ROADS FOR WATER SECURITY
WATER FOR ROADS SAFETY

Road water management in wetlands

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Road Water Management in Wetlands

- Wetland types and their functions: hydrologic/ecologic/economic functions
- Impacts of roads on wetlands
  - Hydrological imbalances
  - Ecosystem change
- Roads vis-à-vis flood in wetlands
- Planning roads in wetlands: considerations
- Water harvesting from retreating wetlands

Wetland Types

- Wetlands are characterized by **water saturation** in the root zone, at, or above the soil surface, **for a certain amount of time during the year.**
- Take **many forms** including marshes, estuaries, mudflats, mires, ponds, fens, pocosins, swamps, deltas, coral reefs, billabongs, lagoons, shallow seas, bogs, lakes, and floodplains.
- Dominant Types:
  - **Shallow lakes and ponds-** are areas of permanent or semi-permanent water with little flow
  - **Marshes and Swamps -**Marshes form in depressions in the landscape, as fringes around lakes, and along slow-flowing streams and rivers. Marshes slow down the rate of rainfall drainage and control its flow into rivers, lakes, and streams.
  - **Bogs-** are characterized by spongy peat deposits or waterlogged peat-lands in old lake basins or depressions in the landscape, acidic waters and a floor covered by a thick carpet of sphagnum moss. Bogs receive all or most of their water **from precipitation rather than from runoff, groundwater or streams.**

Wetland Types…

- Wetlands are mostly freshwater marshes, although some are brackish or alkaline.
  - Forested Wetlands
  - Scrub-Shrub Wetlands
  - Marshes,
  - Wet Meadows and

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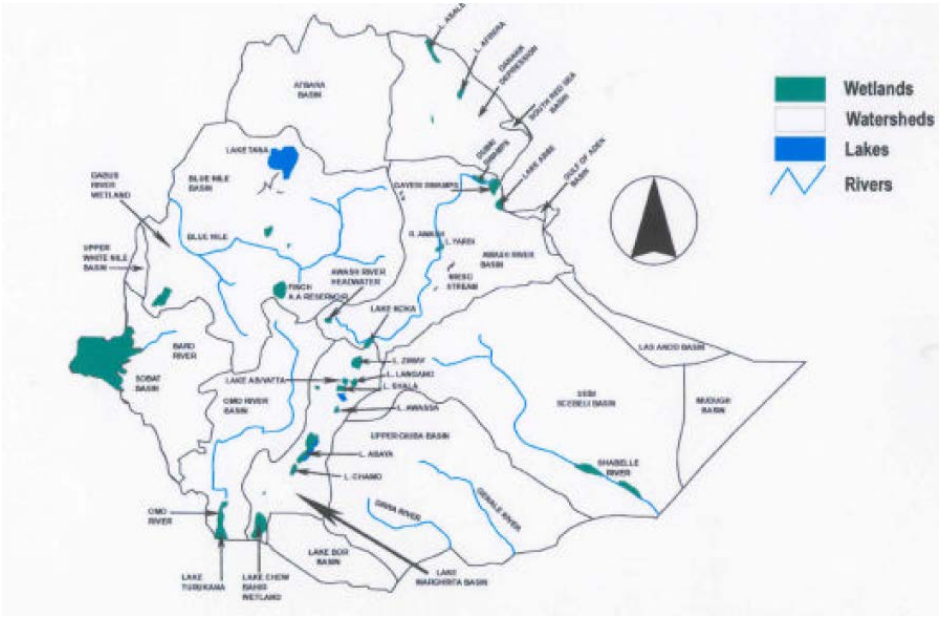

Wetland Types…

- Gambella Wetlands are mosaic of different wetland types

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Wetland Functions

- **Atmospheric maintenance and Hydrologic functions**
  - **Atmospheric maintenance**
    - Wetlands world-wide help **moderate global climatic conditions.** Many wetlands **return over two-thirds of their annual water inputs to the atmosphere though evapotranspiration** (Richardson and McCarthy 1994).
    - Wetlands may also act to **moderate temperature extremes** in adjacent uplands (Brinson 1993)
    - Wetlands **store carbon** within their plant communities and soil **instead of releasing** it to the atmosphere as carbon dioxide.
  - **hydrologic cycle roles**
    - Wetlands play a critical role **in regulating the movement** of water within watersheds as well as in the global water cycle
    - Receive, store, and release water in numerous ways
    - Some wetlands **maintain stream flow** during dry periods
    - Some wetlands **replenish groundwater** and help **maintain the level** of the water table

Wetland Functions

- **Ecological function**
  - Play an **integral role** in the ecology of a watershed.
  - Wetlands are among the **most productive ecosystems**
  - Can be thought of as **"biological supermarkets."** - Many species of birds and mammals rely on wetlands for food, water and shelter, especially during migration and breeding.
  - **Oxidation-Reduction -** redox conditions governed by hydroperiod play a key role in: nutrient cycling, availability, and export; pH; vegetation composition; sediment and organic matter accumulation; decomposition and export; and metal availability and export
  - **Hydrologic flux and life support-** Changes in frequency, duration, and timing of hydroperiod may impact spawning, migration, species composition, and food chain support of the wetland and associated downstream systems (Crance 1988)

Wetland Functions

- **Ecological function ….**
  - **Biological Productivity -** Immense varieties of species of microbes, plants, insects, amphibians, reptiles, birds, fish, and other wildlife depend in some way on wetlands.
  - **Community structure and wildlife support -** Wetland shape and size affect the wildlife community and the wetland's function as suitable habitat (Kent 1994b; Brinson 1993; Harris 1988
  - **Hydrologic flux and life support-** Changes in frequency, duration, and timing of hydroperiod may impact spawning, migration, species composition, and food chain support of the wetland and associated downstream systems (Crance 1988

Wetland Functions

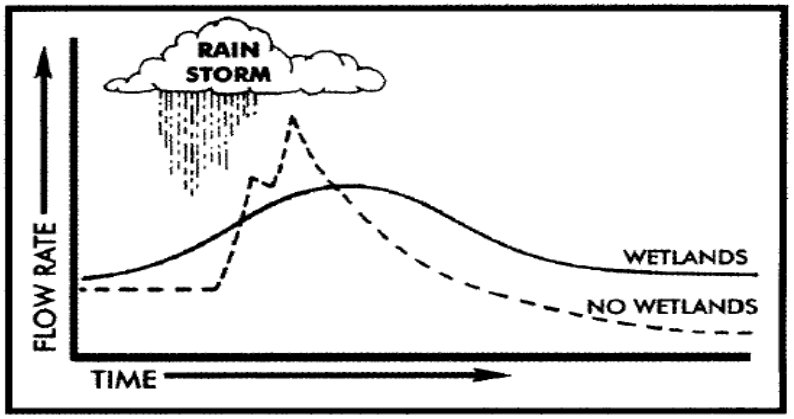
- Economic benefits-
  - Biogeochemical Cycling and Storage-
    - Improve water quality/Water filtration- natural filtration process provide the conditions needed for the removal of both nitrogen and phosphorus from surface water. Improve.
    - intercepting surface runoff and removing or retaining inorganic nutrients, processing organic wastes, and reducing suspended sediments

Wetland Functions

- Economic benefits ….
  - Decomposition – The nutrients and compounds released from decomposing organic matter may be exported from the wetland in soluble or particulate form, incorporated into the soil, or eventually transformed and released to the atmosphere.
  - Aesthetics, Recreation, Education, and Research
  - Fisheries
  - Wildlife Habitat (food supply, tourism, …)
  - Produce products dependent on wetlands such as wetland rice

Wetland Functions

Flood control- Wetlands can play a role in **reducing the frequency and intensity of floods** by acting as natural buffers, soaking up and storing a significant amount of floodwater. wetlands store and slowly release surface water, rain, groundwater and flood waters. Trees and other wetland vegetation also impede the movement of flood waters and distribute them moreslowly over floodplains



This diagram indicates that wetlands reduce peak stormwater flows. (Source: Kusler 1983)

Impacts of roads on wetlands

- **On the hydrology**
  - Dead and dying trees, and ponded water, are the most common visual clue that the hydrology of a site may have been affected by a road.
  - Dead trees tend to be on one side of the road, and it is assumed that flooded conditions cause the dieback.

Large flooded area with many fallen and dead trees- Texas, USA

Ancient red gums are casualties of central NSW wetlands in severe decline- Murray-Darling Basin

Impacts of roads on wetlands…

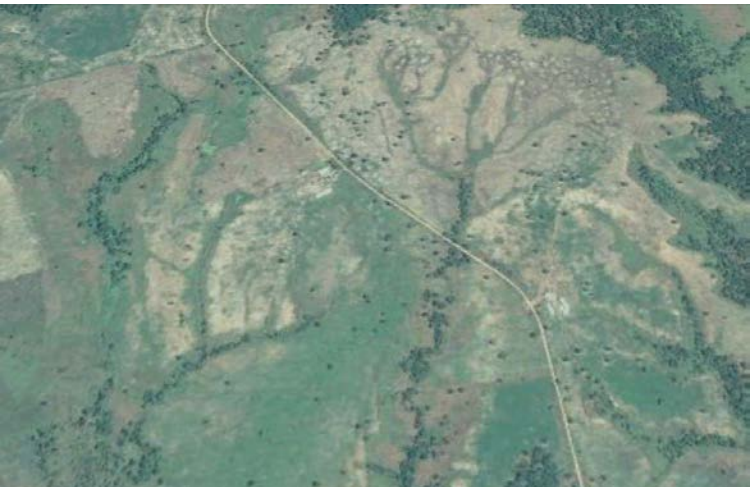
- Gambella wetlands are wide and flat
- Roads are fragmenting the habitats and influence the flow of water, sediments, nutrients and aquatic life in wet season
- Roads affect the livelihood system by changing water storage and moisture availability patterns
- Roads can effect the gradient of local streams and cause them to silt up

Impacts of roads on wetlands

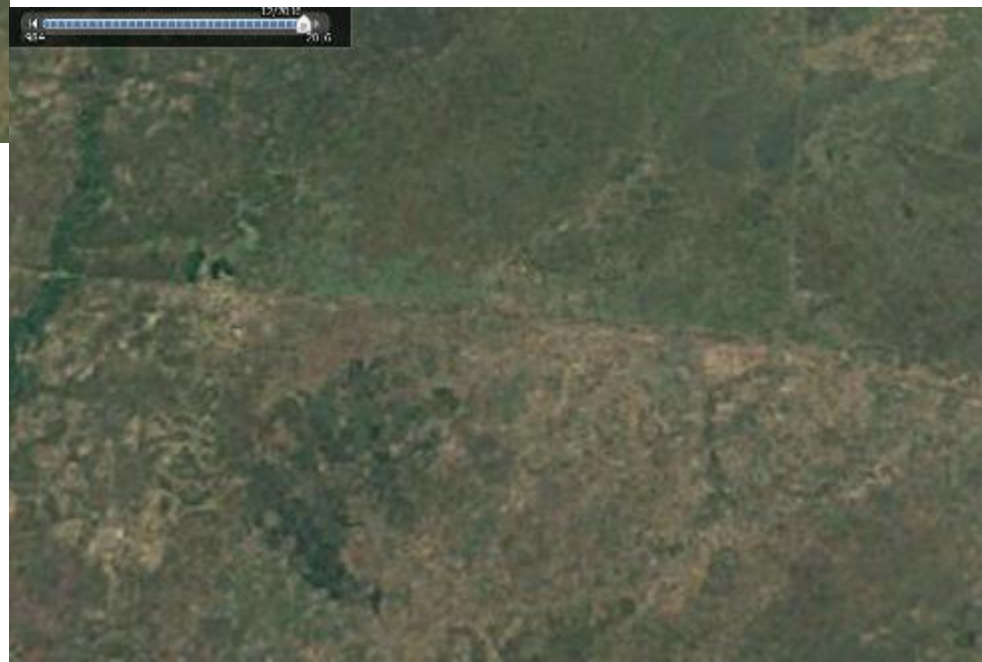
- **On the hydrology….**
  - Impacts may also occur due to beaver activity

Impacts of roads on wetlands…

- **On the hydrology….**
  - Reduced moisture availability on one side of a road



Gambella-Lare Road
1984-2016



Impacts of roads on wetlands…

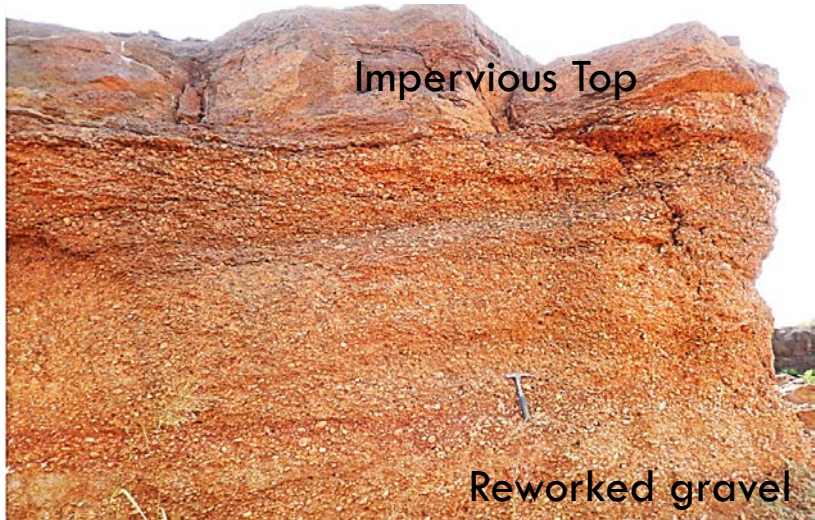
- **On the hydrology….**
  - Reduced moisture availability on one side of a road

Impacts of roads on wetlands…

Impacts also depend on hydrological responses – impoundments may or may not create wetlands

Planning for road water management

- Characteristics of a wetland
  - wetland types or their unique attributes
  - understand wetlands and their hydrologic functions in order to better manage for water movement- flow system (both vertical and lateral water movement), understanding seasonal influences (storm levels, etc.),
- Bearing capacity of the site
- should not interfere with the hydrology of a site; roads should be designed to allow water to move as if no road was present
- fill requirements



Planning for road water management

- Avoiding the building of roads through wetlands by building longer roads that circumvent these areas should be considered when planning

Planning for road water management

- Flow direction – properly define inlet-outlet. This is a challenge for in Gambella wetlands
- Undertake the construction during dry conditions

Managing road water

- **by the use of culverts-**
  - for streams with well-defined channels
  - for balancing water to either side of the road where there is no well-defined channel.
- Culverts can be partially embedded during construction to allow the upper portion to cater to surface flows, with the lower portion catering to daily subsurface flows

Managing road water

- **by the use of culverts…**
  - Culvert diameters 300 to 800 mm for metal pipe, and both metal and plastic culverts are used.
  - The spacing of culverts used to balance water on either side of a road varies, from as close as every 15 m to as far apart as 335 m.
  - Bridges are typically used within a wetland for crossing a well-defined channel.
  - Filling of wetlands without a permit is illegal !!!

Managing road water…

- By use of products to help prevent the blockage of a culvert's inlet or outlet by beaver activity

The Beaver Proof Add On (left) and the Beavercone (right) are examples of products that help prevent the damming or blockage of a culvert by beaver activity

Managing road water…

- Subsurface drainage considerations

Ponded water along impermeable compact road (Lare- Gambela road). A permeable rock fill/ a rock weir subgrade constructed to allow for the passage of water. Note the settlement area on the uphill side (left), which requires periodic cleaning to remove accumulated sediments. Two culverts have been placed higher within the road to provide additional conduits for water during periods of high flow.

Managing road water…

Abutments and bearing requirements

Implementing a floating bridge with approach ramps helps alleviate the use of weak wetland soils to provide bearing capacity to traditional bridge abutments. The approaches of this bridge were built with corduroy

Managing road water…

Approaches

bridge is used to cross a channel where a culvert is not well suited. The road approaches can be designed and built to allow water to pass through; for example, through the use of a permeable fill or open conduits (right)

Roads vis-à-vis flood in wetlands…

Interactions between roads and floods

1. Roads to control or compartmentalize floods
   - Road embankments as dikes
2. Roads evacuating people during floods
3. Roads embankment when reinforced ‘reservoir dam’ storing floods

Example of resilience approach: Room for the River (Netherlands & Gambela)

Creates safety against extreme river floods by widening river cross sections to lower flood levels.

Situating the dikes further away from the river, or lowering the river forelands, to reduce velocities and water levels by providing space for the watercourse.

Requires properly designed flow-through structures that can withstand the high flow velocities.

‘Sponge roads’ option- the cobble stone road

Water harvesting from retreating wetlands

- Paradoxically, there are cases of water stress conditions in Gambella wetlands

Water harvesting from retreating wetlands

Borrow pit provide water as the wetland retreats

Water harvesting from retreating wetlands

- Borrow pits are used
- Fish pond can be developed
- Same approach can be applied to retain water in ponds, trenches and depression as the flood water retreats

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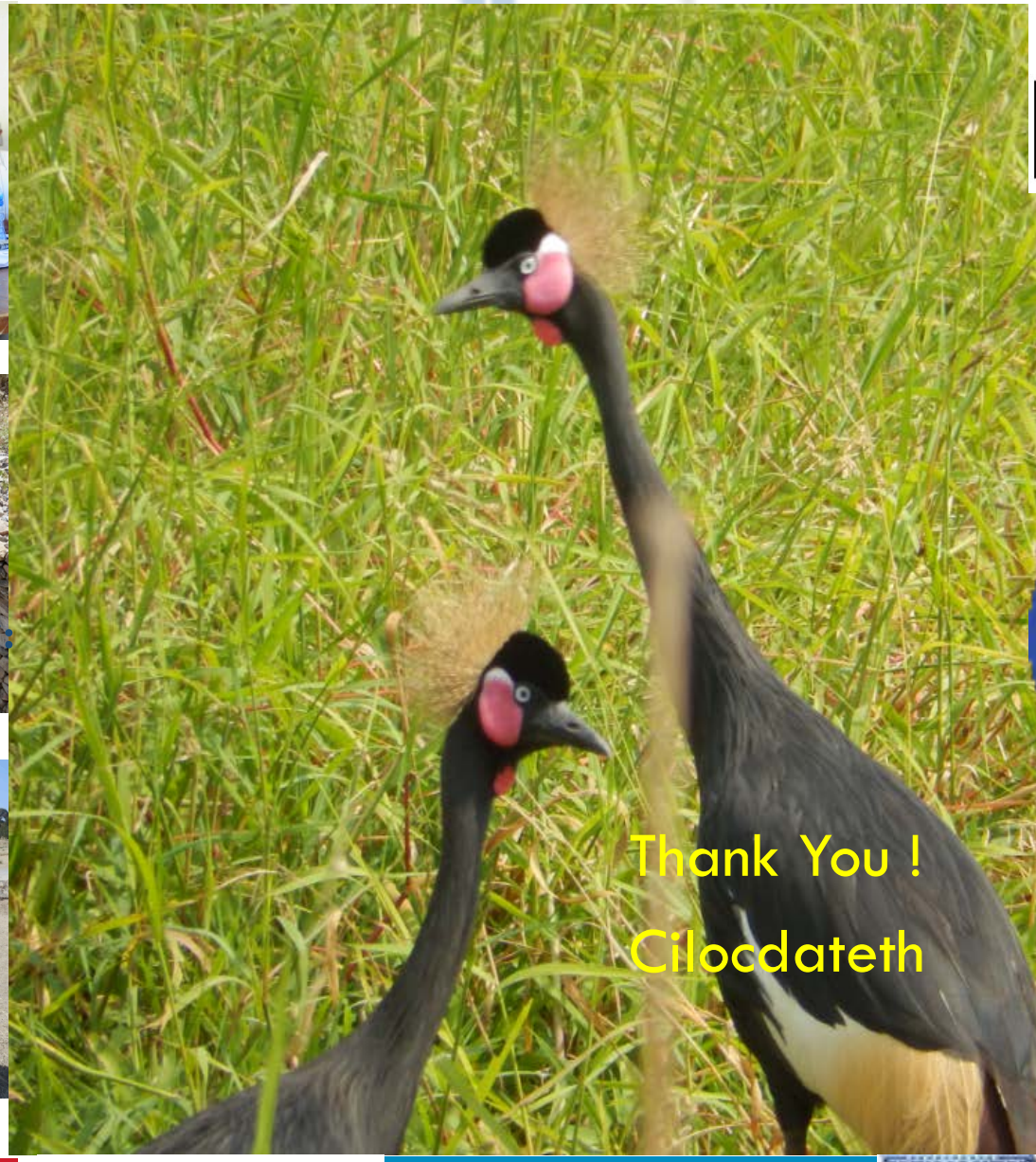

Thank You !

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