WRM in Humid Tropical Regions

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Course: Integrated Water Resources Management
Module: Ecology & Water Resources

WATENV International Master Programme

Lecture:

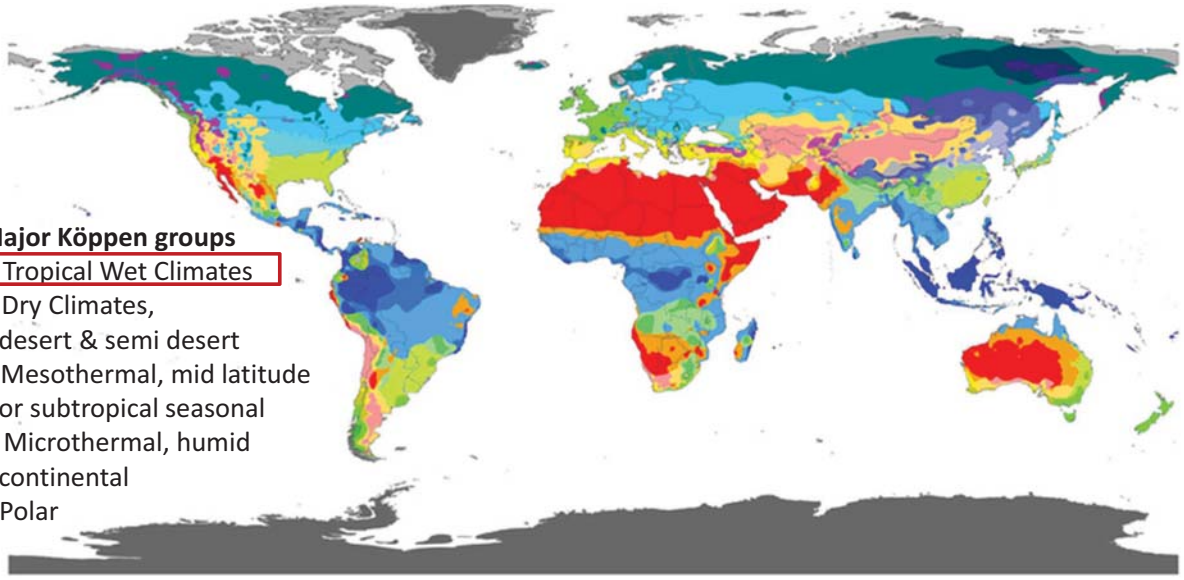
1 The Physical Environment of the Humid Tropics
2 Wetlands in the Humid Tropics

1 The Physical Environment of the Humid Tropics

Tropical climates are characterized by constant high temperature (at sea level and low elevations) — all twelve months of the year have average temperatures of 18 °C (64 °F) or higher.

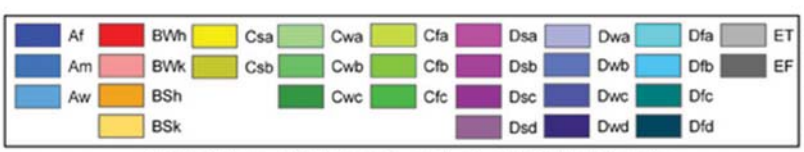
There is abundant rainfall and extreme weather like cyclones and monsoons.

Köppen-Geiger Global Climate Classification



Major Köppen groups

- **A** Tropical Wet Climates
- **B** Dry Climates, desert & semi desert
- **C** Mesothermal, mid latitude or subtropical seasonal
- **D** Microthermal, humid continental
- **E** Polar



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DATA SOURCE : GHCN v2.0 station data Temperature (N = 4,844) and Precipitation (N = 12,396)

PERIOD OF RECORD : All available

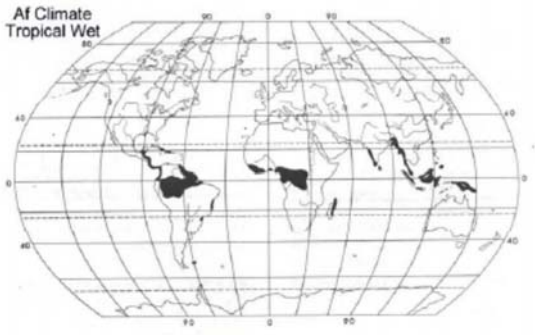
MIN LENGTH : ≥30 for each month.

RESOLUTION : 0.1 degree lat/long

Contact : Murray C. Peel (mpeel@unimelb.edu.au) for further information

Tropical Wet Climates: Rainforest

- Tropical rainforest climate (Af): All twelve months have average precipitation of at least 60 mm. These climates usually occur within 5–10° latitude of the equator (in some eastern-coast areas 25°). This climate has no natural seasons.



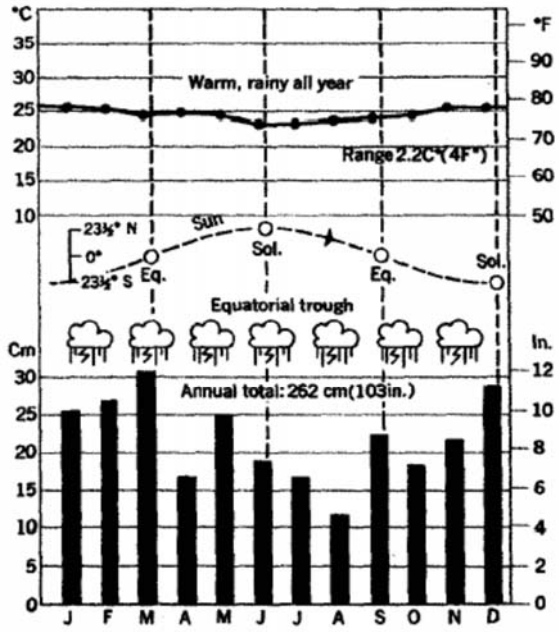
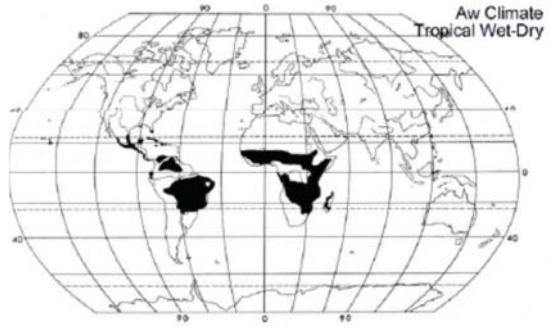


FIGURE 8.10 Wet equatorial climate (1). Iquitos, Peru, is located in the upper Amazon lowland, close to the equator. Temperatures differ very little from month to month, and there is copious rainfall throughout the year.

Tropical Wet-Dry Climates: Savanna

- Tropical wet and dry or savanna climate (Aw): These climates have a pronounced dry season, with the driest month having precipitation less than 60 mm and also less than (100 − [total annual precipitation {mm}/25]).



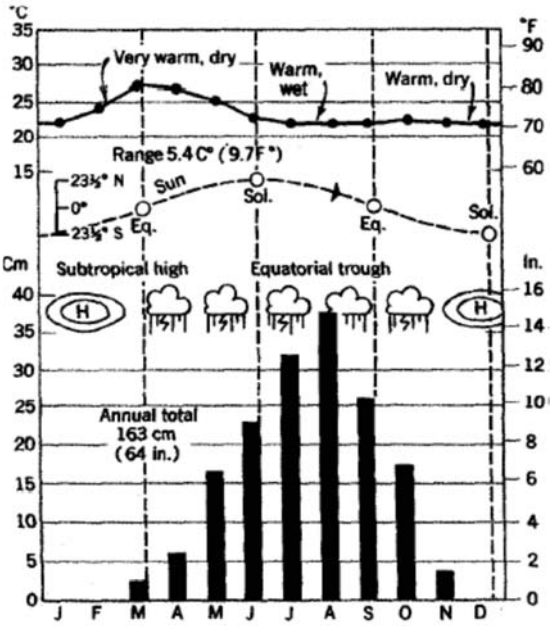


FIGURE 8.13 Wet-dry tropical climate (3). Timbo, Guinea, at lat. 10½° N, is in West Africa. A long wet season at time of high sun alternates with an almost rainless dry season at time of low sun.

Tropical Monsoon Climates

- Tropical monsoon climate (Am): This type of climate, most common in southern Asia and West Africa, results from the monsoon winds which change direction according to the seasons. This climate has a driest month (which nearly always occurs at or soon after the "winter" solstice for that side of the equator) with rainfall less than 60 mm, but more than (100 − [total annual precipitation {mm}/25]).

Vegetation

Biome	Climate	Maximization of Phytosynthesis	Minimization of Water Loss
Tropical Rainforest	Tropical Wet (Ar)	Broadleaf and evergreen habits	Water loss no problem, leaves can grow to max size
Tropical Savanna	Tropical wet/dry (Aw)	Broadleaf and evergreen habits	Deciduous habit, smaller leaves

Land Use and Agriculture

- Land use
  - Growing population and increasing economic activity
  - Water and energy: hydropower, dams
  - Wetland degradation
- Agriculture
  - High rainfall intensities -> high surface runoff, low infiltration, high erosion (loss of fertile soil)
  - High evapotranspiration -> soils dry out fast after rainfall
  - Dry periods long enough to hinder crop growth

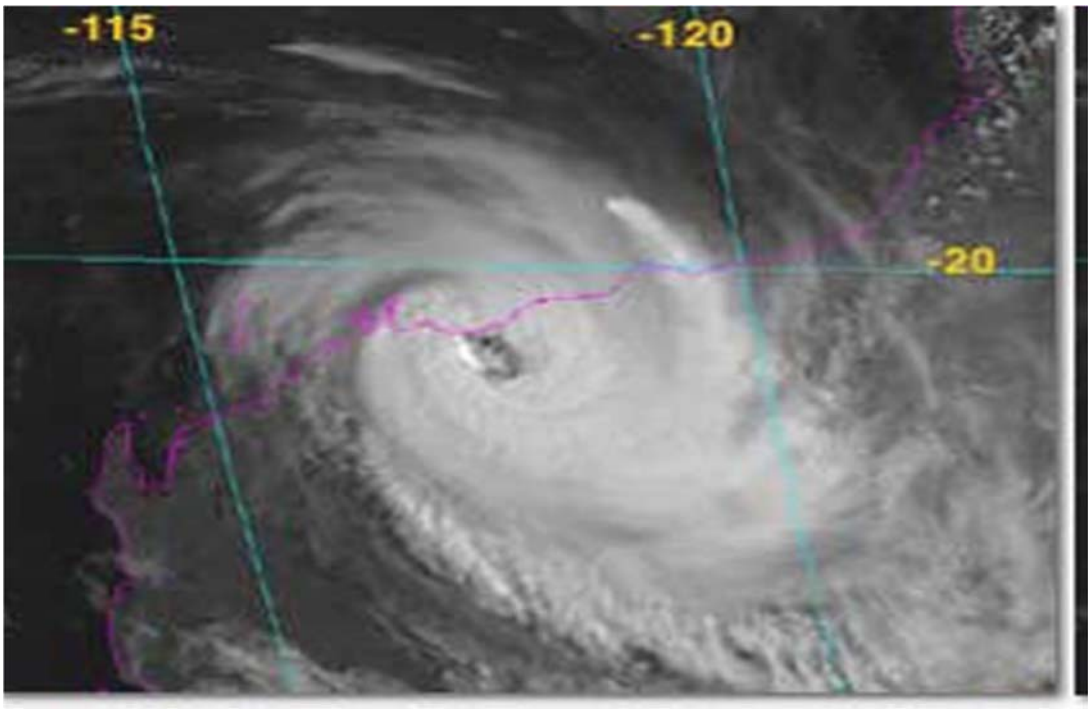
Water in the Humid Tropics

- Uneven distribution of water resources in space and time
  - Monsoon regions: 70 to 80 % of precipitation within two to three month
  - Sequences of wet and dry years (five to ten years duration)
  - Severe flooding, but drought in the other months
  - Tropical cyclones (hurricanes, typhoons) can cause disastrous floods

Rainfall Characteristics

- Rainfall in humid tropical zones > 3000 mm/a, sometimes < 10 mm/a (arid zones: < 20 mm/a)
- Rainfall variability (average deviation in % of mean value) is high for low rainfall values
- Total rainfall is increasing with increasing topographic height up to a maximal zone, above it is decreasing, in the tropics ~ 1200 -1500 m a.s.l. depending on latitude
- Yearly rainfall cycle in the tropics: hygric seasons (rainy season, dry season) instead of thermal seasons in moderate climates
- Exceptional case in the inner tropical convergence zone ITC: daily cycle along with the temperature.

Convection in Tropical Latitudes



Tropical cyclone crossing the northwest coast of Australia.

Tropical Heavy Rainfalls

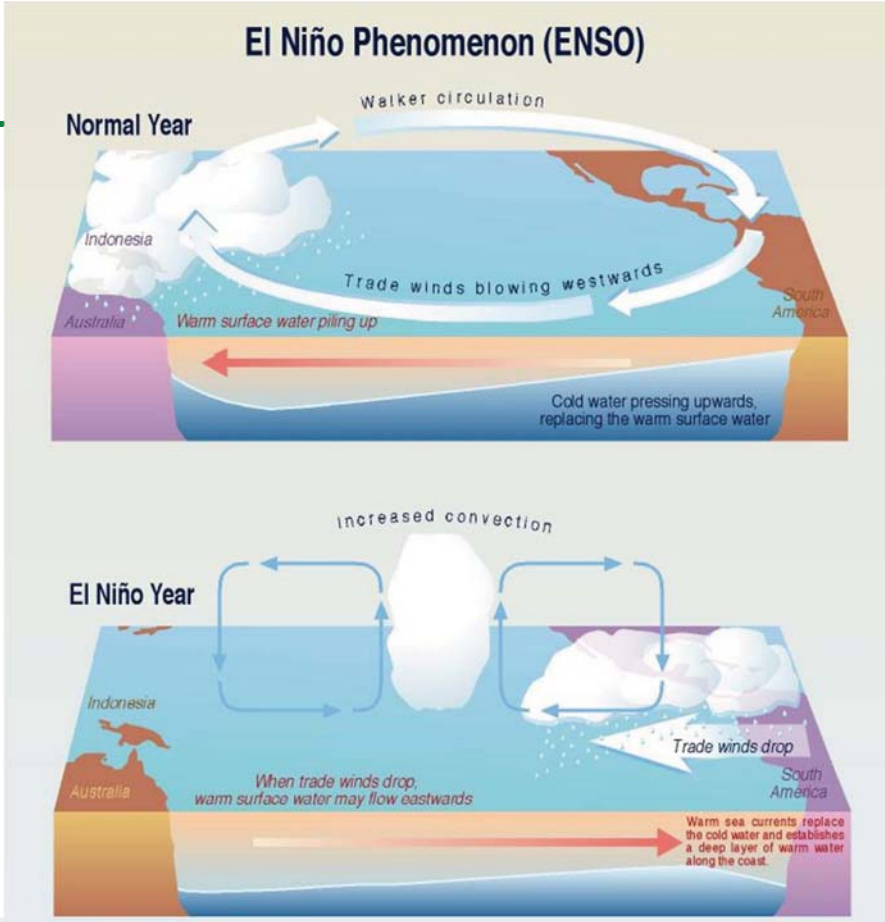
- R_{max} in general in the afternoon at max. convection, in coastal zones during the night or in the morning.
- Rainfall amounts:
  - winter rainy zones: 400 - 700 mm/d
  - summer rainy zones: < 1200 mm/d
  - inner tropics: 200 - 300 mm/d
- Analysis of heavy rainfall: rainfall intensities of defined duration and frequency
- Fog: tropical forest is increasing the rainfall by higher condensation: trop. Mountain forests, cloud forests with epiphytes (e.g. Kilimandscharo)

History of El Niño

- El Niño, as an oceanic phenomenon along the coasts of northern Peru and Ecuador, has been documented since the 1500s.
- Originally, the term El Niño was used to describe the annual appearance of warm waters around Christmastime.
- In some years the warm waters appeared earlier and lasted longer. Eventually, the term El Niño was used to describe these periods of anomalous warming.
- The stronger events disrupted local fish and bird populations

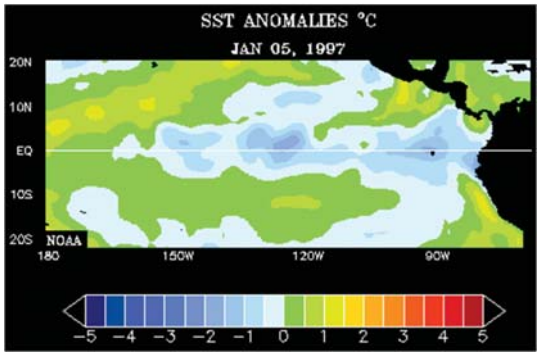
History of the Southern Oscillation

- Beginning in the late 1800s scientists began to describe large-scale pressure fluctuations.
- Sir Gilbert Walker and colleagues extended the early studies and established that a global-scale pressure fluctuation (the Southern Oscillation) is related to rainfall anomalies in many areas of the Tropics (e.g., India and South America).
- The SO was used as the basis for seasonal rainfall predictions (ca 1930s).

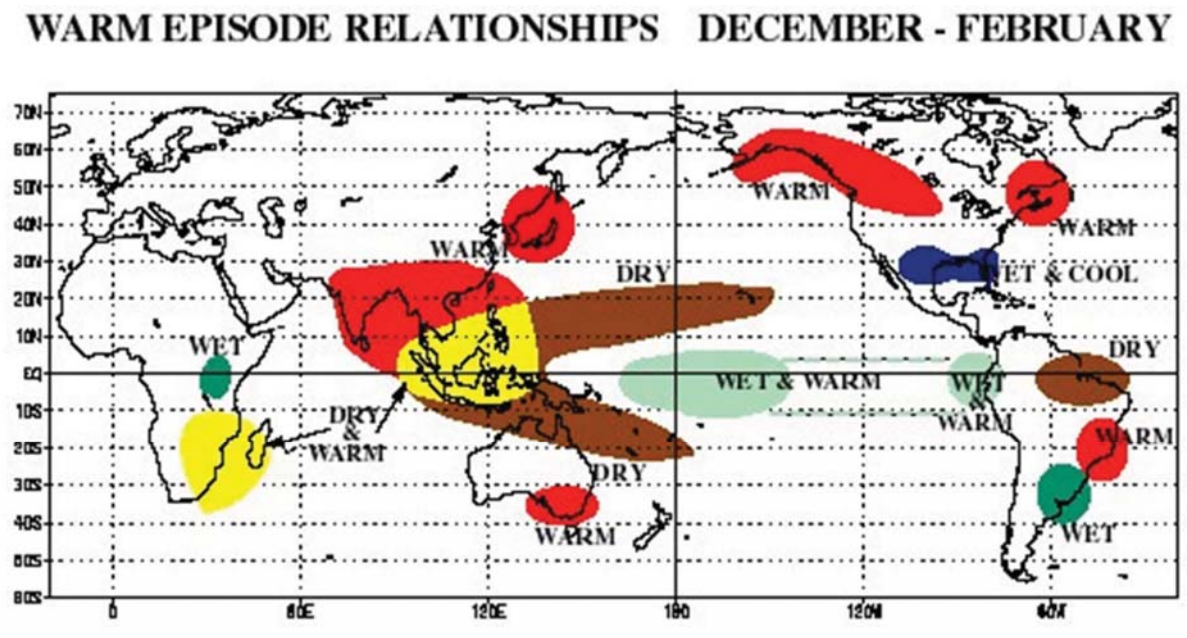


The ENSO Cycle

- Naturally occurring phenomenon
- Equatorial Pacific fluctuates between warmer-than-average (El Niño) and colder-than-average (La Niña) conditions
- The changes in sea surface temperatures affect the distribution of tropical rainfall and atmospheric circulation features (Southern Oscillation)
- Changes in intensity and position of jet streams and storm activity occur at higher latitudes



ENSO and Global Climate



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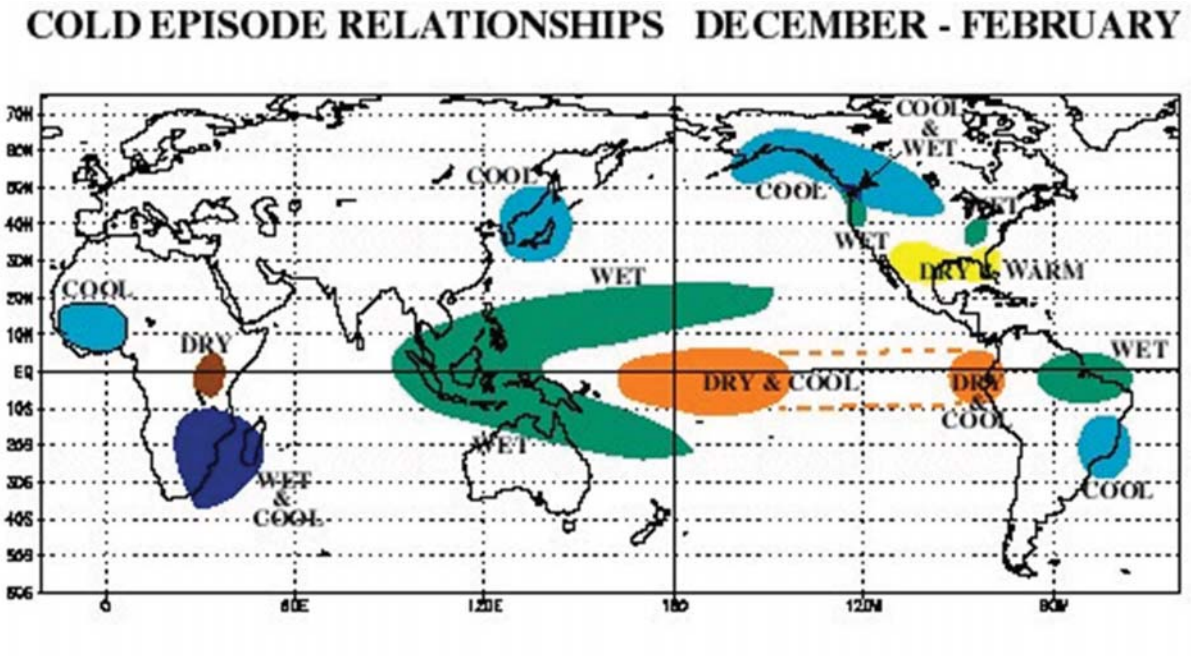


2 Wetlands in the Humid Tropics

Wetland ecosystems typical for tropical landscapes

- River deltas of Amazon, Niger, Ganges-Brahmaputra, Mekong
- Inland Swamps of Brazilian Pantanal, the Congo and Sumatra
- Mangrove forests at low-energy tropical coasts

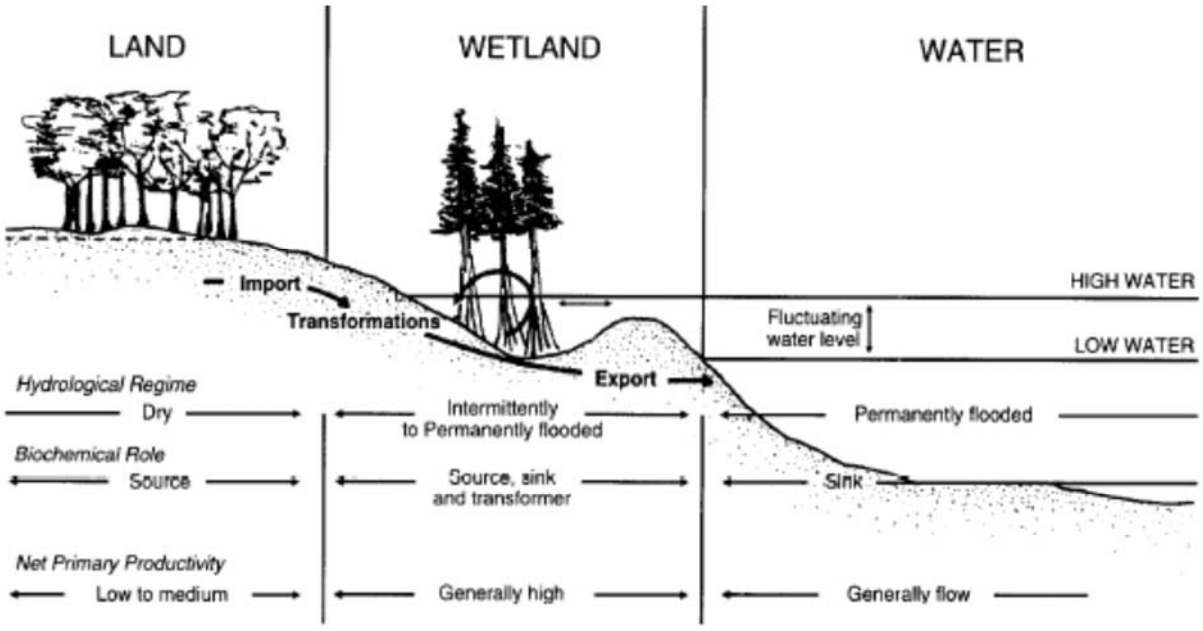
Wetland Definition

Wetlands occupy the transitional zone between land and water, often exhibiting characteristics of both aquatic and terrestrial ecosystems and, in coastal areas, those of both freshwater and marine ecosystems.

Wetlands are characterized by the presence of

1. water, either permanently or periodically;
2. Wetlands have unique, waterlogged soils;
3. Wetlands support vegetation specifically adapted to wet conditions and lack flood-intolerant vegetation.

Wetland Definition



Wetlands occupy the transitional zone between land and water (after Mitsch & Gosselink, 1986; adapted by permission of John Wiley & Sons).

Wetland Hydrology and Soils

- presence of water is the unifying factor behind all wetland ecosystems
- Energy and nutrients are transported to and from wetlands by precipitation, surface runoff, ground water, tides and flooding rivers
- hydrology is the most important determinant for the establishment and maintenance of specific types of wetlands
- Wetlands can be extremely sensitive to changes in hydrology
- Wetlands soils are water-saturated on a permanent or periodic basis: waterlogged soils, hydric soils
  - low in oxygen: limit plants to carry out normal aerobic root respiration
  - high organic content
  - production of gasses such as hydrogen sulfide and methane.

Wetland Vegetation and Fauna

- Wetland plants are uniquely adapted to thrive under conditions of environmental stress which include waterlogged soils, floods interspersed with dry periods, extreme water temperatures and, in some cases, salt.
- Wetland ecosystems provide essential habitat for innumerable species of insects, amphibians, reptiles, fishes, birds, mammals and other fauna.
- A number of rare and endangered species are found exclusively in wetlands, including manatees, crocodiles, hippopotamus, many birds.

Functions of Tropical Wetlands

- regulating tropical hydrologic cycle, e.g. stream flow (slowing flood waters/retention) -> buffering tropical weather extremes
- ground-water recharge
- improving water quality: biochemical interactions with wetland soils and plants -> natural filter
- stabilizing shorelines: dense vegetation reduces flow velocities, trapping sediment
- providing habitat for innumerable species of fish, birds and other animals -> food reservoir

➢ Provide goods and services for humans, have intrinsic ecological value (biodiversity/genetic reservoir)

Source:

Loss and Degradation of Wetlands

- conversion to agriculture (often rice cultivation) and aquaculture : important source of food, employment and foreign exchange earnings – but adverse effects;
- construction of dams and other hydrologic alterations: loss of seasonal wetlands downstream;
- drainage and poisoning to defeat wetland associated diseases: malaria, yellow fever, dengue, encephalitis, Guinea worm, sleeping sickness;
- invasive species;
- (urban) land reclamation by growing population (e.g. many airports built on former wetlands).

References

- Hufschmidt, M.M., Kindler, J. (1991): Approaches to Integrated Water Resources Management in Humid Tropical and Arid and Semiarid Zones in Developing Countries. Report IHP-III Projects 10.1(a) and 10.2(a), UNESCO, Paris.
- Coughanowr, C. (1998): Wetlands in the Humid Tropics. UNESCO IHP Humid Tropics Programme Series 12.

Thank you for your attention!

IWRM in Humid Tropical and (Sub-)Polar Regions

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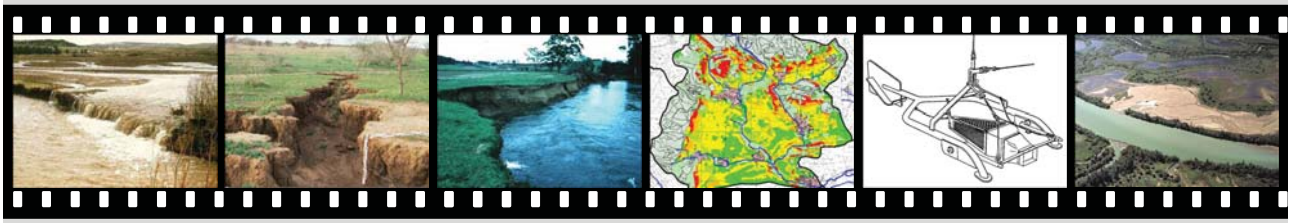

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