ACID SULPHATE SOILS,CHARACTERISTICS AND MANAGEMENT

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Acid Sulphate soils – Nomenclature

- Are soils or sediments containing micro-crystalline minerals pyrites (FeS_2), marcasite or jarosites (KFe3(SO4)2(OH)6) formed naturally under prolonged water-logging,
- Occur, in estuaries, wetlands and shallow groundwater with poor drainage
- Referred to as potential acid sulphate soils
- Dutch farmers named them as Kattakali meaning Cat Clays.
- Chenery (1954) introduced the term Acid Sulphate soils that are drained, have adsorbed sulphate, pale yellow colour of Jarosite, usually have pH (< 4.0) under water.
- Exposure to air by lowering of the water table or drainage causes sulphides to react with oxygen, forming sulphuric acid with extremely low pH

Raw acid sulphate soils

- Formed on drainage and become extremely acidic within weeks or months, of drainage
- Identified by the presence of straw yellow coloured mottles of jarosites ($KFe_3(SO_4)_2(OH)_6$) that develop around the pores and on ped faces
- Drainage water is often red with solubilized iron oxide due to acidity

Distribution of acid sulphate soils :

- Occur in coastal areas under the influence of saline or brackish water, permanent fresh water swamps, in Pleistocene terraces and also in high water swamps with source of sulphur.
- In India these soils occur in extensive areas in coastal saline soil zone of West Bengal commonly known as Sunderbans, Andaman Nicobar Islands covering 390000 ha
- Global extent is over 0.26 million hectare (Mohsin et al., 1995).

Acid Sulphate soils of Kerala

- Are deltaic formation of four major river systems, Pampa, Achencoil, Manimala and Meenachil, confluencing into the Vembanad,lake covering an area of 11 00 sq. km
- Region includes vast stretches of backwaters, bordering mangrove formations, and rice fields,
- Rice fields are mostly reclaimed from the shallow stretches of the lake during the recent past.
- The garden lands, or the *reclaimed purayidams* or homesteads are coconut groves
- Owing to persistent human intervention this wetland ecosystem has been completely damaged Economy of the region is dependent on rice, the only crop that can be raised in lowland areas, supported by coconut in *purayidams,* and by inland fisheries

Historical Background

- In the geological past, the Kuttanad region was a part of the shallow coast of the Arabian Sea.
- Geological uplift, resulted in formation of shallow bay into which several rivers discharged.
- It is a low lying deltaic region 0.6-2.2 m below Mean Sea Level deltaic region
- Soils are generally acid saline in nature and remains water logged for a major part of the year
- Has been declared as a Ramsar site by UNESCO
- Designated as a Globally Important Agricultural Heritage System (GIAHS)System by FAO, United Nations

Kuttanad ecosystem

- Kuttanad is divided into three distinct zones
- *Karappadam*, *Kari lands* and *Kayal lands* based on texture, acidity, salinity, electrochemical properties etc.
- Paddy is the main crop in Kuttanad and the traditional paddy crop grown here is known as *Punja* (November - March).

Characteristics of Kuttanad Soils

Kayal

- **Deep, poorly drained, strongly acid, clay soils with very high organic matter Contain sulphur bearing sediments at shallow depths and are potential acid sulphates**
- **CEC and exchangeable bases are fairly high**

Karappadam

- **Occur on the fringes of Kuttanad close to the laterite uplands**
- **Soils are poorly drained, deep, acidic clay, organic carbon levels much lower than the Kayal soils and sulphur bearing minerals occur at deeper layers**
- **CEC and exchangeable bases are fairly high**

Kayal Soil profile

Kari soils

- These soils have high levels of organic matter often reaching more than 20 per cent
- Sulphur bearing minerals within 50 cm from the surface.
- They are black in colour,poorly drained, heavy textured are extremely acid.
- Draining of the potential acid-sulphate soils results in ultra acid conditions and formation of acid sulphate soils.

Karappadam soils

- Occur along the inland water ways and rivers.
- Soils are deep, poorly drained with clay loam surface texture and silty clay subsoils.
- Very strongly acid to extremely acid in the subsoil layers due to the presence of decaying organic debris

Soil profile

Genesis of acid sulphate soils

- Consists of two main processes:
- Formation and oxidation of pyrite.
- For formation of pyrites, Fe2+ must be available, which is usually from the weathering of iron containing parent material pyrites, marcasite under anaerobic condition
- Sulphur in pyrite is derived from the sulphate in sea water, and S rich sediments which is biologically reduced to sulphide in anaerobic conditions
- Energy source for bacterial sulphate reduction is organic matter is mainly biological materials algae and diatoms in the marine sediments
- Ferrous sulfide is usually an important ingredient which is developed due to chemical reactions :

$4Fe(OH)3 + 4CaSO4 + 9CH2O \longrightarrow 4Fes + 4Ca(HCO3)2 + CO2 + 11\ H2O$

$CH2O$ represents organic matter

$2FeS2 + 2H2O \longrightarrow FeSO4 + H2SO4$

Thiobacillus ferro oxidans

Thiobacillus thio oxidans

$2S + 3O2 + H2O \longrightarrow 2H2SO4$

Characteristics

- Low pH (3-5.2) of the Kari soils of Kuttanad is due to the presence of undecomposed organic matter in the form of wood fossils with free and combined sulphur
- Soils are dark brown to black in colour, rich in organic carbon, sandy to clayey in texture, with random deposits of lime shells and humus, high CEC
- Organic matter in Kari soils of Kerala is predominantly ligno-protein complex comprising large quantities of lignin,
- Compared to exchangeable acidity, potential acidity is very high and large quantities of lime and leaching with water, providing sub-surface drainage etc. are required to ameliorate the acidic conditions.

Contd …

- Toxic quantities of iron, aluminum, manganese and sulphides are present in the soil.
- Toxicity becomes severe at the top soil as a result of toxic salts coming out by capillary rise to the surface especially during summer months.
- Once exposed, it leads to the production of sulphuric acid and seeps out into flood water and drainage.
- The runoff from acid sulphate soils is extremely acidic very high levels of. Fe^{2+}, Al^{3+} and SO_4^{2-} in the runoff water.
- Presence of sulphuric acid lowers the soil pH and reduces the availability of other nutrients to plants.
- Acid sulphate soils remain safe to the environment until exposed to oxygen
- Plant nutrient content shows wide variations being an alluvial material

Mineralogy of Acid sulphate soils

- Studies Ghosh *et al.,* (1976) on Kari soils of Kerala reveal
- Kaolinite is the dominant clay mineral (34.3%)
- Smectite (18.32%).
- Illite (6-12%),
- Chlorite (0-11%),
- Vermiculite (0-5%),
- Amphibole (0-4%), Gibbsite (0-17%),
- Quartz (0-2%) and Fledspar (0-2%) were also present.

Causes of low productivity in acid sulphate soils

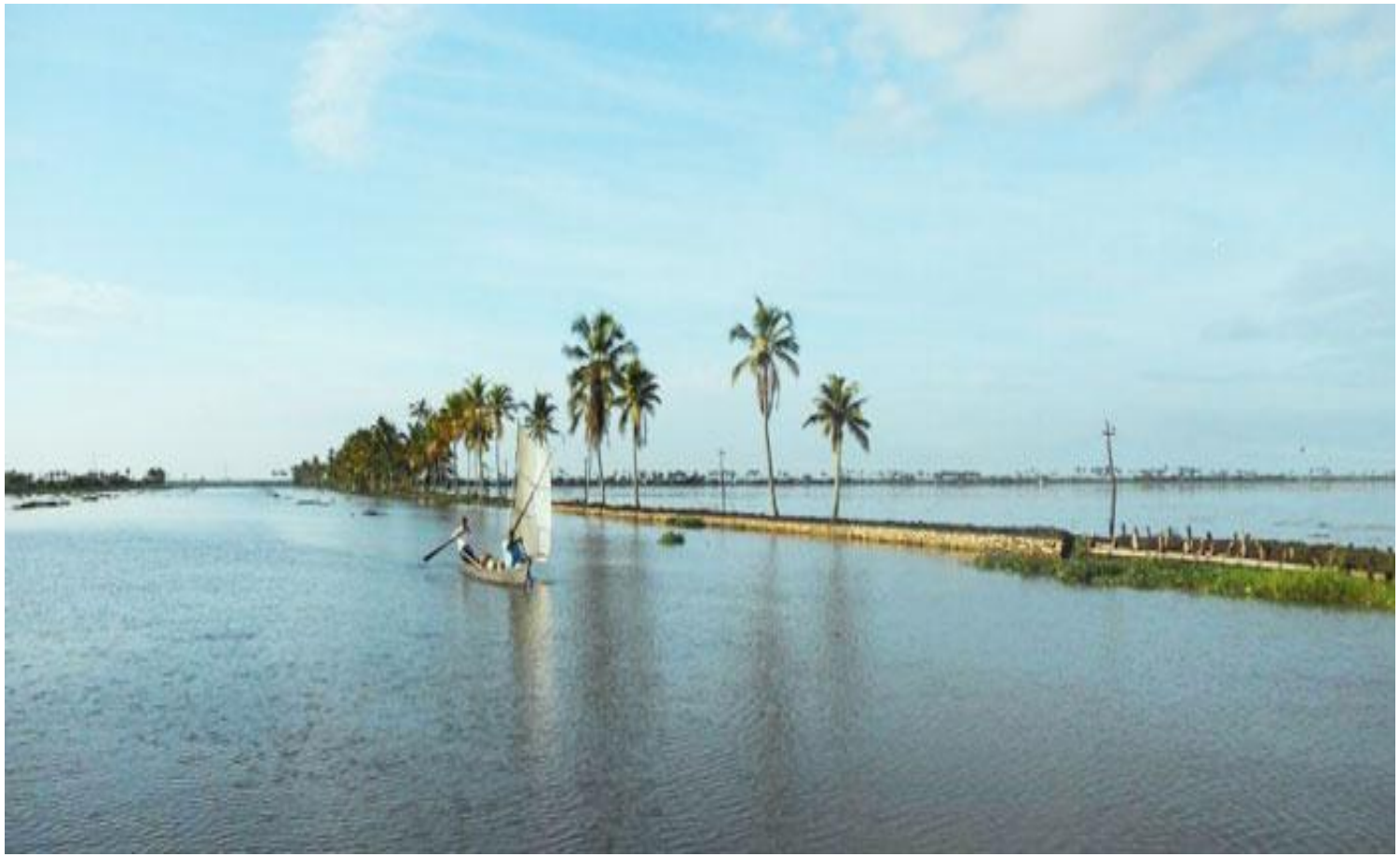
- Injury of hydrogen ions.
- Low pH causing impaired availability and absorption of plant nutrients.
- Increased solubility of iron, aluminum and manganese resulting in toxicity.
- Decreased availability of phosphorus and molybdenum.
- Low base saturation due to leaching and removal of bases
- Abnormal biotic factors causing impaired mycorrhiza and virulence of plant diseases.
- Salt injury in areas with sea water inundation
- Toxicity due to hydrogen sulphide (H2S) and Akiochi disease causing injury to roots
- Injury by organic acids, acetic acid, n-butyric acid and propionic acid which are phyto toxic

Factors governing reclamation and successful use of soils

- Degree of acidity developing dependent on extent of drainage
- Depth of less acid top soil covering extremly acidic sub soil layer
- Depth of Potential acid sulphate soil horizon buried below,
- Timely control of water table during dry season

Management Interventions

- Appropriate water management to prevent drying of soils
- Liming and leaching with rain water, sea water in succession .
- Choice of rice varieties, and water table control.
- Improvement of drainage and leaching out of soluble salts repeatedly during summer
- Farming system approach can halt the negative trend in the rice production
- Livestock, fishery and duckery are some of the enterprises that are compatible with rice



A large expanse of Water bodies comprising of rivers and lake system confluencing into the Vembanad lake - A Ramsar Site

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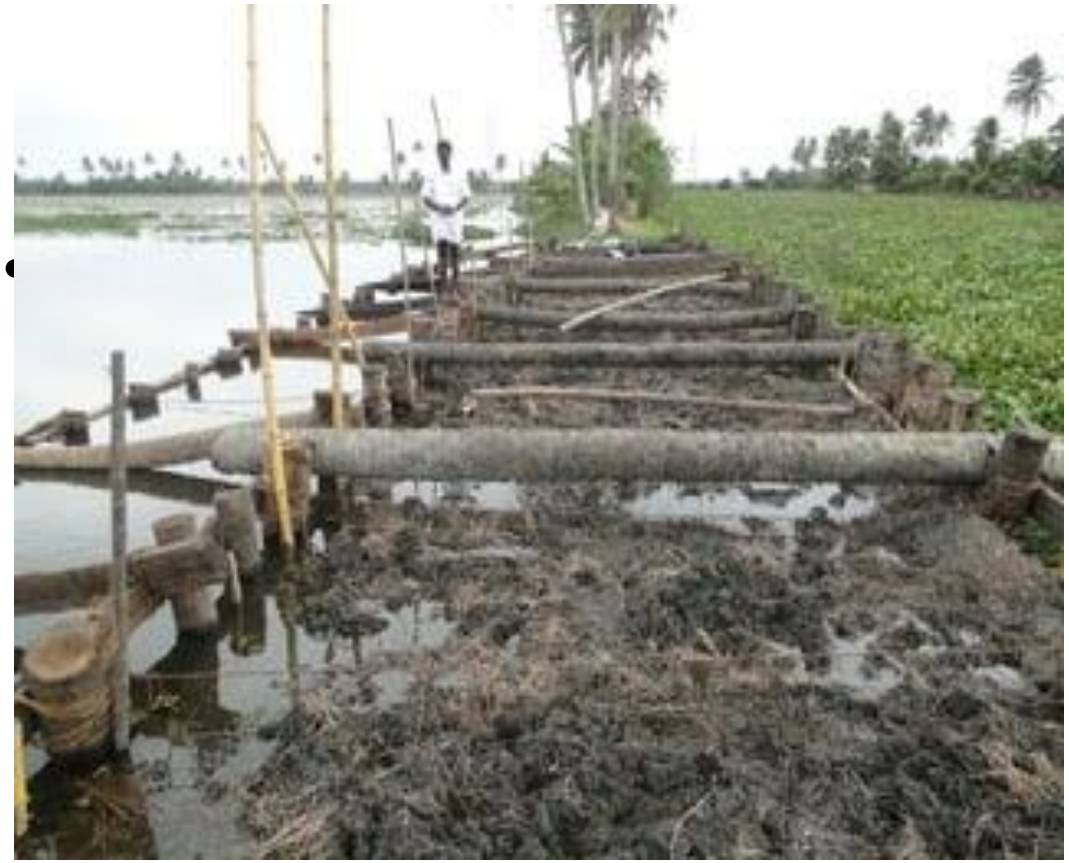
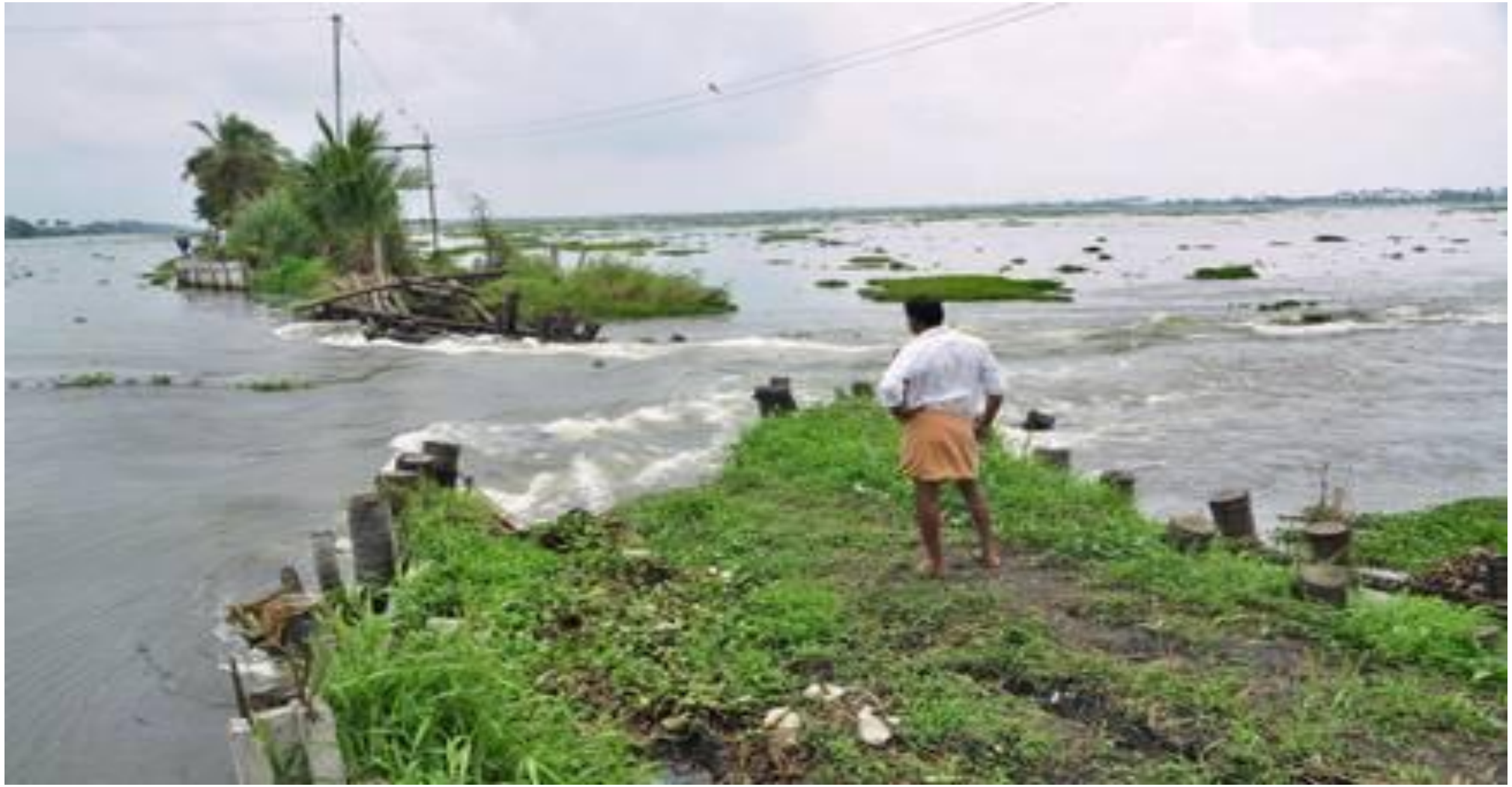
Construction of an Earthern Bund



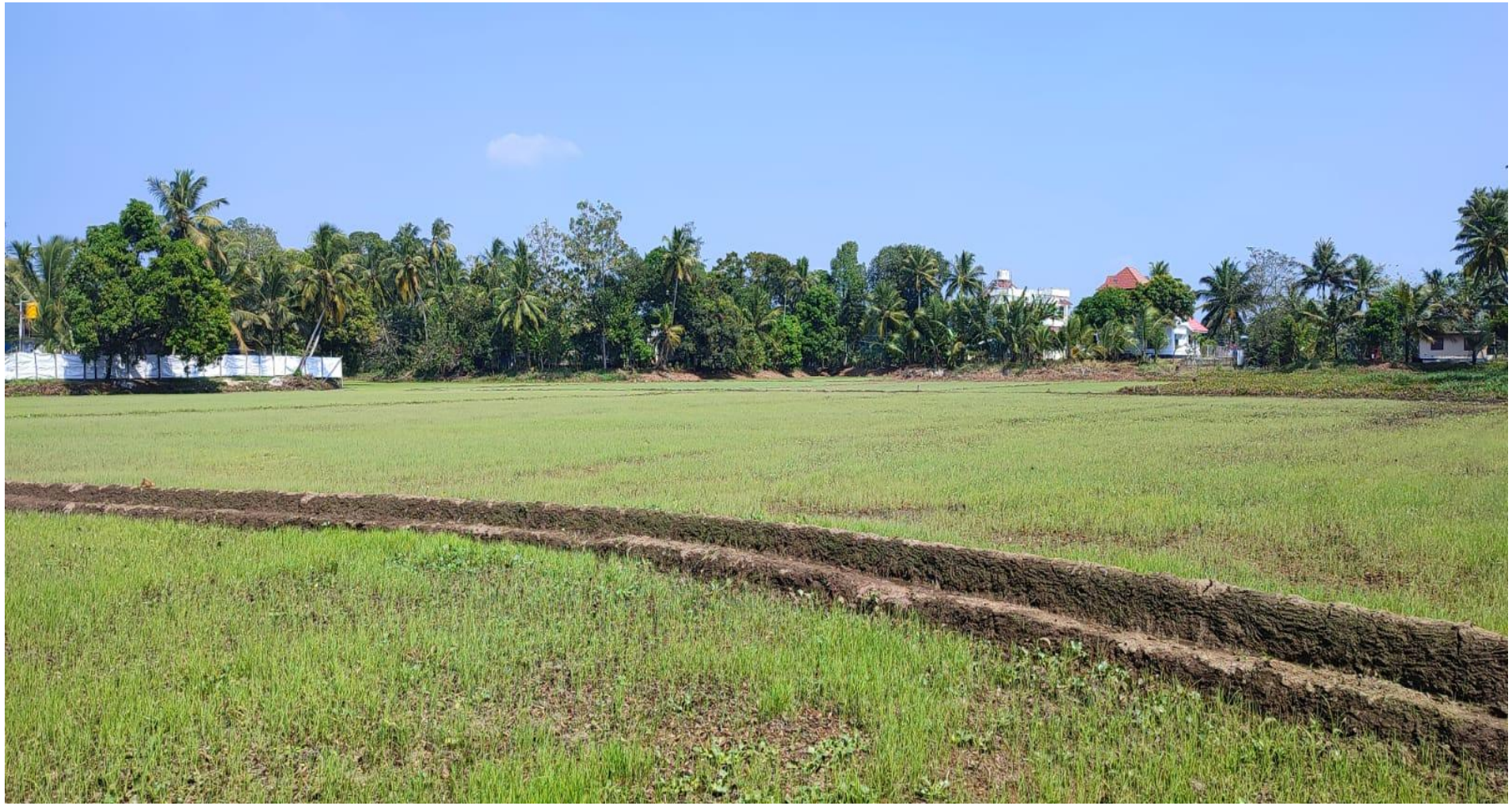
- Made of clay, dug out of the canal beds and stabilized with bamboo and coconut trunks on the sides
- High risk of breaching of bunds by strong waves and heavy currents during the monsoon.
- Frequent breaching of bunds cause major crop losses and a heavy drain on farmers resources for repair and maintenance

Completed Earthern Bund

Bund Breach During Floods

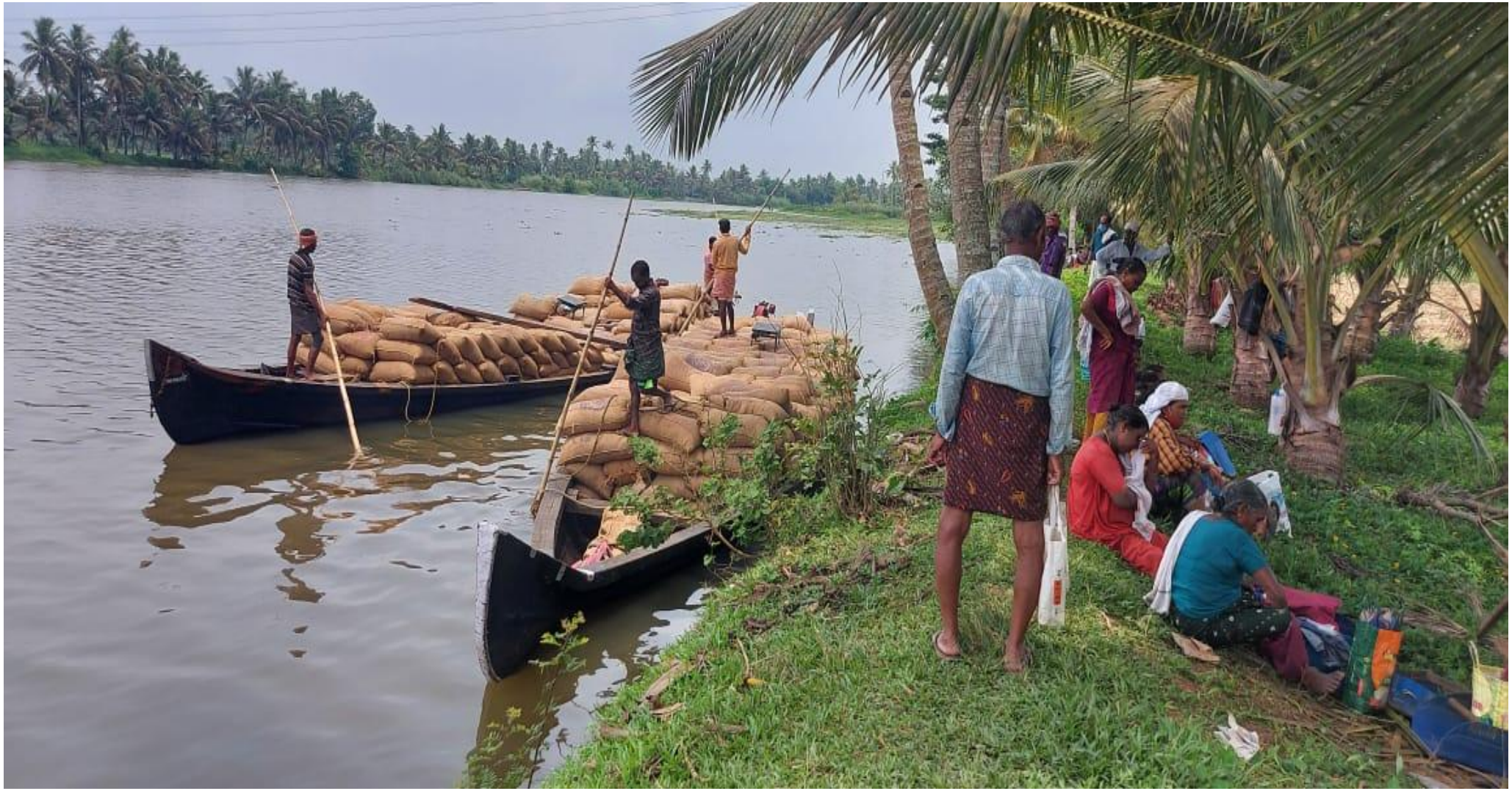


CULTIVATED PADDY FIELD AND ADJACENT COCONUT GARDEN



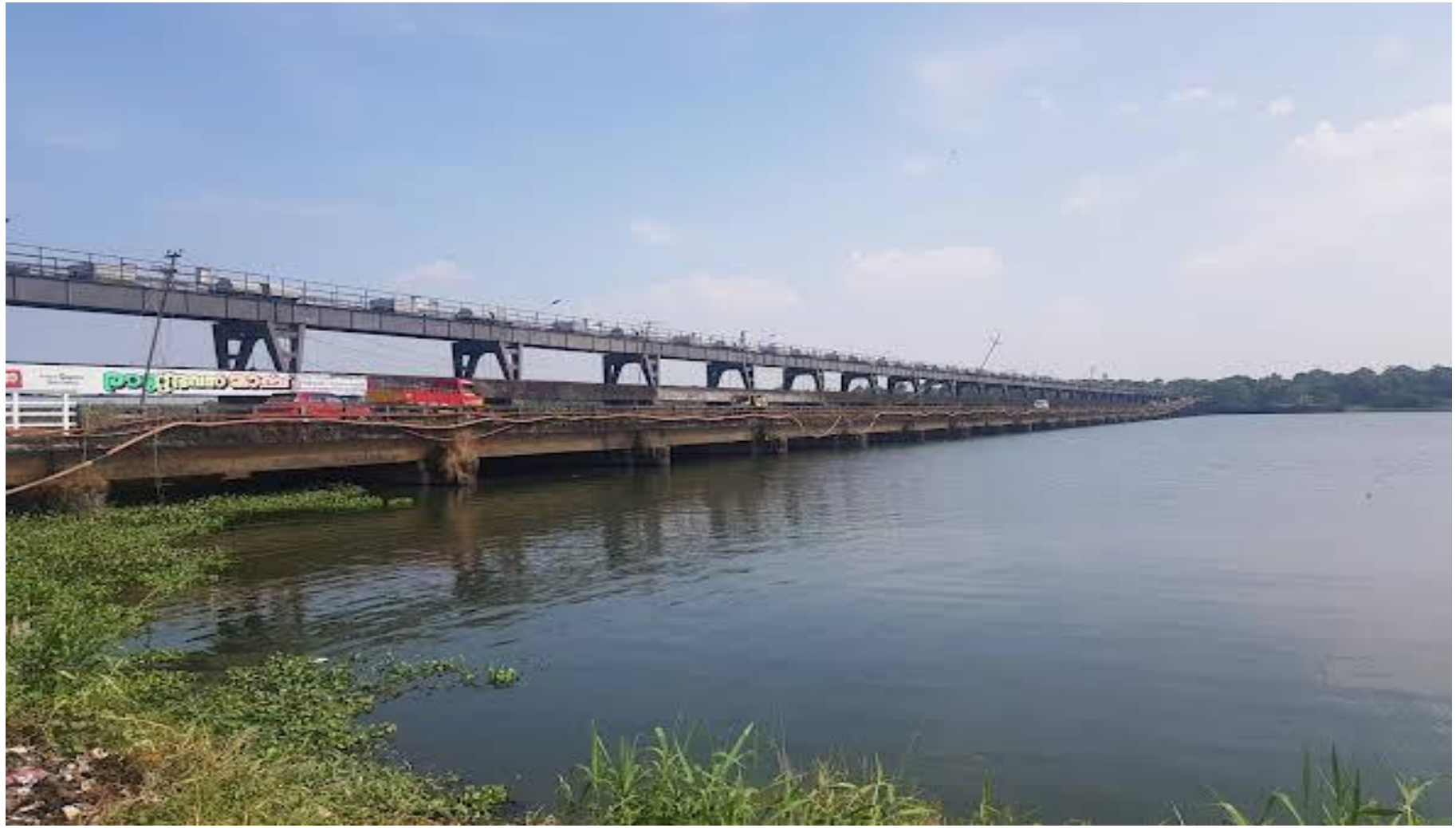
HARVESTED PADDY READY FOR TRANSPORT

Paddy grains being transported in country boats



Thaneermukkom Barrage and Regulator Another viewr

Thaneermukkom Barrage and Regulator



THANEEMUKKOM BARRAGE

- Constructed to prevents tidal action and intrusion of salt water into the Kuttanad low-lands across Vembanad Lake and added benefit by cultivation of additional crop started functioning in 1976
- Negative Impact
- Ecological problems especially rampant multiplication of water weeds
- Deterioration in fish catch from freshwater
- Absence of cleansing of backwater by brackish water
- Consequently –pollution of backwater and adjacent land areas

Revitalization of the area- An urgent need

- **The Globally Important Agricultural Heritage Systems (GIAHS) status calls for immediate efforts to revitalize the region with thrust on**
- **Sustainable food security systems**
- **Combating pollution related hazards**
- **Conservation and enhancement of valuable endemic biodiversity**
- **Maintenance of several vital ecosystem services**
- **Protection of the fragile and unique system from any external pressure**

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Thank You