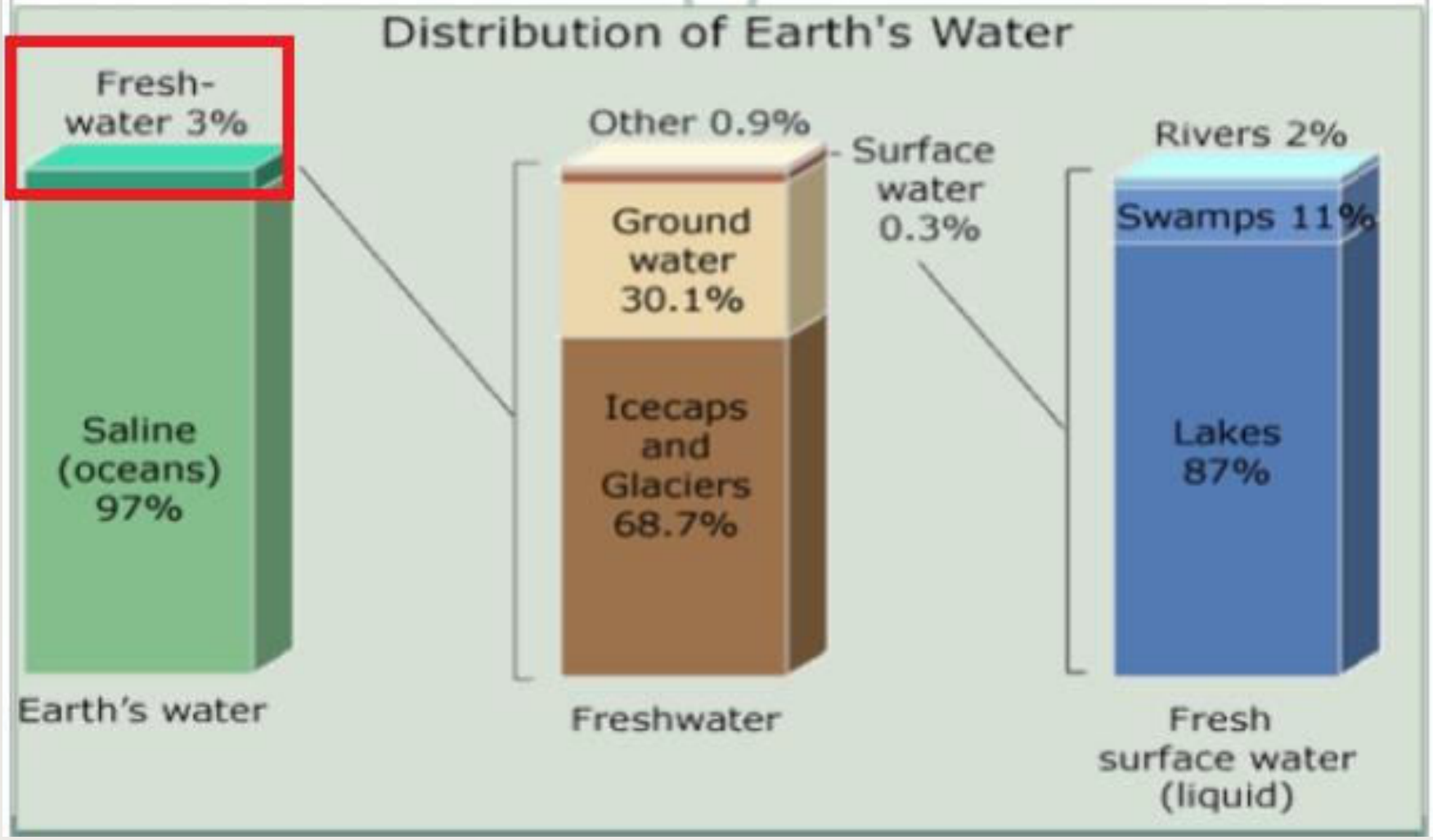
- Wat are water resources?:
- A water source refers to bodies of water (such as rivers, streams, and ground water) that are potentially useful for humans: e.g. drinking-water supplies, irrigation water, etc.

Importance of Water Resources

Below mentioned is the importance of water resources in points:-

- It is significant since life cannot survive without it.
- Agricultural, commercial, household, leisure, and environmental activities all use water in some way.
- Almost all of these human uses necessitate the use of freshwater.
- Freshwater makes up just 2.5 percent of the Earth's total water, and over two-thirds of it is frozen in ice caps and glaciers.
- In several regions of the world, water demand currently exceeds availability, as well as many other areas, are prepared to face this deficit in the near future.
- Irrigation in agriculture is expected to account for 70% of global water consumption.

Distribution of water on Earth



Where and in what forms is water available in Suriname?

- How does water move from the **atmosphere** to the ground and back?
  - Precipitation
  - Evaporation and transpiration
- How is freshwater found at the **surface**?
  - Rivers and streams
  - Lakes (Brokopondo lake)
  - Wetlands (swamps)
- How freshwater can be found **underground**?
  - Groundwater

Key water resources in Suriname

- Suriname is rich in hydrologic resources.
- Its abundance of water is considered "**white gold**"
- Key water resources are**: Groundwater, Surface water and rainwater**
- Types of water resources: There are **renewable and nonrenewable** water resources.
  - Renewable water resource is the average **flow** of rivers, lakes, and aquifer **recharge** produced from the process of precipitation.
  - Nonrenewable water resources are deep aquifers or groundwater that possess a **minor recharge rate** on the human time-scale. Therefore, it can be nonrenewable.

Water resources

- **QUALITATIVE TERMS**:
- Water resources in Suriname are grouped in: saline, brackish, fresh water
- **Fresh water =**
  - maximum total dissolved solids (TDS) 1,000 milligrams per liter (mg/L);
  - maximum chlorides 600 mg/L;
  - maximum sulfates 300 mg/L
- **Suriname identified as one of world's top two sources of fresh water**

- Brackish water = maximum TDS >1,000 mg/L but 15,000 mg/L
- Saline water = TDS >15,000 mg/

Suriname: The freshwater resources can be divided into:

- Natural freshwater resources, including rivers, creeks, swamps and marsh covering 12,000 km2, discharging 4,975 m3 per second into the Atlantic Ocean
- Manmade Brokopondo Lake, a hydropower facility, covering 1,560 km2.
- Groundwater

How much surface and groundwater is available

Between 1971 and 2020, Suriname volume of groundwater produced remained stable at around 90 billion cubic meters.

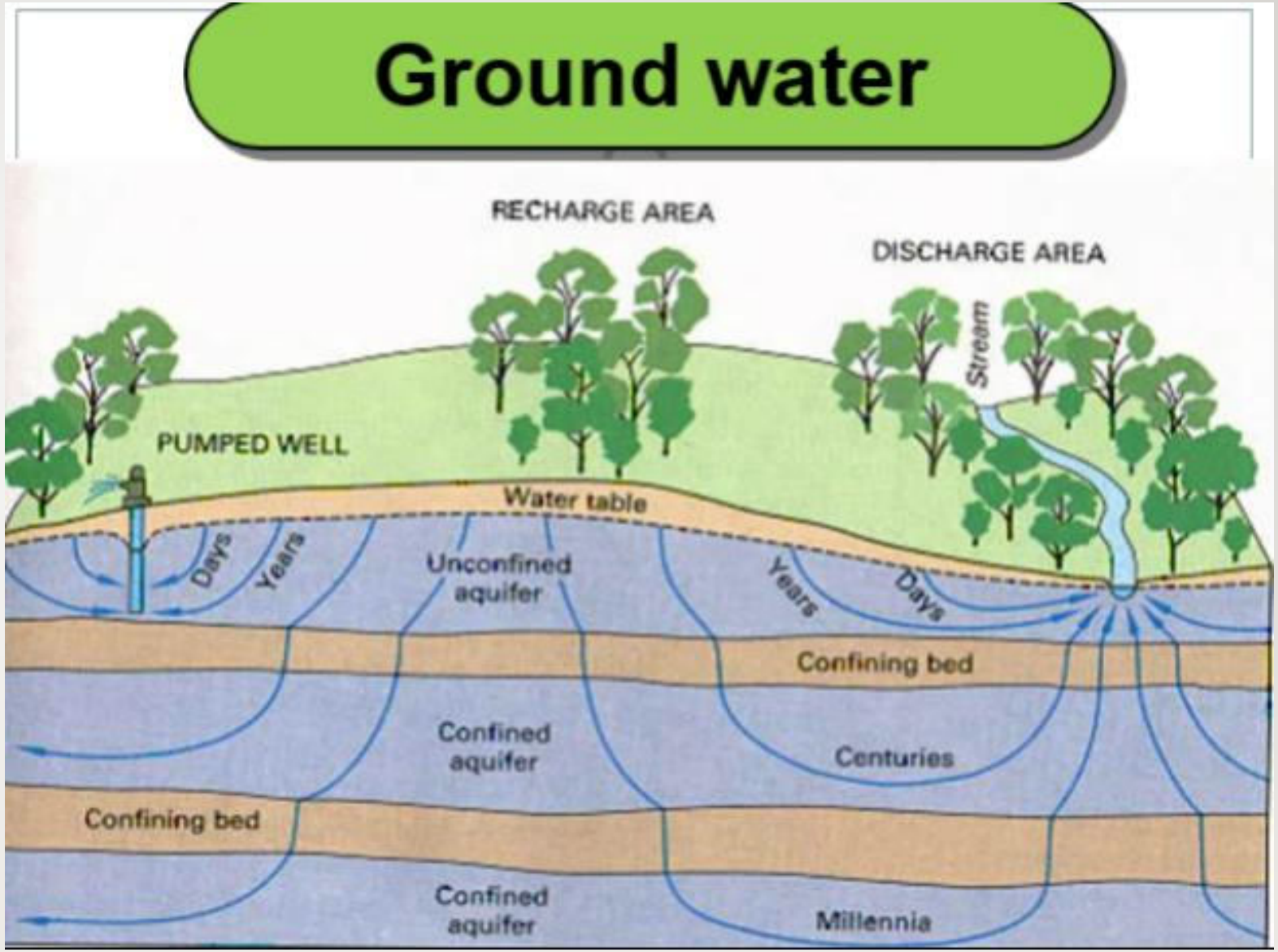
Between 1971 and 2020, Suriname volume of surface water produced remained stable at around 99 billion cubic meters.

Groundwater

- There is an abundance of good quality groundwater which is contained in the coastal basin.
- 95% of the country's total supply of drinking water from the country comes from groundwater.
- Groundwater doesn’t get easily polluted like surface water.
- Supports wetlands, helps keep land surfaces stable, and is a critical water resource.
- Much of the water underground is replenished either very slowly or not at all, and is thus termed “non-renewable”.
- If the infiltration of precipitation recharges the aquifer, the groundwater is considered “renewable” and can be used for irrigation, domestic and other purposes.
- Groundwater in saturated layers beneath the surface of the earth and these are called aquifers (in the coastal area)
- Most renewable groundwater is of a high quality and does not require treatment, it should be analysed before it is used to avoid possible health impacts.

- Three distinct names are given to aquifers depending on their type. They are:

- Unconfined aquifers
- Confined aquifers
- Springs



Location of Aquifers

- Aquifers are found in the coastal zone, the thickest and most extensive aquifers are found in the west of Suriname.
- In the east only limited aquifers are found. In the interior there are no extensive aquifers.
- Groundwater conditions of the Precambrian shield are generally unfavorable, because the geological formations have little or no primary permeability.
- People in the interior therefore rely mainly on surface water resources; (the extend of groundwater in the hinterland is not known)

Location of Aquifers

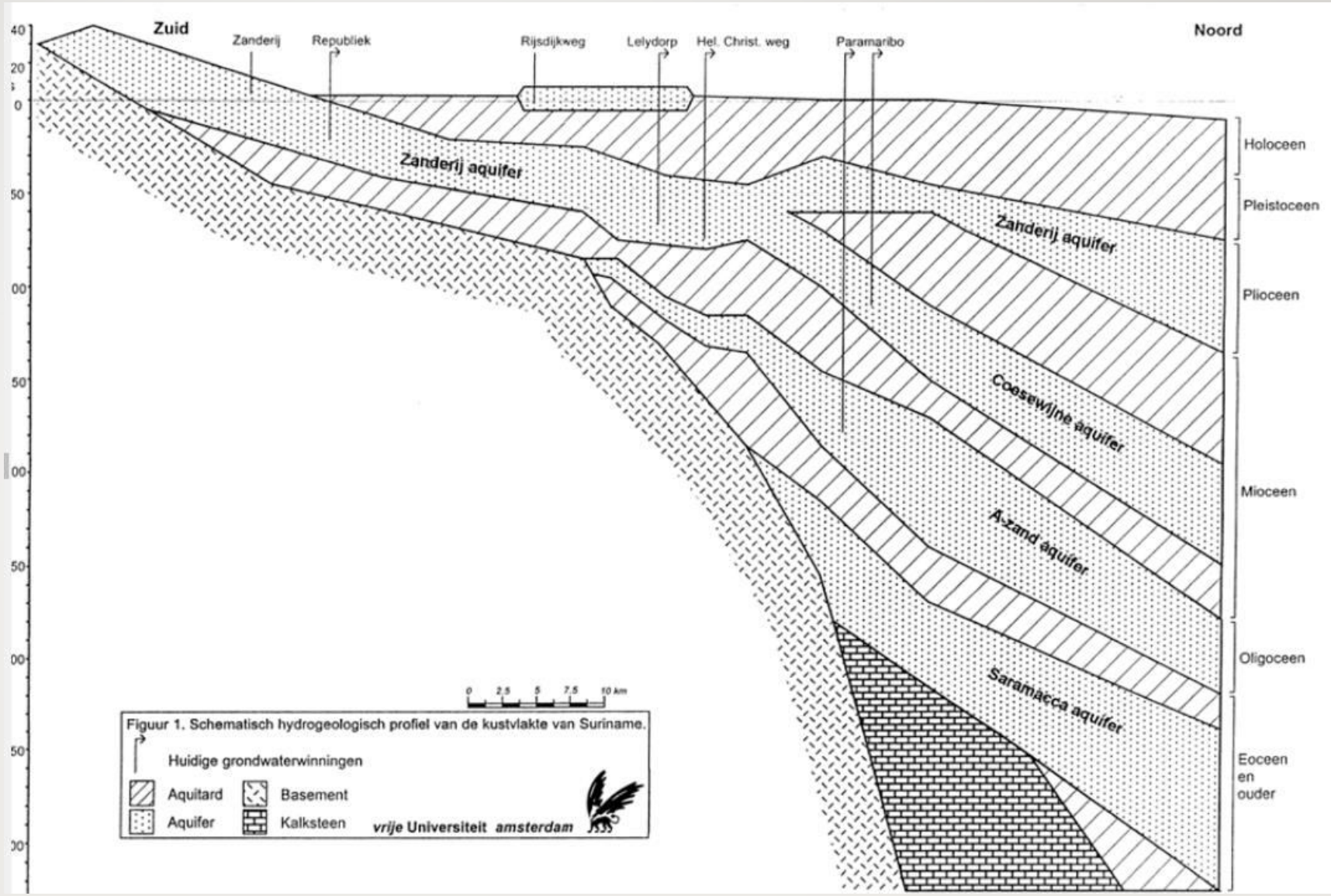
The most important freshwater aquifers from which water is withdrawn are the:

- A-sand aquifer: no recharge; depths from 130-190 m (for Paramaribo);
- Coesewijne aquifer: no recharge; depths from 70-110 m (deeper in Nickerie);
- Zanderij aquifers: partly recharged from Savannah area; depths from 15-60 m (deeper in Nickerie).

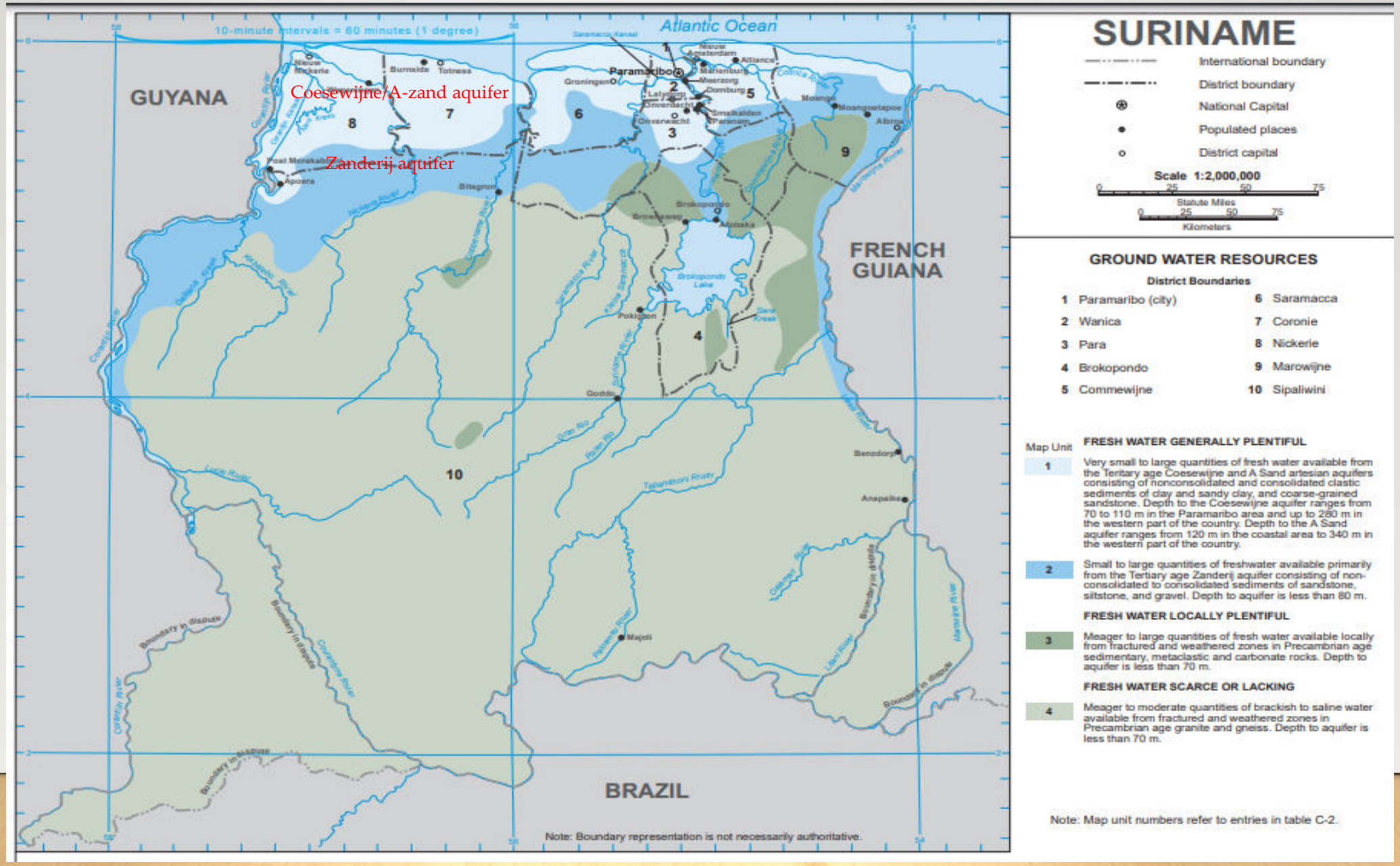
- Due to exploitation of the aquifers and the limited recharge, a problem that is faced is the advancing of brackish water towards the extraction points.
- In some area's (especially in Nickerie, the north of Paramaribo and in Commewijne) salt contents are already higher than the guideline value of 250 mg/l.

Aquifers in Suriname

- - Nickerie
- - Onverwacht
- - A-sand
- - Coesewijne
- - Zanderij
- - Coropina
- - Demerara



Most important freshwater aquifer



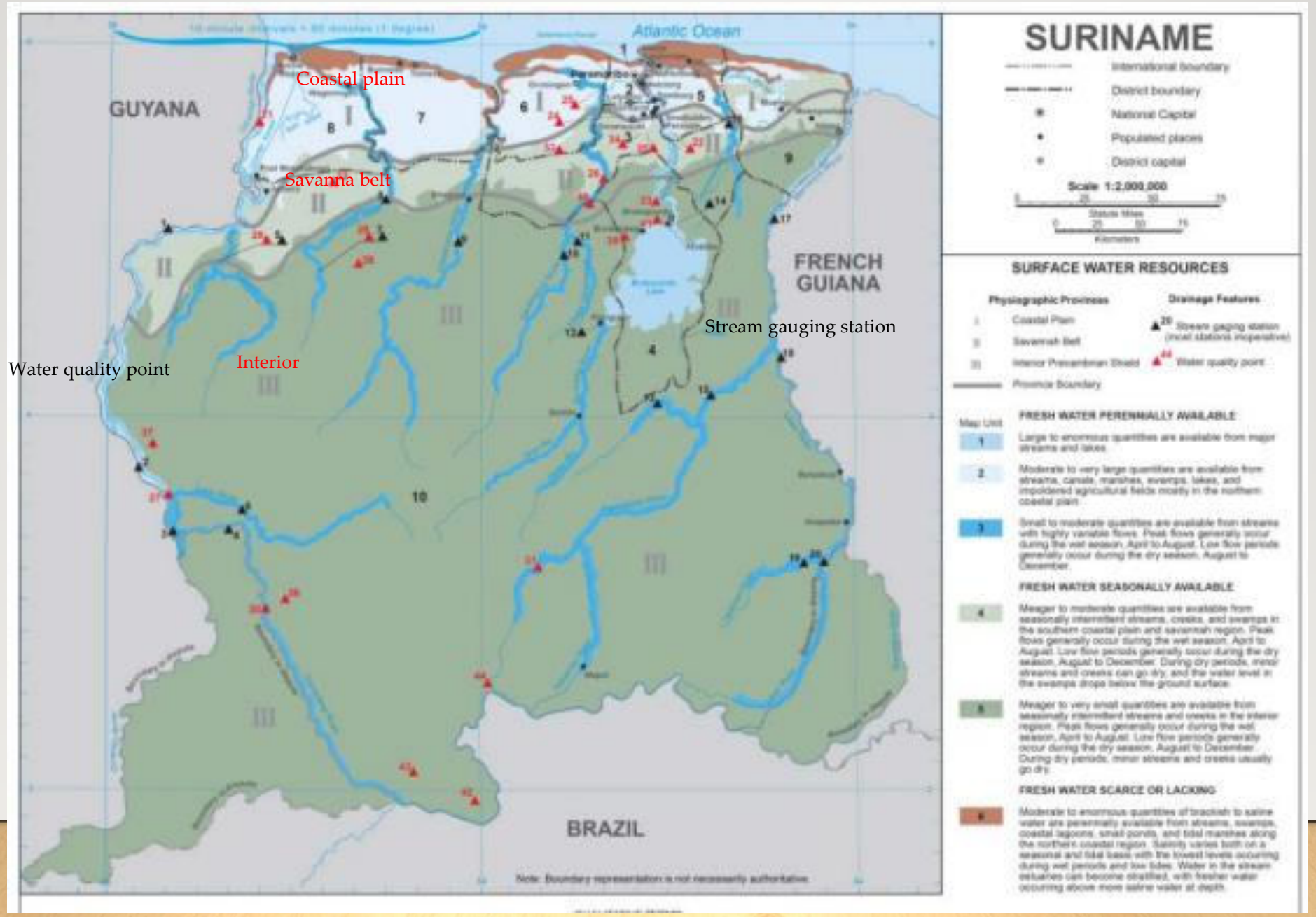
Surface water

- These water bodies perform many functions in the environment, and provide people with the prime source of drinking water, energy and recreation, as well as a means of irrigation and transport.
- Few examples of surface water: rivers, wetlands, lakes
- information is available on quality and quantity of present supplies of surface water
- Surface water can be easily contaminated.

Surface water

- Wetlands: play a key role in local ecosystems; many of them have been destroyed, but the remaining wetlands can still play an important role in preventing floods and promoting river flows.
- Suriname does not have many fresh water lakes.
- Brokopondo Lake (Brokopondo Meer) was created by damming the Suriname River. It covers an area of 1,560km² and is very low in dissolved oxygen because of vegetation drowned when the reservoir was constructed.
- Nani Lake (Nani Meer), in the Nickerie Distrikt, is the only natural fresh water lake.
- Many exhausted bauxite mines have turned into small lakes.
  - Topibo Lake (Topibo Meer) is a large red-mud lake complex at the old mining complex near Paranam.

Surface water map



Water use for various purposes

- Water is crucial for a variety of aspects including commercial use, domestic use, industrial use, irrigation, livestock, mining, hydroelectricity, etc.
- Only surface water is used for agricultural purposes, while groundwater is used as drinking water because of its high quality and the relatively higher extraction cost.
- The groundwater resources of Suriname are used for public supply and to a lesser extent for industry. Ninety-five per cent of the country's total supply of potable water comes from groundwater
- Drinking water from Suriname has **great export potential**, but so far it has not been widely commercialized in the international market.

Water uses and users

- The available water resources are used in many different ways and by different groups of users. These uses of water resources in **Suriname:**

Uses	Users
Conservation of ecosystems	Flora and fauna of Suriname, Ecotourism
Potable / domestic water use	SWM, bottling companies, citizens of Suriname, users of bottled water (also exported)
Agriculture	Farmers, waterboards
Industry	Private companies
Energy supply	Staatsolie/EBS
Waste water discharge	Citizens of Suriname
Transport	Transport companies, citizens of Suriname
Fisheries	Fishermen, commercial and for own use
Recreation	Tourists (local and from abroad), people working in the tourist sector
Mining	Mining companies, illegal miners

Threats to water resources

- Increasing water demand
- Increasing water scarcity
- Increasing water pollution
- Increasing ecosystem degradation
- Climate change (extreme drought and rain)
- Depletion of aquifers caused by overconsumption

- Sustainable water security will not be achieved through business-as-usual: the traditional, fragmented sectoral approach to water resources and has led to poor services and unsustainable resource use.
- Need to re-think the way water is managed

Challenges

Suriname is facing several challenges regarding sustainable and integrated water resource management, such as:

- lack of drinking water in some regions of the country,
- flood risks during heavy rainfall and shortages of irrigation water in dry seasons.
- water quality in the whole country: water pollution due to inadequate wastewater treatment, the use of pesticides and pollution from the mining sector
- the lack of awareness among the general population on the importance to address the country's water issues in an integrated manner.
- water management is fragmented at a national level: acting is especially difficult.
- lack technical and institutional capacity to develop and implement robust integrated water management plans.
- different institutions within the government have a different understanding of IWRM while some are not yet familiar with the concept

History of global water resource development

- Need to rethink the way water is managed
- Although many parts of the concept (WRM) have been around for several decades - in fact since the first global water conference in Mar del Plata in 1977 - it was not until after Agenda 21 and the World Summit on Sustainable Development in 1992 in Rio that the concept was made the object of extensive discussions as to what it means in practice.
- In the early 1990s it was 'rediscovered' by some water professionals, and then subsequently heavily promoted by several donors and international institutions.
  - the water problems had become multi-dimensional, multi-sectoral and multi-regional, with multi-interests, multi-agendas and multi-causes, which could be resolved only through an appropriate multi-disciplinary, multi-institutional and multi-stakeholders coordination.

History of global water resource development

Baseline: from WRD to IWRM

- **W**ater **R**esources **D**evelopment (**WRD**)
- **W**ater **R**esources **P**lanning (**WRP**)
- **W**ater **R**esources **M**anagement (**WRM**)
- Integrated **W**ater **R**esources **M**anagement (**IWRM**)

WRD and WRP

- **WRD** means **actions**, mostly physical, that lead to the beneficial use of water resources for single or multiple purposes.
- **WRP** is planning of the development, conservation and allocation of a scarce resources, matching water availability and water demand, taking account the full set of **different level** objectives and constraints and the interests of stakeholders.

WRM and IWRM

- **WRM** is to ensure the sustainability of the water environment for multiple uses as an integral part of a country's **economic development** process.
- **IWRM** includes the whole set of technical, institutional, managerial, legal and operational activities required to plan, develop, operate and manage water resources for sustainable development

IWRM

Integrated Water Resources Management is the process of coordinating conservation, management and development of water, land and related resources across sectors, in order to maximize the **economic** and **social benefits** derived from water resources in an **equitable manner** while preserving and, where necessary, restoring freshwater **ecosystems.**

IWRM: aim and criteria

- The aim of IWRM is to ensure the multi-functional use of water resources for the present and future generations.

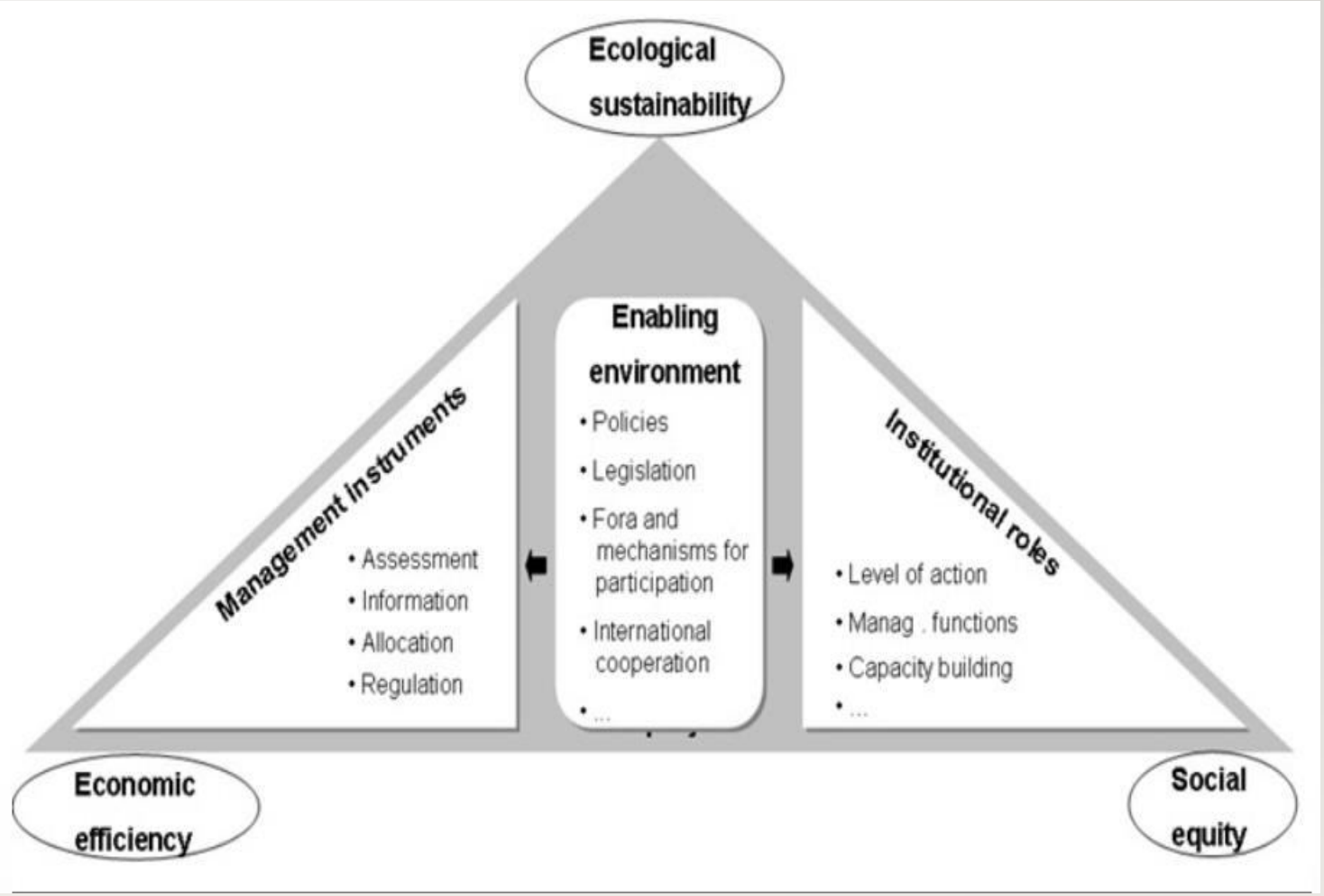
The three major criteria:

- Economic efficient use of natural resources
- Equitable sharing of welfare
- Sustainability

IWRM framework

- The IWRM framework consists of three E's:

- **Economic efficiency in water use**: Because of the **increasing scarcity** of water and financial resources, the finite and vulnerable nature of water as a resource, and the increasing demands upon it, water must be used with **maximum possible efficiency**;
- **(Social) Equity:** The basic right for **all people to have access to water** of adequate quantity and quality for the sustenance of human well-being must be universally recognized;
- **Environmental and ecological sustainability:** The present use of the resource should be **managed** in a way that does not undermine the life-support system thereby compromising use by **future generations** of the same resource."



IWRM: Intergrated parameters

- All natural aspects of the water system: surface water, groundwater, water quality (physical, biological and chemical).
- All sectors depending on water: agriculture, households, industry, hydropower, navigation, fisheries, recreation, ecosystems.
- The relevant national objectives and constraints: social, economic, institutional, environmental.
- Institutions at all relevant levels: basin, national, provincial, local.
- The spatial variation of resources and demands: upstream-downstream interaction, basin-wide analysis, inter-basin transfer.
- The temporal variation: floods, droughts, peak demands, growth patterns.

Basis of IWRM

- The basis of IWRM is that different uses of water are considered together.

Navigation	Industrial
Flood protection	Mining
Irrigation	Electricity
Domestic and commercial	Fishery
Environmental control / ecosystem	Salinity
Recreation / tourism	etc

IWRM and the SDGs

- By aligning and integrating interests and activities, IWRM can foster more efficient and sustainable use of water resources to achieve the SDGs.
  - IWRM provides an essential framework to achieve not only SDG 6 – to "ensure availability and sustainable management of water and sanitation for all" – but also to achieve all Sustainable Development Goals (SDGs).
  - The global score of SDG indicator 6.5.1 – which measures the degree of implementation of IRWM
- IWRM is not simply a process designed to carry us to a set of SDGs targets, but a way of thinking that enhances our capacity to tackle multi-objective, multi-sectoral development planning such as is embodied by the SDGs.

Key components

- The following five components were identified as key in the framework to support the implementation of IWRM in **Suriname**:
- 1. The enabling environment, comprising political engagement and support, and awareness, engagement and participation of the general public and private stakeholders.
- 2. The legal framework, covering a variety of current and required future laws that structure the water governance system and provide regulatory tools for policy instrumentation and regulation.

Key components

- 3. The institutions and capacity, focusing on coordinating procedures and processes of public entities involved in (parts of) water management, as well as their capacity (in terms of numbers and qualifications of personnel and material supports).
- 4. The knowledge and knowledge infrastructure, covering data collection, exchange, research into different parts of water systems, development of knowledge-based tools for policy development, etc.
- 5. The financial means, required to support capacity development, knowledge development, and other actions, and in the end investments in water infrastructure as needed.

Water resources planning and management

- Today, most countries are placing unprecedented pressure on water resources.
- The global population is growing fast, furthermore, chronic water scarcity, hydrological uncertainty, and extreme weather events (floods and droughts – climate change) are perceived as some of the biggest threats to global prosperity and stability.
- Most economic activities (e.g. agriculture, energy, industry, and mining) affect not only the quantity but also the quality of water resources, thereby further limiting water availability.
- Allocation of limited water resources among competing economic sectors and environmental water needs will be an increasing challenge for many countries.
- Water-resources management issues have become so pressing that the World Bank / World Economic Forum named water as one of its top challenges

Water resources planning and management

- To strengthen water security, we will need to invest in:
  - institutional strengthening, information management, and (natural and man-made) infrastructure development.
  - Institutional tools such as legal and regulatory frameworks, water pricing, and incentives are needed to better allocate, regulate, and conserve water resources.
  - Information systems are needed for resource monitoring, decision making under uncertainty, systems analyses, and hydro-meteorological forecast and warning.
  - Investments in innovative technologies for enhancing productivity, conserving and protecting resources, recycling storm water and wastewater, and developing non-conventional water sources should be explored in addition to seeking opportunities for enhanced water storage, including aquifer recharge and recovery.

Basic principles of water resources planning and management

- Basis of IWRM are 4 principles, the Dublin principles (for managing freshwater resources), formulated in 1992 during the International Conference on Water and Environment.
- **The Dublin Principles (DP) highlight the importance of water as a resource for environmental protection and human development.**
- DP has found universal support amongst the international community as the guiding principles for IWRM

- The **Dublin principles** are:
- 1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
- 2. Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.
- 3. Women play a central part in the provision, management and safeguarding of water.
- 4. Water has an economic value in all its competing uses and should be recognized as an economic good.

Tools and techniques in water resources management

- Demand for freshwater resources has rapidly increased due to ever-increasing human populations and economic development.
- For this reason, managing our water resources to meet domestic and industrial water needs, sustainable agriculture, and a productive environment for all living organisms is vital.
- Efficient management of water resources using advanced tools and techniques helps reduce water and sewer costs, irrigation requirements, control energy wastages, and ensure clean and safe water for all.

Tools and Techniques for IWRM

1. Structural measures
   - Flood control structures
   - Water harvesting
2. Non-structural measures
   - Modelling
   - Remote sensing and Geographical Information System (GIS)
   - Weather indexes
   - Early warning system

Structural measure

- Viewing as structural hard-engineered interventions, such as floodway and reservoir, as well as more natural measures, such as wetlands and natural buffers
- Reducing flood and drought hazards by controlling the flow of water in rivers and streams.
- Tending to transfer flood risk from one location only to increase it in another
- Remaining some residual risk of flooding
- Keeping water away from people

Non-structural measures: Example of decision support tools (DST)

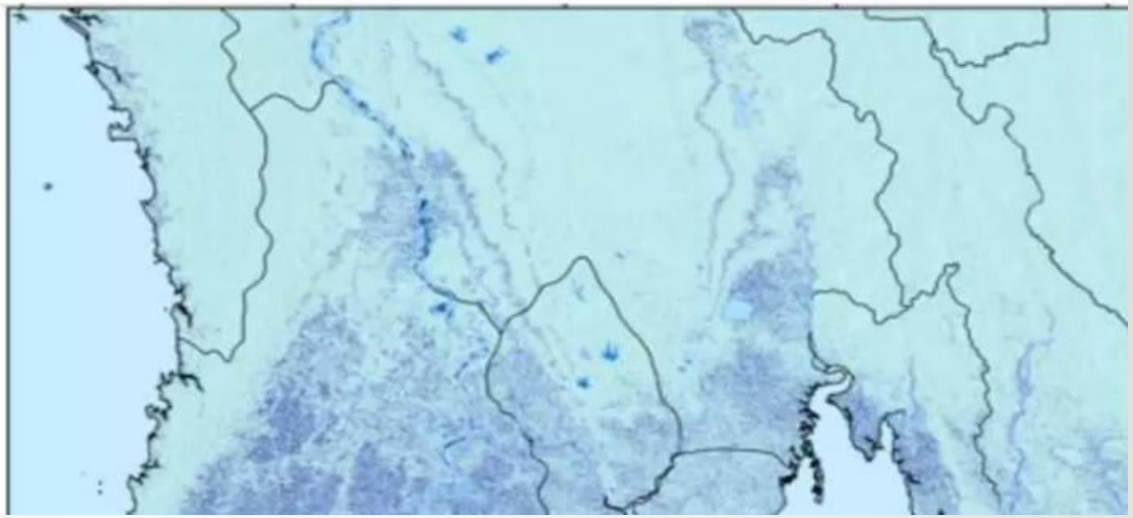
- Geographical Information Systems
- Hydrological Modelling
- Climate Models

DST to understand the integration...

in the natural systems:

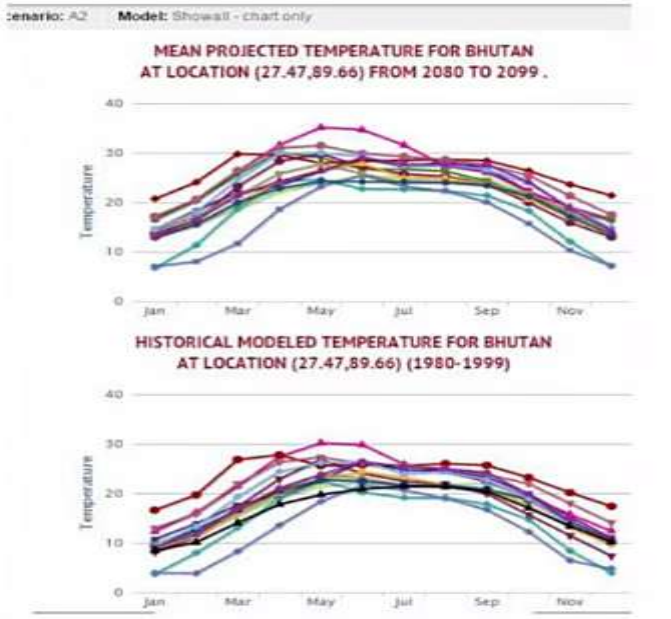
- between land and water
- between rainfall, surface water and groundwater
- between water quantity and quality
- between upstream and downstream
- between the freshwater system and the coastal waters

- Geographical Information Systems
  - Geodatabases
  - Remote Sensing
  - Spatial Analysis
  - Web-visualization

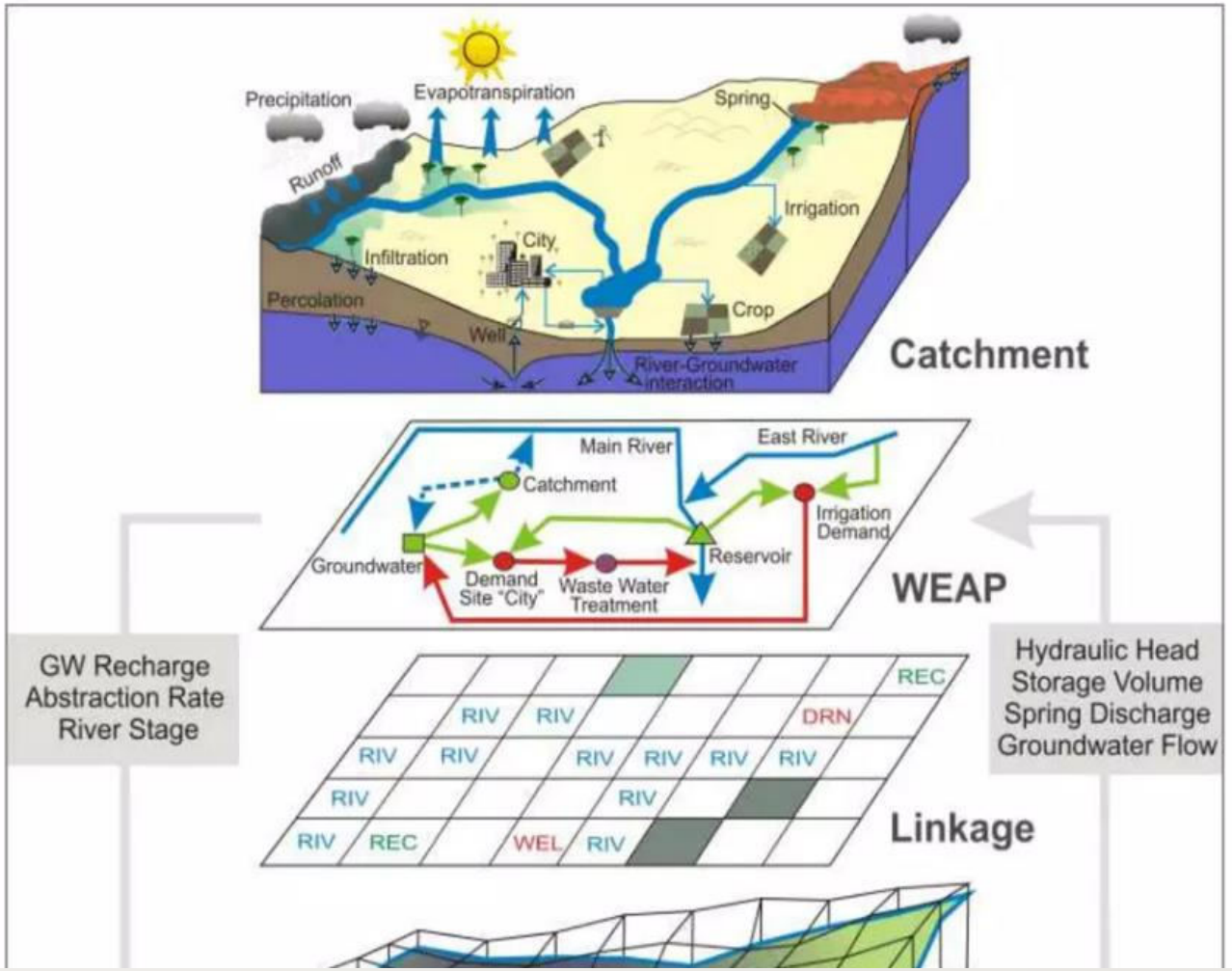


Climate Change Models

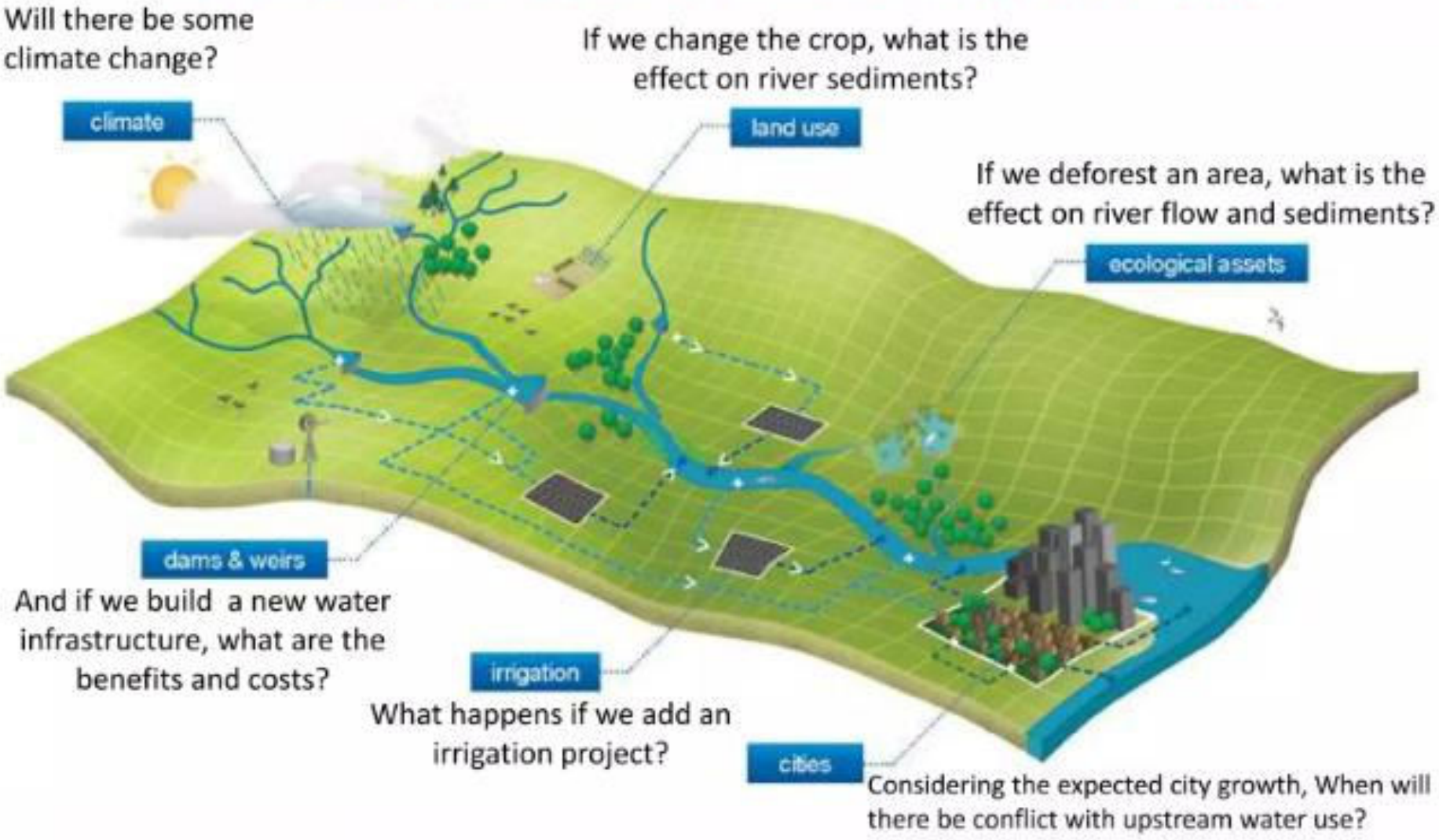
- Trends in temperature and rainfall
- Vulnerability to climate change (based on social and economic data)



- Hydrological Modeling
  - River Flow
  - Groundwater Flow
  - Water Quality
  - Flood
  - Water use
  - Reservoir Management



Practical use of DST in IWRM



River basin planning, modeling and analysis

IWRM: Among or Beyond

- **IWRM** is the management of freshwater systems as part of the broader natural environment and in relation to their socio-economic environment.

Links with:

- IRBM – Integrated river basin management
- ICZM – Integrated coastal zone management

River Basin Analysis and Modeling

- Water balances: simulation models
- Other models and tools: Commercial and international software
  - Economic models
  - GWP Toolbox

- The GWP IWRM ToolBox is for anyone interested in adopting better practices for the management of water or learning more about how to improve water management at a local, national, regional or global level.

Water balances (1)

Simple input-storage-output model

- In river basin much more complex:
  - precipitation
  - evapotranspiration
  - river discharge
  - use by human activities
- In particular human interference can strongly affect the water balance in a river basin

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Thank you

THE END

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Basic information and applying processes of flood and drought management

- According to the World Disaster Report (WDR, 2003) the most common natural disasters are classified into two categories:
- **(i) Hydro meteorological disasters-landslides/avalanches; droughts/famines; extreme temperatures and heat waves; floods; hurricanes; forest fires; wind storms; insect infestation and storm surges.**
- (ii) Geophysical disasters - earthquakes; volcanoes and tsunamis.
- Today, droughts and floods are a common feature and their co-existence poses a potent threat, which cannot be eradicated but has to be managed.

Water-related hazards

- Water-related hazards form a subset of natural hazards; the most significant ones include floods, mudslides, storms and related ocean storm surge, heat waves, cold spells, droughts and waterborne diseases.
- As climate change increases the frequency and intensity of extreme weather, the number of water-related disasters is expected to rise.
- Water-related hazards account for 90% of all natural hazards, and their frequency and intensity is generally rising.

- Water-related risks arise from too much water, too little water, or polluted water.
- Climate change is disrupting the global water cycle and will increase the frequency and severity of disasters.
- Water-related disasters pose both direct impacts (e.g. damage to buildings, crops and infrastructure, and loss of life and property) and indirect impacts (e.g. losses in productivity and livelihoods, increased investment risk, indebtedness and human health impacts).

Causes of floods

- Flooding occurs when a river's discharge exceeds the capacity of its channel to carry that discharge and the river over flows its banks.
- Floods becomes a problem when the water rises to a height where it threatens property, human lives, economic activities.
- Various factors interact to cause flooding.
- The causes of flooding can be divided into 3 categories:
  - Climatic (weather and climate – related causes)
  - Human (caused by people)
  - Physical (caused by features of the land)

Physical Causes of FLOODING

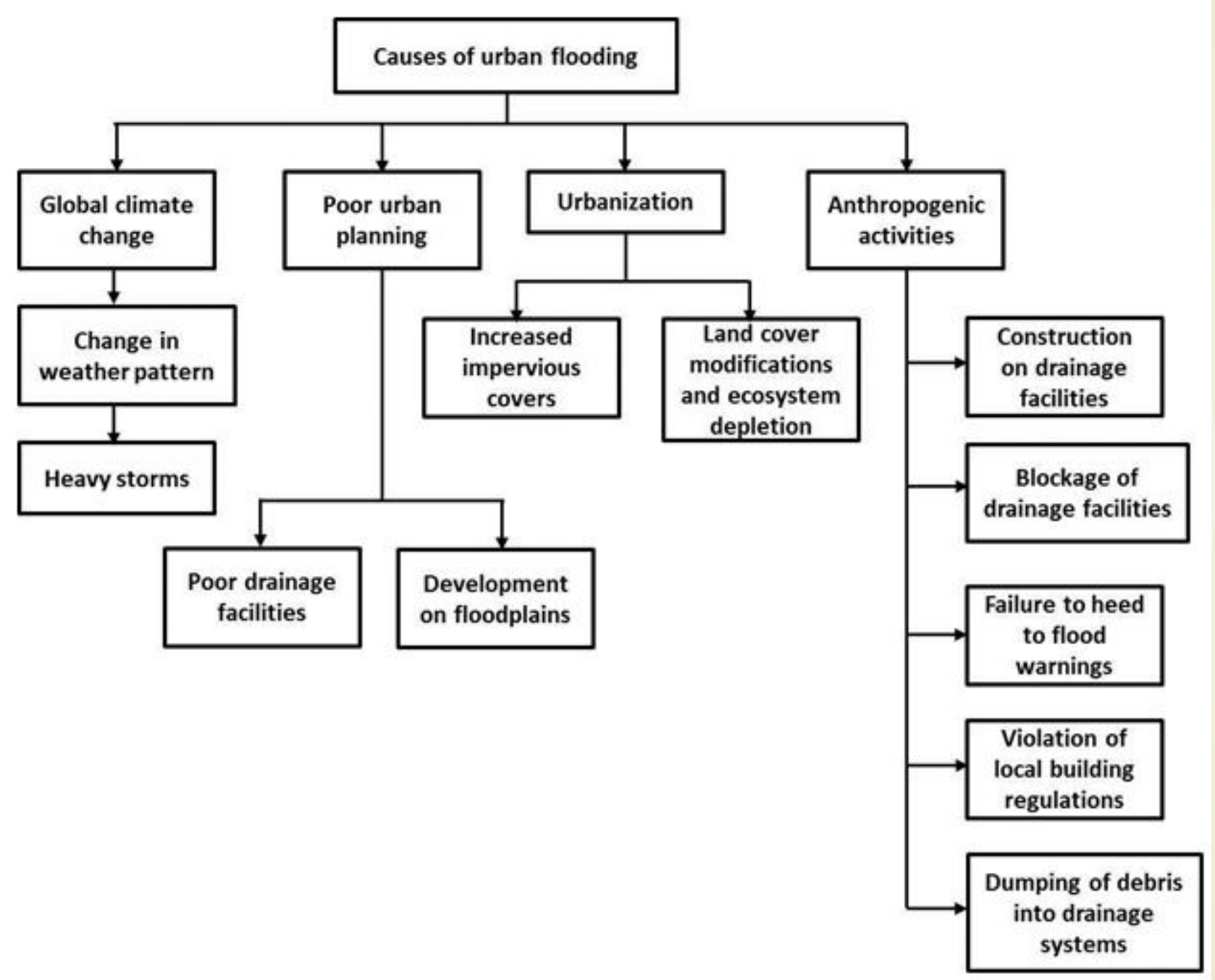
- Excessive levels of precipitation over a long time reduces infiltration capacity (heavy rainfall)
- Intense precipitation over a short time in areas where the ground is baked hard from the sun (compacted -/ dry soil; impermeable rock) (doesn't allow water through)
- Climatic hazards e.g. cyclones in Bangladesh, hurricanes in the Gulf of Mexico bring abnormal amounts of precipitation.
- Ver wet, saturated soils
- Steep slopes

Human Causes of FLOODING

- Urbanisation; because towns and cities have more impermeable surfaces (roads, roofs, pavement, etc.). These artificial surfaces don't allow water to infiltrate soil which can eventually increase the overland flow of water.
- Deforestation; Natural vegetation allows the soil to absorb a lot of water. Removing trees reduces the amount of water intercepted and increases run-off
- Changes in land use (the change in land use patterns due to the increasing need for land for agriculture and other land uses)
- Building construction (building on flood plain, run-off reach channel quickly)
- Climate change
- Bad maintenance of drainage channel
- Illegal dumping of waste in drainage channels

Climatic Causes of FLOODING

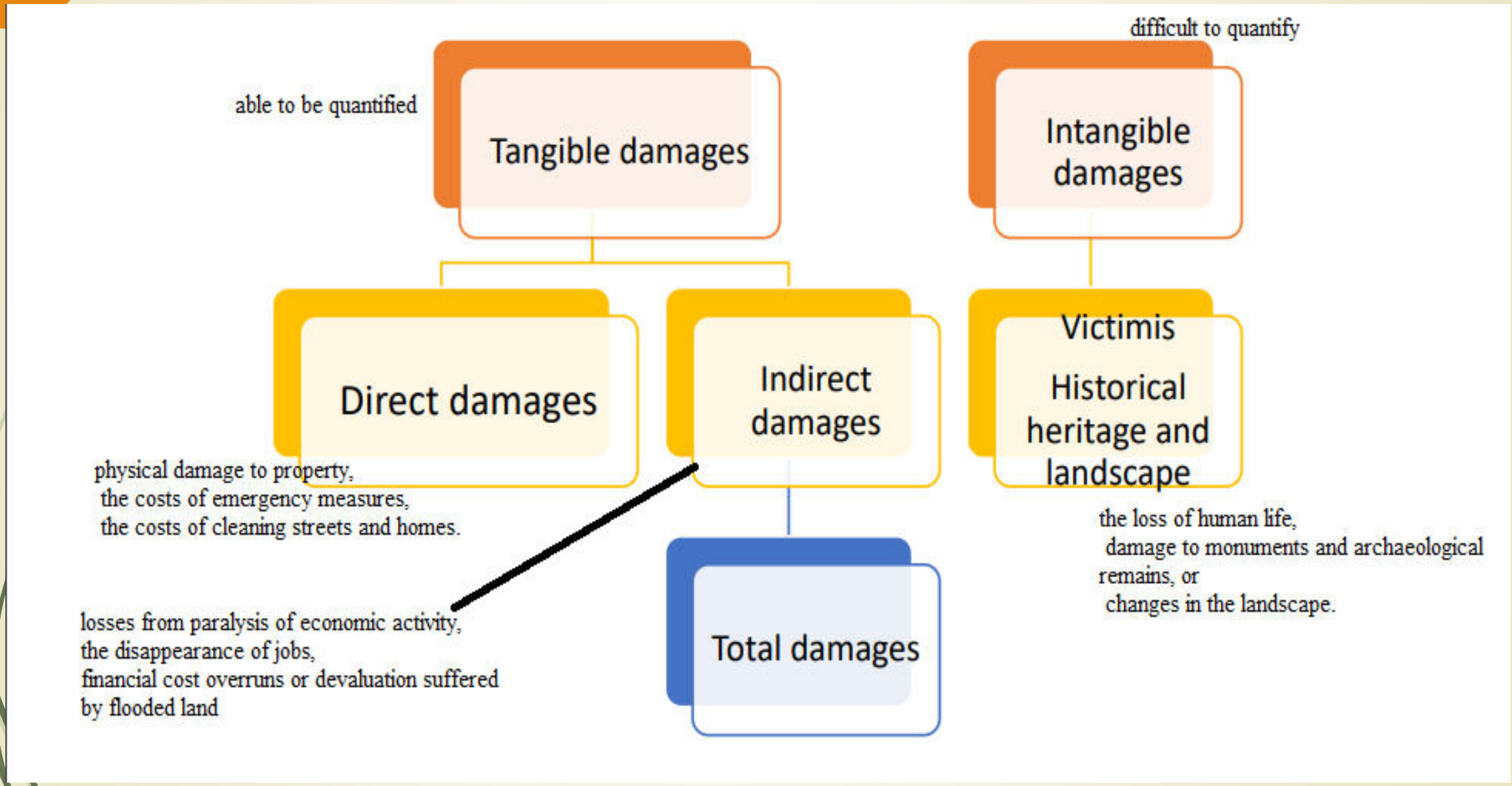
- It all starts with the release of **greenhouse gasses** like carbon dioxide and methane (industry / landfills).
- As humans keep burning fossil fuels, the atmosphere gets hotter.
- That hot air holds more water vapor, and so when it rains, it rains harder.
- Other impacts of climate change, such as sea level rise, will make coastal storms and floods even more damaging, as erosion and flooding will occur further up the shoreline.
- Climate change projections also show that tropical cyclones are likely to occur further south and be more damaging. This will bring more severe storms and rainfall events to many areas


Causes of urban flooding
Global climate change
Poor urban planning
Urbanization
Anthropogenic activities
Change in weather pattern
Heavy storms
Increased impervious covers
Land cover modifications and ecosystem depletion
Poor drainage facilities
Development on floodplains
Construction on drainage facilities
Blockage of drainage facilities
Failure to heed to flood warnings
Violation of local building regulations
Dumping of debris into drainage systems

Impacts of flooding

- In the **case of flooding**, there is a difference between tangible - and intangible impacts.
- Tangible impacts classify into direct and indirect.
- Direct impacts include physical damage to property, the costs of emergency measures, or the costs of cleaning streets and homes.
- While indirect impacts include losses from paralysis of economic activity, the disappearance of jobs, financial cost overruns or devaluation suffered by flooded land.
- Intangible impacts include the loss of human life, damage to monuments and archaeological remains, or changes in the landscape.

Type of damages due to floods



Causes of drought

- Drought is a climate extreme characterised by persistent unusual dry weather conditions affecting the hydrological balance (dry conditions and lack of precipitation).
- A drought is basically caused when the water inside the ground is being used up, but the ground is not being replenished by the water through rainfall.
- Drought is generally defined as "a deficiency of precipitation over an extended period of time (usually a season or more), resulting in a water shortage."
- The conditions are usually associated with lack of precipitation, deficit in soil moisture and water reservoir storage, leading to widespread impacts.
- When there is a drought, there is less water available for growing crops, farming animals, industry and our cities. When a drought goes on for a long time, towns are at risk of running out of water.

Types of drought

- Drought is often categorized into five general types: meteorological, hydrological, agricultural, ecological, socioeconomic.

FIVE TYPES OF DROUGHT

1. **METEOROLOGICAL** drought refers to an extended period of dry weather patterns.
2. **HYDROLOGICAL** drought refers to low water supply in our rivers, lakes, aquifers, and other reservoirs that often follows meteorological drought.
3. **AGRICULTURAL** drought occurs when a water shortage significantly damages or destroys agricultural crops.
4. **ECOLOGICAL** drought is the most recently defined type of drought and refers to widespread ecological damage caused by the lack of soil moisture.
5. **SOCIOECONOMIC** drought refers to when a water shortage affects the supply and demand of drought commodities, such as water, food grains, and fish.

a meteorological drought leads to a soil moisture deficit that limits water availability for natural vegetation and crops.

effects of prolonged periods of precipitation deficit and reduced surface or sub-surface water on surface or sub-surface water supply

Ecological drought

Meteorological Drought

Reduced precipitation → Less water enters ground

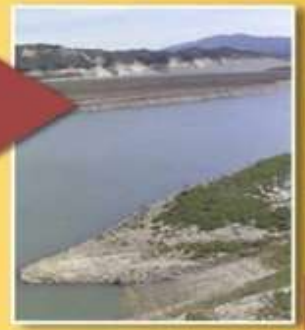
Higher temperatures and winds, lower relative humidity, greater sunshine → Increased water loss from plants, land, ocean

Agricultural Drought

Reduced soil moisture

Crops suffer; reduced yields

Hydrological Drought



Reduced water in streams, lakes, reservoirs

Wildlife habitats stressed

Socioeconomic Drought

Demand of economic goods exceeds supply; strains on community and economy

a period of unusual precipitation deficit

Impacts increase over time

Causes of drought

- Droughts happen gradually. But they can be just as deadly as other weather hazards
- Droughts can be triggered by **natural causes** such as weather patterns, but increasingly they are caused by **human activity**.
- **Human causes of drought:**
- **Climate change**: Global warming makes extreme weather more likely. It can make places drier by increasing evaporation.
- **Deforestation**: Plants and trees capture and release water into the atmosphere, which creates clouds and then rain.
- **Agriculture**: Intensive farming contributes to deforestation in the first instance but can also affect the absorbency of the soil, meaning it dries out much more quickly.
- **High water demand**: There are several reasons water demand might outweigh the supply, including intensive agriculture and population spikes. Also, high demand upstream in rivers (for dams or irrigation) can cause drought in lower, downstream areas.

Impacts of drought

The lack of precipitation can cause a variety of problems for local communities:

- damage to crops
- wildfire and effect on wildlife
- hunger and famine
- a shortage of drinking water.
- these effects can lead to devastating economic and social disasters, such as **famine, forced migration** away from drought-stricken areas, and conflict over remaining resources.
- can cause water shortages in streams or storages such as reservoirs, lakes, groundwater, and resulting in negative impacts to natural and socio-economic systems.

Impacts of drought

- soils dry out, plants reduce photosynthesis and breathe less in order to save water and preserve their tissues. As a consequence, they are no longer able to capture carbon dioxide from the surrounding air and more CO2 remains in the air.
- water flow and volume decreases during drought typically led to increased salinity due to reduced dilution and concentration of mass.
- reduce surface and ground water levels (triggering hydrological drought) and can lead to reduced water availability and also to a deterioration of water quality. This condition also intensifies water shortages by lowering the amount of usable water within a region.

Climate of Suriname

- Suriname has two basic seasons: **the dry season and the wet or rainy season**. A short wet season lasts from the beginning of December to the end of February. This is followed by a short dry period up to the end of April, a long rainy period up to mid-August, and a long dry season up to the end of November.
- People in Suriname felt they had generally been spared from disasters associated with natural hazards until the floods of early May 2006.
- Interestingly, most Surinamese were not aware that 50 years earlier, in 1946, parts of the Interior had experienced major floods, although these were not as severe as those in 2006.
- Many people and even experts believed that there were unlikely to be other major floods in the near future.
- However, in 2007 large urban and peri-urban areas flooded to a height of 40 cm after excessive rainfall. This caused the overflowing of canals and creeks and the veins of Suriname's urban and rural drainage system.
- In 2008 the Interior flooded again, affecting other parts of the country

Climate of Suriname

- Since the historic floods of May 2006, people have been more conscious of the impact of climate change in Suriname.
- However, consultations with stakeholders revealed that sections of the government and society are cautious about blaming the flooding in the Interior on climate change alone.
- They noted that the exceedingly heavy rainfall that lasted for days was an important factor, but not the only one.
- Many believed that an increase in **uncontrolled gold-mining activity** was one of the causes of the severe flooding since sand from the mines washes down to the river and creeks where it accumulates and can **affect the absorption capacity and free flow of the water**.
- Such flooding had a major impact on the inhabited areas which are usually along the creeks and rivers.

1. Suriname's exposure and vulnerability to risk (1)

- Although Suriname is situated outside the hurricane zone, the aftermath of the hurricanes that proliferate in the Caribbean region are often experienced in the form of heavy rainfall. Weather events like the passage of the Inter Tropical Convergence Zone (ITCZ), very strong winds ('sibibusies') and the El Niño and La Niña phenomenon have a big influence on the weather in Suriname.

- As such, Suriname is regularly confronted with a series of extreme weather conditions (flooding, heavy winds and salt water intrusion), and in recent years there also seems to be a pattern of severe flooding in the interior areas of Suriname (2006, 2008, 2021 and 2022).

- Suriname is also prone to frequent river and surface water flooding, particularly when coincident with spring tides which limit drainage. Flood-risks in the capital city of Paramaribo, which contains the most substantially populated urban area on the Suriname coast, are particularly exacerbated by poor drainage-capacity due to either limited planning integration or insufficient maintenance.

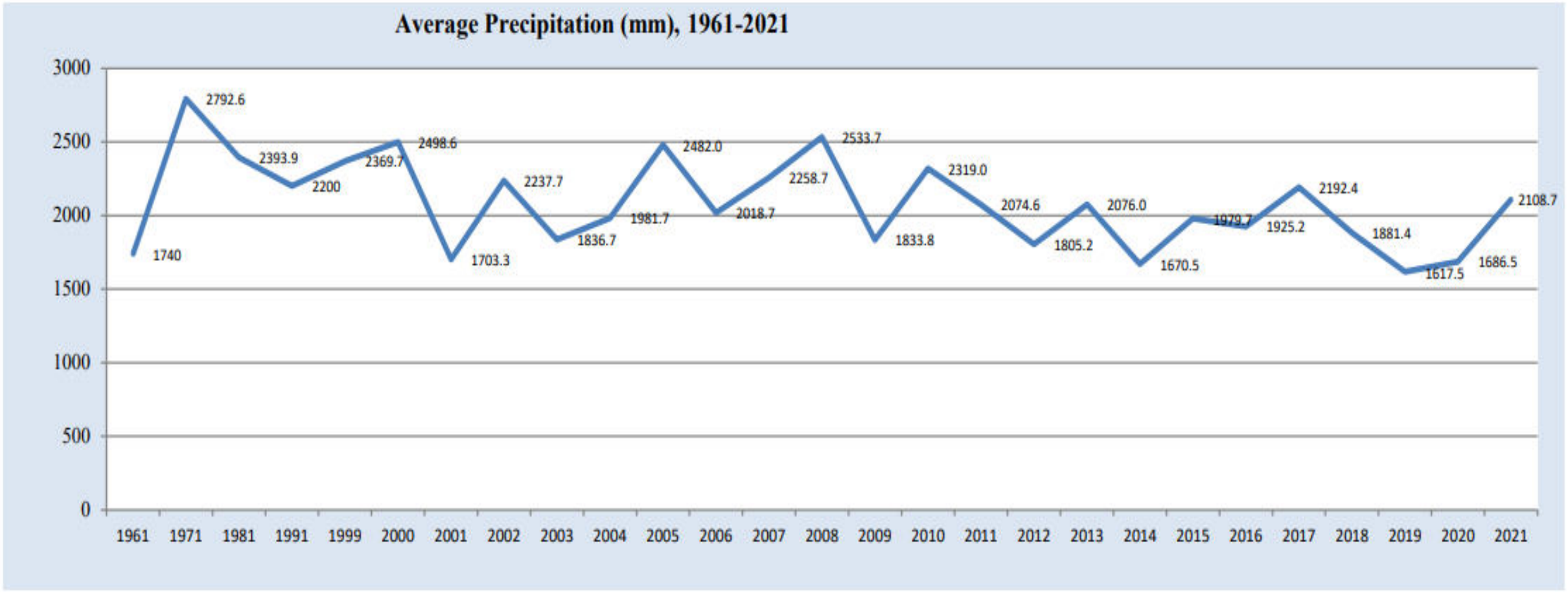
1. Suriname's exposure and vulnerability to risk (2)

Sea level rise

The coastal plain is vulnerable to sea level rise. Paramaribo is approximately between 0 and 3 m above sea level. According to statistics from the World Bank[12] Suriname is one of the most vulnerable countries in the world to the impact of sea-level rise due to climate change. Most of the population lives within a few meters above mean sea level, making coastal populations particularly susceptible to coastal erosion and flooding risks.

6b. Selected Disaster statistics: Precipitation (1)

- Suriname has a tropical hot and wet climate and annual rainfall varying between 1,600 mm/year 2,600 mm/year.

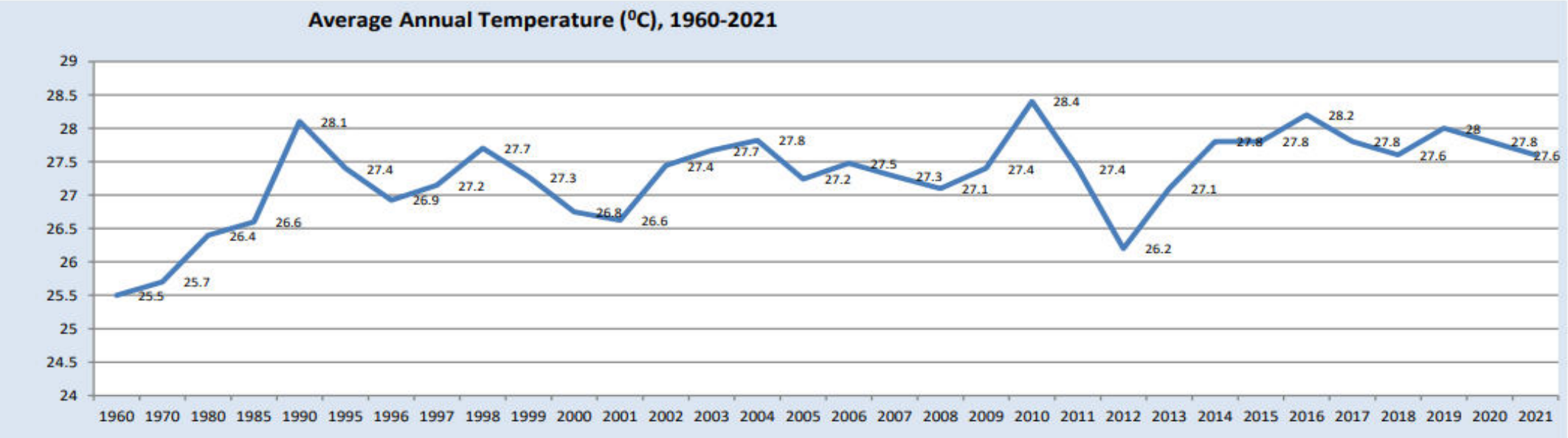


Source: Meteorological Service Suriname and World Bank- knowledge Centre: https://climateknowledgeportal.worldbank.org/country/suriname/climate-data-historical

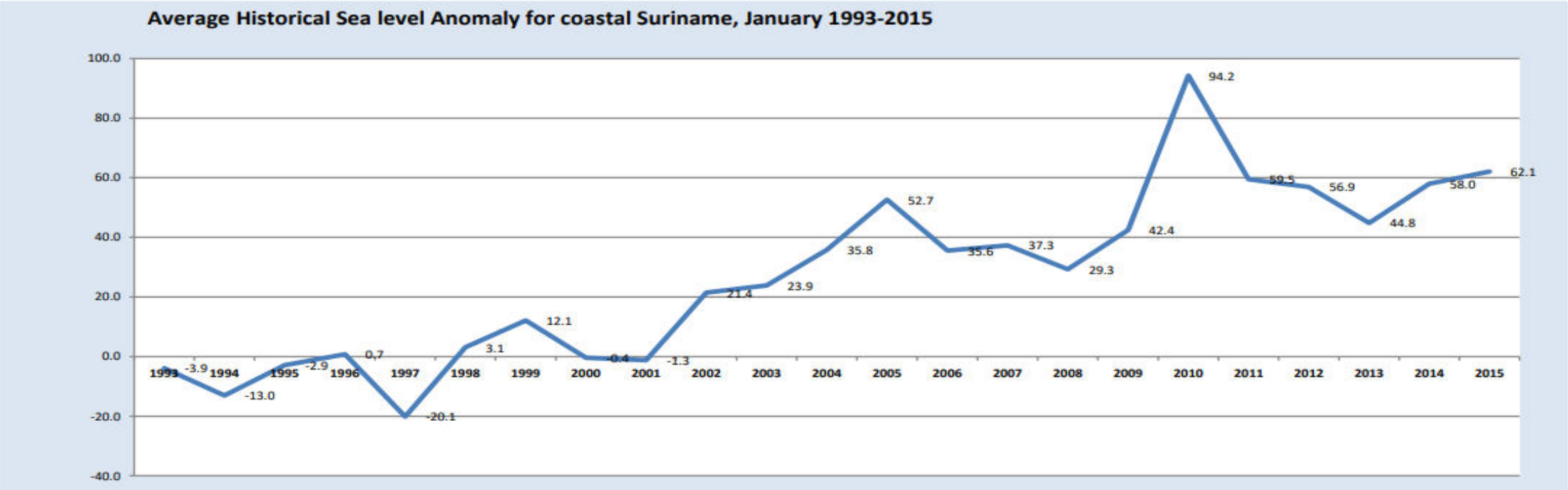
6b. Selected Disaster statistics: Temperature (2)

- Suriname has mean temperature between 25°C-27.5°C.

- Since 1960, the average annual temperature increased by 0.2°C at an average rate of 0.05°C per decade.



6b. Selected Disaster statistics: Sea level rise (3)

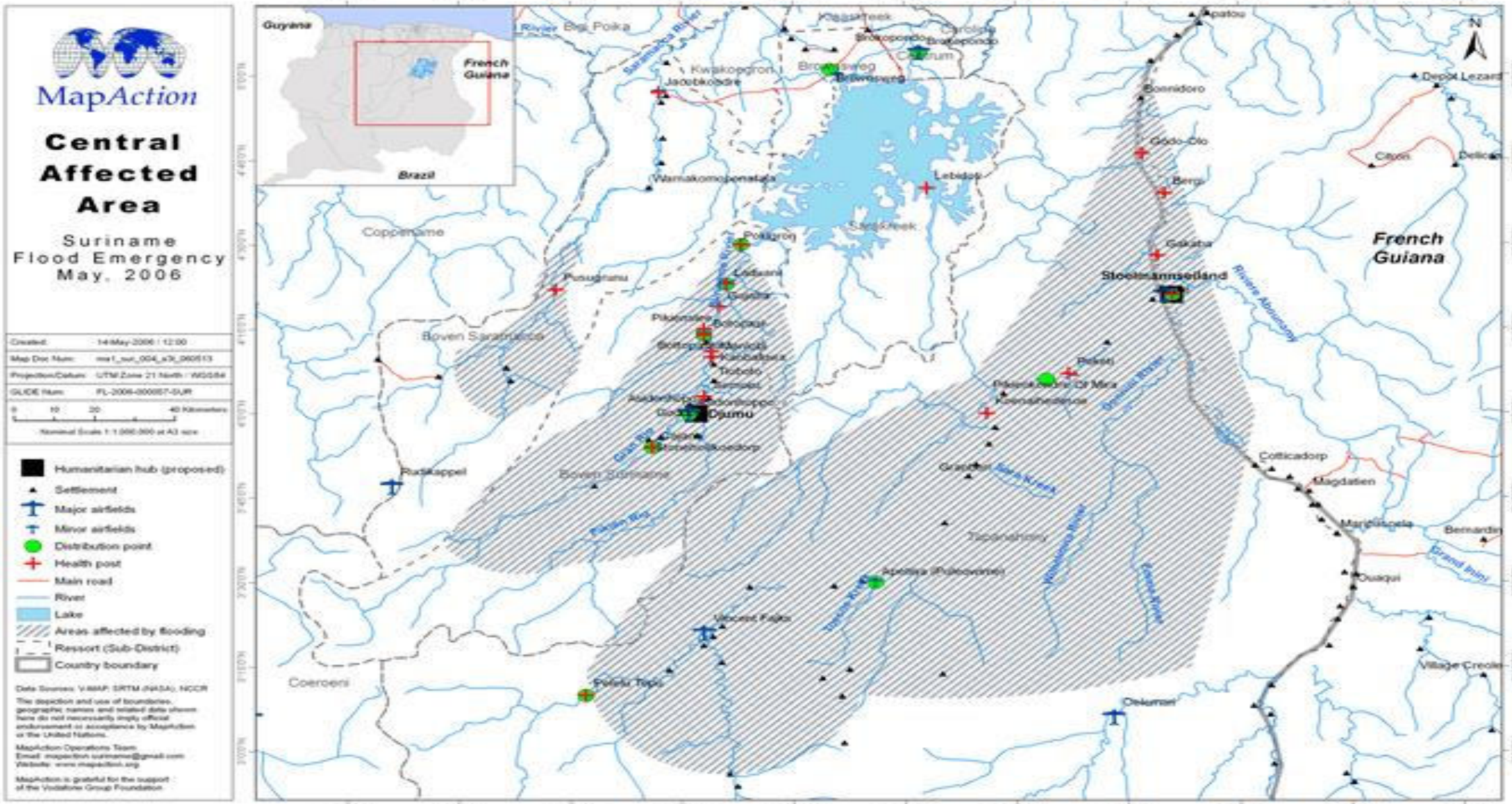


Graph : Average Historical Sea Level Anomaly for coastal Suriname, January 1993-2015
Source: World Bank- knowledge Centre: https://climateknowledgeportal.worldbank.org/country/suriname/climate-data-historical

According to the State of the Climate Report, almost 30 percent of the country is within a few meters above sea level, making it susceptible to coastal flooding. Nearly 80 percent of Suriname's population (two thirds of whom live in the capital Paramaribo) and most of the country's fertile land and economic activities are located in the 384 kilometer-long coastal plain. Therefore, sea level rise presents significant development challenges. It is estimated that a one-meter rise would impact over 6.4 percent of GDP, 7 percent of the population, and 5.6 percent of agricultural land.

Gross domestic product (GDP)

Flooding: affected areas 2006



Flooding: affected areas 2008

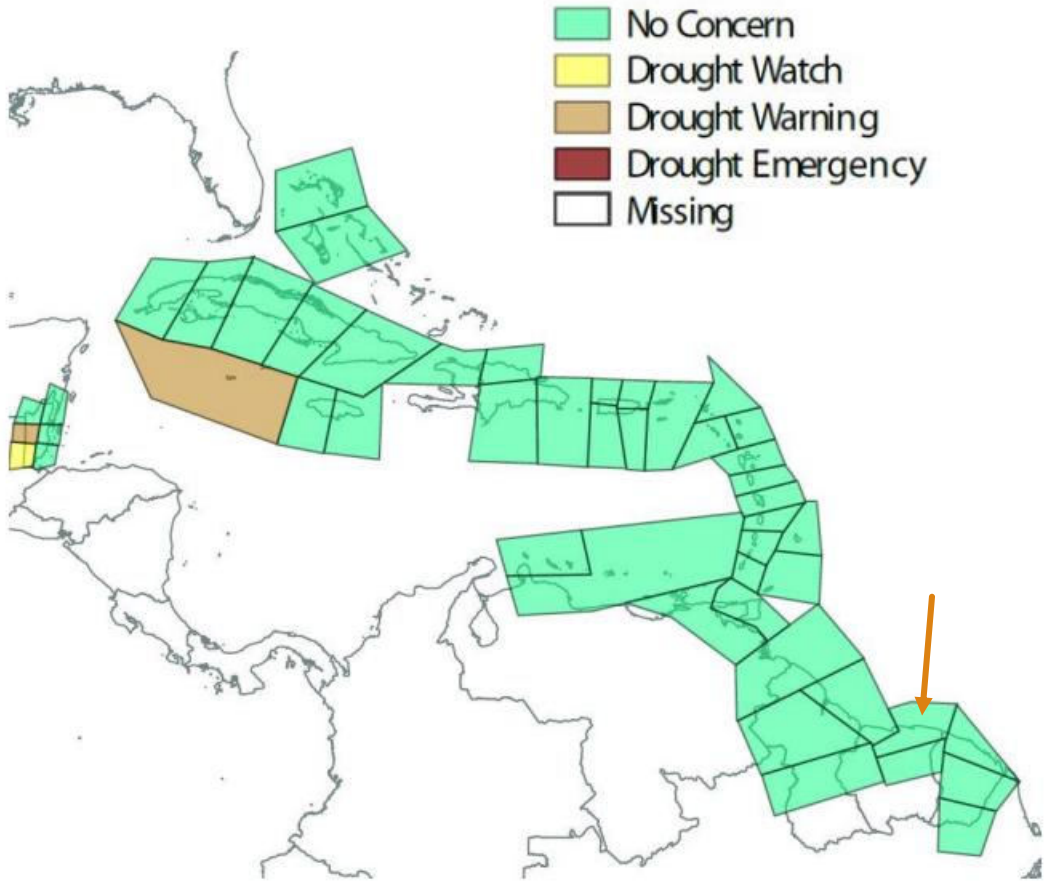
- On 28 May 2008 constant rainfall flooded several villages located on the northern part of the Marowijne River according to the Government Department for Regional Development.
- Heavy rainfall increased with high peaks in the week from 1 to 7 June 2008, leading to the overflow of the Tapanahony and Marowijne rivers and consequently flooded the villages that lay along the riverbanks.
- The most affected areas, the Tapanahony, Lawa, upper Marowijne and Coeroeni, are in southern and eastern Suriname.

South Eastern Suriname flooded. Source: International Federation

Suriname exposure to drought

- There is no national data available on drought. Suriname is dealing with flooding during the rainy season. Therefore, the focus of Suriname is on precipitation & flooding.
- In Suriname, water scarcity is classified as very low or non-existent.
- However, additional information may show some level of hazard.
- Droughts will occur much less than once every 1000 years. For Suriname, drought hazard does not need to be explicitly considered
- Although the drought hazard is considered to be very low or non-existent in Suriname, country must consider future drought events.
- WATER MANAGEMENT: should consider water scarcity/drought management measures to alleviate risk, including water storage, alternative sources, and reduced use of resources.

What is the predicted short term drought concern by the end of January 2020?



Short term drought alert levels by the end of January 2020

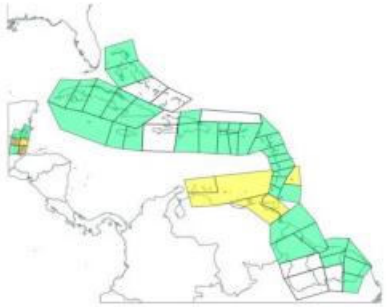
(updated **October 2019** – covering August to January 2019)

Current update (October 2019):

We are currently in the wet season. Currently, no shorter term drought concern is developing throughout the region. Exceptions are:

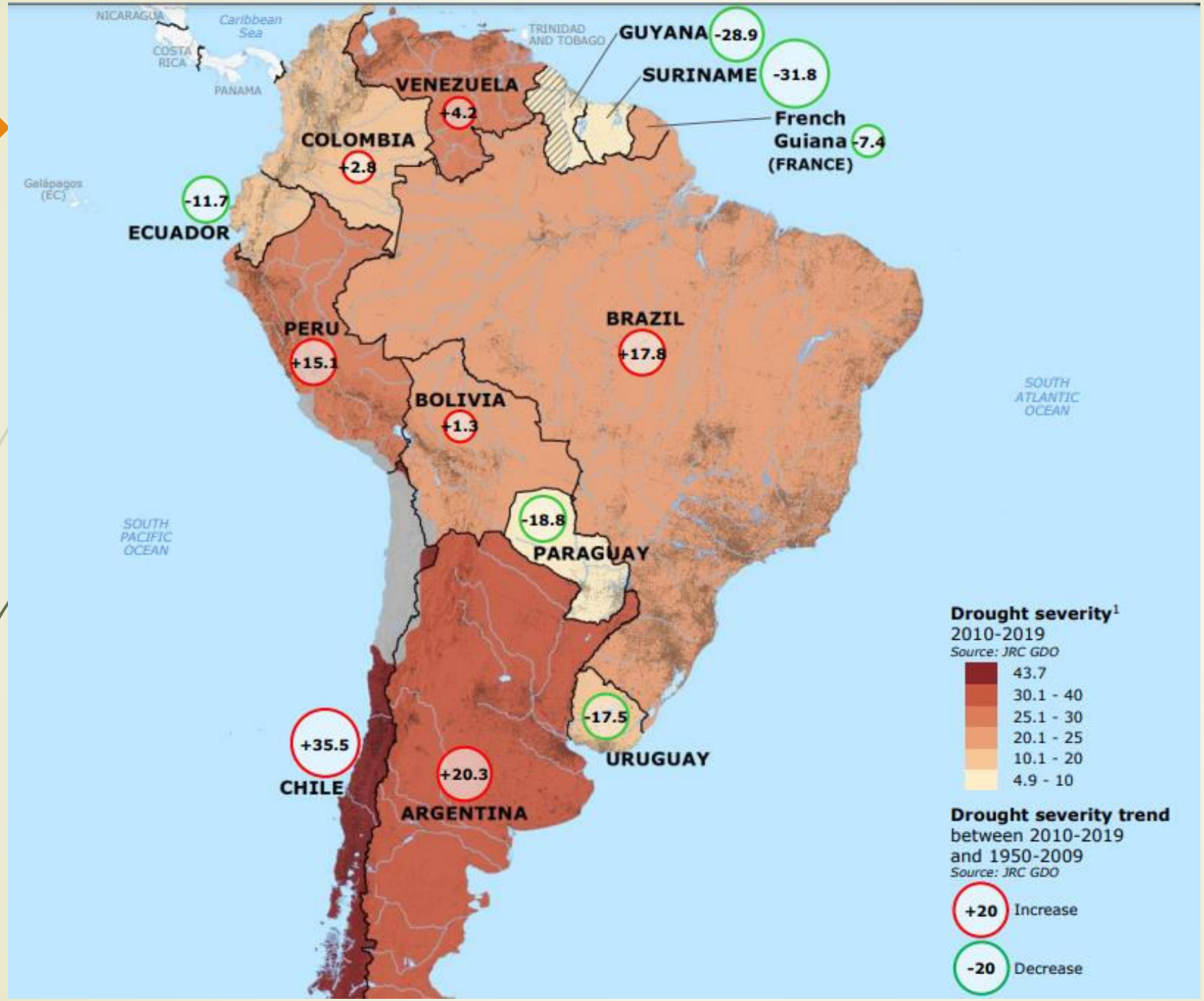
A **drought warning** should be considered for The Cayman Islands and west-central Belize .

A **drought watch** should be considered for the southwest Belize.



Previous short term drought alert levels by the end of December 2019

For climate information specific to your country, please consult with your national meteorological service. *CariCOF outlooks speak to recent and expected climate trends across the Caribbean in general.*


NICARAGUA
Caribbean Sea
COSTA RICA
PANAMA
TRINIDAD AND TOBAGO
GUYANA -28.9
SURINAME -31.8
French Guiana (FRANCE) -7.4
VENEZUELA +4.2
COLOMBIA +2.8
Galápagos (EC)
-11.7
ECUADOR
PERU +15.1
BRAZIL +17.8
BOLIVIA +1.3
SOUTH ATLANTIC OCEAN
SOUTH PACIFIC OCEAN
-18.8
PARAGUAY
-17.5
URUGUAY
+35.5
CHILE
+20.3
ARGENTINA
Drought severity[1]
2010-2019
Source: JRC GDO
43.7
30.1 - 40
25.1 - 30
20.1 - 25
10.1 - 20
4.9 - 10
Drought severity trend
between 2010-2019
and 1950-2009
Source: JRC GDO
+20 Increase
-20 Decrease

Water Resource Management & Disaster Risk Reduction

- Water-related risks arise from too much water, too little water, or polluted water.
- The occurrence of floods and droughts are expected to increase with a changing climate, with the IPCC predicting these water-related disasters to increase in both frequency and severity, as the whole global water cycle is affected by global warming.
- In fact in many places these changes are already taking place and the world is ill-prepared to respond to these risks.
- Although the increasing risk will be difficult to manage with higher levels of global warming, the IPCC WG II report on impacts, adaptation and vulnerability, concludes that there are opportunities to respond to the risks.
- Thus, water management and development strategies have a pivotal role in reducing the exposure and vulnerability of people and assets to water-related extremes.

Water Resource Management & Disaster Risk Reduction

- Improving individual and institutional capacity will be key in reducing water-related disaster risks and vulnerabilities and adapting to climate change impacts
- Integrated Water Resources Management is an effective way to strengthen resilience for disaster risk reduction and climate change adaptation.
- Encouraging other sectors to consider water in their policies and planning is the only way to ensure water-related disaster risk reduction.
- Water management is key in disaster risk reduction and building resilience.
- Reduce the risk of droughts and floods through more effective water resources management.

Water Resource Management & Disaster Risk Reduction

- Water is key in managing disaster and addressing climate change impacts, because water is the medium through which most climate impacts and many disasters such as droughts and floods are felt.
- To recognize this reality and to respond accordingly is essential. It also presents several development opportunities.
- Various adaptation measures that respond to climate variability, and build upon existing land and water management practices, have the potential to strengthen the resilience of vulnerable communities to climate change and to ensure water security, and thus directly contribute to sustainable development.
- Innovative technological practices and implementation of strategies at the appropriate levels are necessary measures to address the needs of adapting to climate change, while at the same time addressing the urgency of mitigating climate change.

Water Resource Management & Disaster Risk Reduction – Suriname adaptation options

- Better water management is in dire need in dealing with the effects of disaster risk reduction. Suriname need to invest in strategies that focus on limiting agricultural impacts from drier climates and conditions, increase water efficiency as well as reduce consumption of water
- The current and future plans in the water sector includes the improvement of the integrated approach to water policy.
- First steps were taken for the development of an integral water resource management system, in which all parts related to water are better attuned to each other.
- The necessary preparations will also be made for the establishment of a Water Authority Suriname, which will mainly focus on the implementation of an Integral Water Management System and management plan.

Water Resource Management & Disaster Risk Reduction – Suriname adaptation options

- Undertake in-depth studies (including water balance and aquifer replenishment studies) and establish an observation network and monitoring system, in order to enhance water management and sustainable use of water resources.
- Develop pilot projects to assess artificial recharge of aquifers and conduct feasibility studies to explore the possibility of additional groundwater projects, as well as alternative freshwater resources, to buffer the effects of saltwater intrusion.
- Explore the development of mechanisms to facilitate Integrated Water Resources Management (IWRM), including appropriate institutional and legislative frameworks at all stages of water planning and management. Undertake an assessment of water needs and sources, identify and appraise options for new sources.
- Review and amend draft legislation to ensure that climate change is taken into account. Include provisions for
  - 1) the protection of water resources
  - 2) the promotion of their sustainable use and
  - 3) for water quality standards and wastewater discharge.

Water Resource Management & Disaster Risk Reduction – Suriname adaptation options

- Assess options for the establishment of an institutional organization for the enhancement of water management, for example water boards and a water authority.
- Develop robust land management and waste management policies to reduce the discharge of pollutants including sediments, sewage, agrochemicals and mining pollutants into water systems, and to protect aquifers from surface contamination.
- Develop policy and guidance for the construction of drinking water storage mechanisms for use in times of drought; possibilities include artificial controlled ground reservoirs, water towers, or bottled water reserves in strategic locations throughout the country. Develop policy to increase efficiency of drinking water supply mechanisms.
- Develop and implement land and waste management solutions to reduce discharge of pollutants into water resources.
- Develop, implement and monitor drinking water storage mechanisms for use in times of drought and flooding. Identify and implement waste water recycling schemes, including mining and forestry sectors. Waste water from domestic and tourism use can be re-used, for example for agricultural irrigation

Water Resource Management & Disaster Risk Reduction – Suriname adaptation options

- Construct an emergency network of agricultural irrigation pipes and pumps connected to reliable water sources, such as nearby larger fresh water rivers or controlled reservoirs.
- Develop and upgrade infrastructure for water supply, irrigation, drainage and flood protection, in order to increase the efficiency of water use, including storage and distribution, without compromising sanitation systems.
- Develop and implement a leakage management programme, including mains rehabilitation, to reduce water leakage from distribution and supply networks.
- Awareness raising programme on the impacts of climate change on water resources and management of these impacts. Awareness raising programme on avoiding contaminated water post-disaster.

Need to balance ecological sustainability with developing water resources for human use

- Water resources can be considered as "ecosystem products" whose protection and sustainable management will, in turn, also protect and safeguard water resources.
- Water bodies – rivers, lakes, groundwater, etc. – provide a wide range of services for ecosystems and human society (food and agriculture, drinking, natural flood mitigation or energy).
- The water resources are not only basic natural resources of social and economic development, but also the basic elements of comprise the whole ecological environment system.
- The intention to manage water to meet human needs, the needs of freshwater species and ecosystems have largely been neglected, and the ecological consequences have been tragic.

Need to balance ecological sustainability with developing water resources for human use

- Healthy freshwater ecosystems provide a wealth of goods and services for society, but the use of freshwater flows must be better managed if we hope to sustain these benefits and freshwater biodiversity.
- The establishment and maintenance of such flow and sediment regimes, namely environmental flows, is an essential element in preserving riverine ecosystems and the services they provide. They should be included as a constraint in water resource assessment and in national legislative frameworks.
- Environmental flows not only refer to the minimum amount of water (low flows) to be maintained in a river but is also related hydromorphological processes and local ecological objectives for the river.
- River management not taking into account the dynamic nature of rivers, has provoked undesired effects.
  - incision processes and bank erosion undermining channel stability, sediment starvation, coastal erosion, disconnection with groundwater bodies and, ultimately, loss of habitat and ecosystem services.

Need to balance ecological sustainability with developing water resources for human use

- Environmental flows are fundamental to the management of water resources as a tool for ecosystem and biodiversity conservation and adaptation to climate change at a country scale (ecologically sustainable water management).
- Ecologically sustainable water management is a repeating process in which both human water demands and ecosystem requirements are defined, refined, and modified to meet human and ecosystem sustainability now and in the future, rather than a single, one-time solution.
- This implies an aggressive and continual search for compatibility between ecosystem and human water needs, and requires a commitment from all parties to ongoing participation in an active dialogue.

Need to balance ecological sustainability with developing water resources for human use

Suggestion for a general framework for ecologically sustainable water management: six basic steps that should be performed iteratively.

- 1. Define ecosystem flow requirements (The flows and water levels required in a water body to sustain the ecological function of the flora and fauna and habitat processes)
- 2. Determine influence of human activities
- 3. Identify areas of potential incompatibility (conflicts between human uses of water and ecosystem flow needs)
- 4. Foster collaborative dialogue (share vision for the river's future conditions that can be used in water management decisions)
- 5. Conduct water management experiments to resolve uncertainty (Building a Knowledge Base through Research and Monitoring)
- 6. Design & implement an adaptive management plan

Resource water quality

- Even though Suriname has an abundance of water resources, a significant portion of the population does not have access to safe drinking water for personal and domestic purposes.
- The national percentage of population with access to safe drinking water is 72.6 percent.
- The highest percentage of population with access live in the urban areas (the coast) reaching between 85–90 percent, followed by the rural area with 66.6 percent and lastly the interior with just 20 percent.
- People in the interior make use of water from rivers and other water resources (i.e. rainwater catching).
- The water from these sources is not considered to be safe and appropriate for domestic purposes as it is often untreated with the accompanied health risks.
- The coast has an abundance of high-quality groundwater in coastal aquifers that run tens to hundreds of metres deep (A-sand, the Coesewijne, and Zanderij aquifers)

Human activities and affect on water quantity and quality

- Water is becoming scarcer as the human population continues to grow and demand high quality water for domestic purposes and economic activities.
- Water quality comprises the physical, chemical, and biological characteristics of a water body
- Human activities affect both water quality and quantity.
- Human activities change land use and land cover, which changes the water balance and usually changes the relative importance of processes that control water quality.
- Human activities alter the natural characteristics of air, land, and water, which subsequently affect water quality.
- Furthermore, most human activities generate waste ranging from gases to concentrated radioactive wastes.

Human activities and affect on water quantity and quality

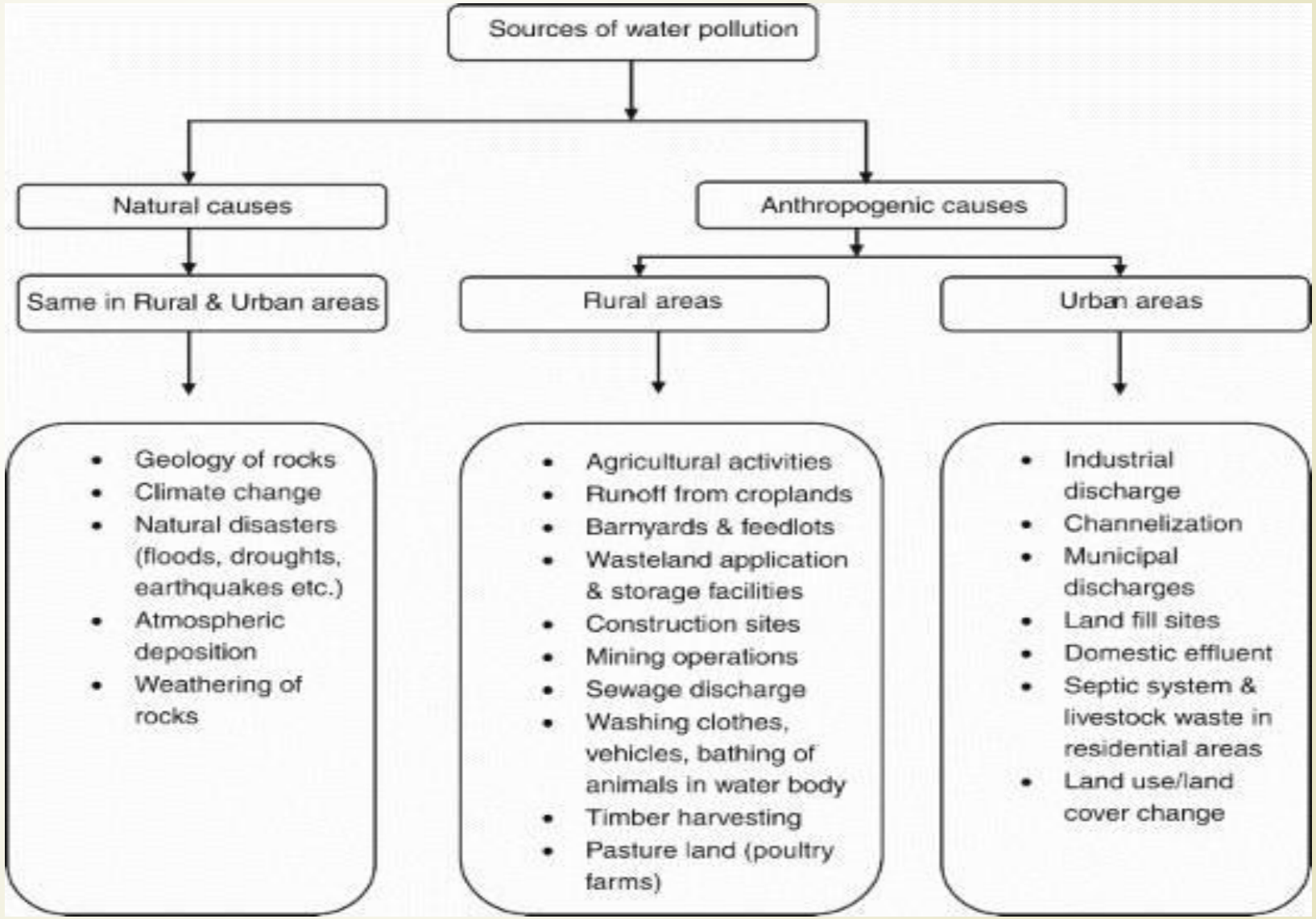
- Anthropogenic factors affecting water quality include impacts due to agriculture, use of fertilizers, manures and pesticides, animal husbandry activities, inefficient irrigation practices, deforestation of woods, aquaculture, pollution due to industrial effluents and domestic sewage, mining, and recreational activities.
- These anthropogenic influences cause elevated concentrations of heavy metals, mercury, coliforms and nutrient loads.
- The quality of surface water and groundwater is a sensitive issue as far as health is concerned. Contamination of these resources should be prevented, controlled and reduced.

Human activities and affect on water quantity and quality

- Water quality, measured by assessing the physicochemical and biological properties of water against a set of standards, is used to determine whether water is suitable for consumption or safe for the environment.
- Water quality and quantity are thus linked, although they are not often measured simultaneously.
- Water quantity is measured by hydrological monitoring stations that record water level, discharge and velocity.
- Water quality is determined by analysis of water samples collected periodically by these monitoring stations.
- The results of water quality monitoring are important in determining the spatial and temporal trends in surface water and groundwater.

Natural and anthropogenic sources of water pollution

- Floods and droughts may bring about changes in water quality through dilution or concentration of dissolved substances.
- Where there are low river flow rates, the main effect on water quality is when there is a temperature increase, increased concentration of dissolved substances and decreased concentration of dissolved oxygen



Human activities and affect on water quantity and quality

- Human activities can affect water quality directly and indirectly.
- Direct effects are those that change water quality through the addition of some chemical constituent, physical characteristic, or biological component
- The discharge of wastewater to a stream directly affects the stream chemistry, the application and leaching of fertilizer affects groundwater chemistry that can affect surface water by groundwater discharge
- Indirect effects include alteration of the landscape (construction, mining, and farming), which affects hydrological pathways that change the rates at which water interacts with the environment and flushes out materials from that landscape.

Strategies to minimize the negative impacts of human activities on water resources

There are several possible solutions to mitigate the negative impact caused by human activities in rivers:

- 1. Improved waste management: Implement effective waste management practices, such as proper disposal and recycling systems, to prevent waste from entering rivers.
- 2. Water pollution control measures: Implement regulations and monitoring systems to control discharge of pollutants into rivers, such as industrial effluents, sewage, and agricultural runoff. This can be achieved through strict enforcement of pollution control laws and installation of water treatment facilities.
- 3. Reforestation and conservation: Protect riverbanks by reforesting them with native vegetation to prevent erosion and sedimentation. This also helps filter pollutants and provides habitats for aquatic species.
- 4. Sustainable agriculture practices: Promote the use of sustainable agricultural practices, such as organic farming and integrated pest management, to reduce the use of harmful chemicals and prevent runoff into rivers.

Strategies to minimize the negative impacts of human activities on water resources

There are several possible solutions to mitigate the negative impact caused by human activities in rivers:

- 5. Education and awareness: Increase public awareness and education campaigns about the impact of human activities on rivers. This can lead to behavior change and responsible actions by individuals and industries.
- 6. Engage in collaborative efforts: Encourage partnerships and collaboration between governments, NGOs, industries, and local communities to promote sustainable water management practices and address the issues collectively.
- Implement river cleanup initiatives: Organize regular river cleaning campaigns involving local communities, schools, and volunteers to remove trash and debris from the river and its banks.
- 7. Continuous monitoring and research: Regularly monitor water quality, measure the impact of human activities, and conduct research to identify emerging threats and develop effective solutions.

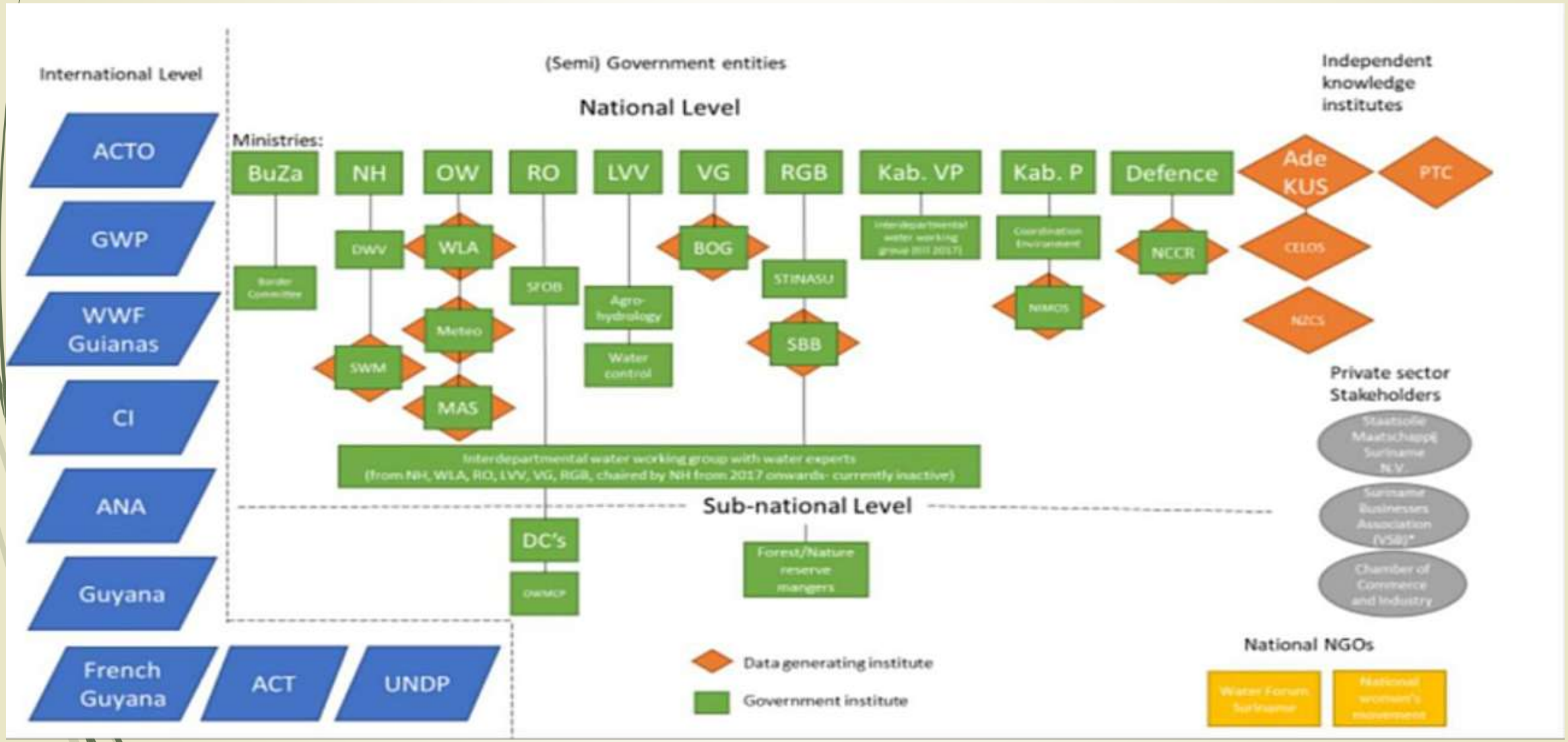
Need for integration of different actors in water resources management

- IWRM requires the participation of all stakeholders' and a multitude of innovative tools for its successful implementation.
- Since sectoral competition is increasing, water demand is reaching the supply limit, and the multitude of actors in the same geographical territory along with other various complexities, such as climate change, water conflicts, and governance issues are all making water management more difficult.
- The last three decades, the water debate shifted its focus from assessing the available resources (supply management) to a more integrated approach involving a wide range of fields, including environmental, social, and economic aspects, which represent the purpose of Integrated Water Resources Management
- Countries are now obliged to manage water resources in an integrated manner which applies to multiple aspects of water functioning (water quality and quantity, irrigation, drinking water supply, recreation, etc.), the involvement of stakeholders, decision-makers, and the existing policy domain

Need for integration of different actors in water resources management

- Policy making in the field of water resources management, takes place in a network of different parties, called actors, who all have their own interests and concerns, and who all control a part of the resources needed for successful policy implementation
- Finding technical solutions to the problems of just one actor is not sufficient for successful water policy development, as this is likely to neglect the interests of other actors that might be able to frustrate the policy implementation in a later stage
- The existence of such multi-actor complexity puts additional demands on the water experts, as they have to take into account the different problem perceptions, interests and positions of the actors
- In Suriname a number of governmental agencies and institutions, without clearly defined roles, are involved in the protection and monitoring of water resources.

All parties involved with water resources management in Suriname



Need for integration of different actors in water resources management

- **Ministry of Natural Resources (NH) (Leading ministry for IWRM)**
  - The Ministry of Natural Resources delegated its responsibilities with regards to water supply to the Suriname Water Company (SWM), is responsible for the water supply in the densely populated urban area in the Coastal zone of the country and in the rural area
  - NH is responsible for water management, where necessary in an inter-ministerial manner. The ministry of Natural Resources is considered to be the leading actor in the implementation of IWRM
- **Ministry of Public Works, Transport and Communication (OW) The relevant departments are:**
  - the Meteorological Service: (MDS) is the preeminent authority responsible for data related to the "supply" of water (important part of the hydrological cycle) and provides information necessary to manage spring waters of the country
  - the Hydrodynamic Service (WLA). WLA has a very important function in terms of research and data collection which is essential for the formulation of an integrated water policy

Need for integration of different actors in water resources management

- **Ministry of Agriculture, Animal Husbandry and Fisheries (LVV).** Two important departments when it regards water management are the Department **"Management Water boards" and the "Pesticides Office"**. In the context of monitoring the proper use of land and waters issued for the agricultural sector, this ministry has responsibilities towards rehabilitation of the dry and wet infrastructure within the water boards
- **Ministry of Regional Development and sport (ROS).** The Ministry is responsible for the further development of the **participatory process in decision-making** at the level of the constituencies and districts. The **garbage disposal and sanitation** in the districts are inadequate which forms a potential source of contamination. The regional government is also responsible for the **management and maintenance of secondary and tertiary civil engineering facilities** (channels) which are outside the jurisdiction of the Ministries of Public Works and Agriculture

Need for integration of different actors in water resources management

- **Ministry of Spatial Planning, land and forest management (RGB).** The responsibility of the ministry of spatial planning, land and forest management is restricted to regulate and monitor formally protected areas, nature reserves and is responsible for all natural water in protected areas.
- **NIMOS The National Institute for Environment and Development in Suriname.** NIMOS is the technical working arm of the Ministry of ROM. It is the intention with the approved Environmental law, NIMOS is transformed into an environmental authority. An important task of this authority will be to control pollution of the environment and determining of environmental standards. In this way, the rivers and other waterways will get legal protection against pollution

Need for integration of different actors in water resources management

- All in all, there is some capacity for IWRM implementation within the government, mostly in terms of human resources (hours).
- Many state that more knowledge on IWRM is required to adapt to the complexity of water challenges.
- Also responsibilities are divided between many governmental agencies and institutions, the ability to manage potential conflicts of interest between different sectors and/or stakeholder groups is not present.
- Also financial means to collect data and properly monitor all water resources in Suriname is lacking.
- The density of the measurement network is low and accuracy is not always on a desired level

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Thank you

THE END

Exercise

- Make for Suriname a SWOT Analysis for the water resources

Suriname: The SWOT Analysis for the water sector

Suriname: The SWOT Analysis for the water sector presented the following strengths and weaknesses:

Strenghts	**Weakness**
Sufficient resources of ground and surface water	Insufficient legal, regulatory and institutional framework to protect and regulate the sector
Central role of water supply	Legislation and regulations relating to water supply
Opportunities	**Threats**
Partnerships for financing of projects	Climate change induced drought due to prolonged dry periods

Suriname: The SWOT Analysis for the water sector

- Water resources in Suriname may experience stress as a result of climate change through the combined effects of reduced annual rainfall, increased evapo-transpiration, and prolonged dry periods.
- Reduced rainfall and the resulting reduced discharge will lead to saltwater intrusion in the rivers, creeks and streams that flow directly into the Atlantic Ocean. A linear projection of this relationship with respect to a one-meter sea-level rise causes a displacement of the saltwater wedge by approximately twenty kilometres upstream
- The tidal effect of the Atlantic Ocean on the water system and the freshwater discharge from upstream. It is certain that under such conditions, water resources of all rivers and significant parts of the wetlands in the coastal zone will decline rapidly.
- Without proper adaptation measures, saltwater intrusion will have a significant impact and even jeopardize the agricultural sector, while other sectors will be strongly affected as well.