SOIL RELATED CONSTRAINTS FOR CROP PRODUCTION IN KERALA

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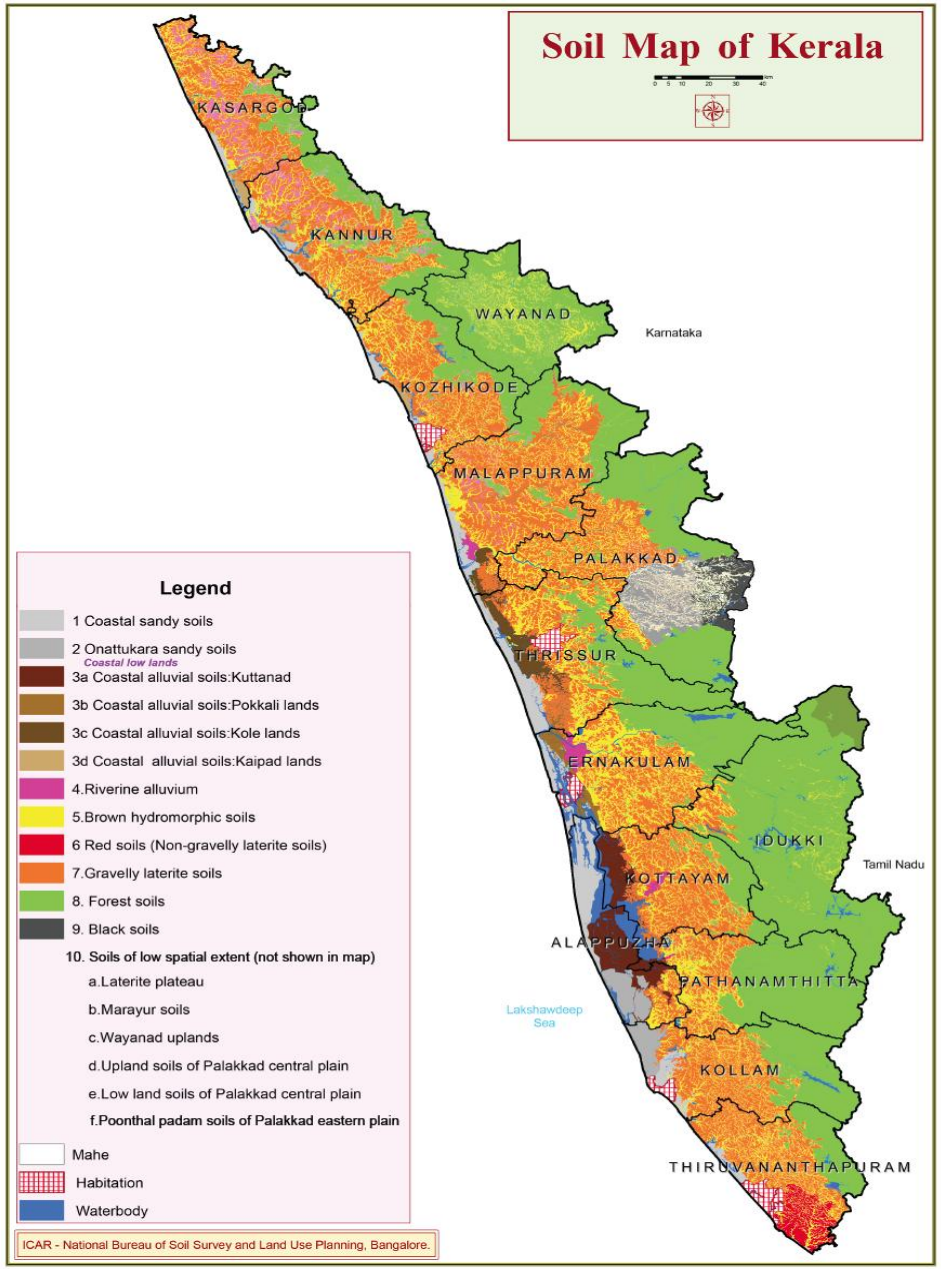
General characteristics of soils

- Kerala falls in the humid tropical belt with high rainfall and temperature conditions conducive to intense weathering processes
- It is the *type locality* of laterite and over 90 percent of geographic area is covered by highly weathered laterite soils
- In general, the soils are acidic, kaolinitic, gravelly with low cation exchange capacity, inherently poor in bases and plant nutrients, low water holding capacity and high phosphorus fixation



The major soil groups of Kerala

1. Coastal sandy soils (Coastal plains)
2. Onattukara sandy soils (Onattukara plains)
3. Coastal Alluvium (Potential Acid Sulphate)

3a. Kuttanad soils
3b. Pokkali soils
3c. Kole soils
3d. Kaippad soils

4. Riverine alluvial soils (River banks)
5. Brown hydromorphic soils (Valleys of midlands, foothills and highlands)
6. Red non Gravelly laterite soils (Southern midlands and highland plateaus of (Western Ghats)
7. Gravelly laterite soils (South, Central and Northern midlands and foothills)
8. Forest soils (Western Ghats and Escarpments)
9. Black soils (Palakkad eastern plain)
10. Special group (soils of limited spatial extent)

a. Laterite plateau
b. Marayoor soils (Lowhills and rolling lands)
c. Wayanad upland soils
d. Upland soils of Palakkad central plains
e. Low land soils of Palakkad central plain
f. Poonthal padams (Lowlands of Palakkad eastern plains)

Soil related constraints affecting soil health

Physical

Soil erosion

- Major soil physical constraint affecting soil health
- Nearly 49 % of the area has moderately steep to very steep slopes (5 to 30 % slope)
- Soils of the mid land laterite region with undulating topography have high erodibility
- Serious water erosion with substantial losses of top soil and available nutrients
- Moderate erosion reported in nearly 69 % of the area and severe erosion in 4%

Soil related constraints affecting soil health (contd.)

- Average soil loss of 15 to 40 t/ha/y (estimated from various cropping systems in Kerala)
- Soil loss from a cleared forest is around 500 t/ha/y (in the Western Ghat regions)
- Removal of the surface soils exposes the laterite bed below , causing dehydration and formation of petro plinthite
- Extensive areas of such degraded landscape occur in Kozhikode, Malappuram, Kannur and Kasaragod districts
- Maintenance of soil cover and adequate soil and water conservation measures are to be given priority

Iron stone formation-Pertoplinthite

Root Zone Limitation

- Severe water erosion causes removal of surface soils and exposure of the laterite beds
- Laterite pan is soft when under a column of soil but hardens on exposure
- Plant root penetration and workability difficult
- Nearly 64 % of soils of the state are very deep (> 150 cm)
- Twenty five percent soils are deep (100-150 cm)
- Remaining areas covered by moderately shallow soils, rocks and laterite outcrops (KSLUB, 2009)

Soil related constraints contd ....

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Root zone limitation

Presence of gravel and hard pan

- Laterite soils cover nearly 75 % of the cropped area
- Soils have very high ferruginous gravel content with wide variations (40 to 70 %) in the soil profile
- High gravel content increases bulk density and adversely affects the foraging capacity of plant roots
- Bulk density values of 1.5-1.8 are observed making root penetration difficult
- High gravel content decreases soil volume leading to poor inherent soil fertility
- Lesser available water capacity and other hydrological properties

Drought stress

- Reduced soil volume due to gravelliness results in low available water capacity
- Intense water stress experiences in the root zone during summer months
- Severe drought stress occurs in the northern districts of the state

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Drainage and hydrology

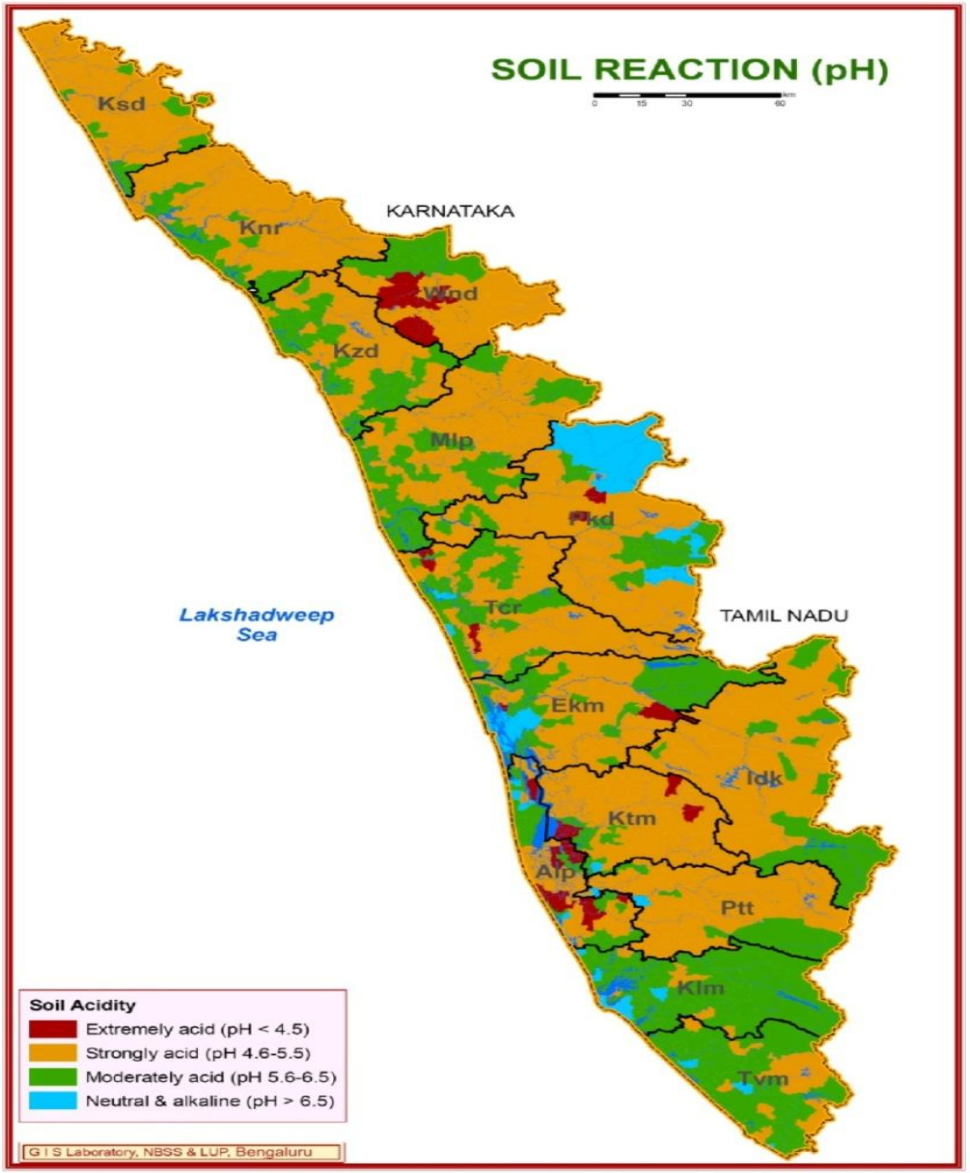
- Majority of the soils (75 %) of Kerala are well drained
- The coastal alluvial soils (5 %) are excessively drained
- Poor drainage conditions due to water logging and flooding in the lower landscape positions , characteristic features of Kuttanad, Kole, Pokkali and Kaippad lands
- Topographic disadvantage being located below sea level
- Drying of soils during summer months results in aerobic conditions and subsequent formation of acid sulphate soils
- Being rich in sulphur sediments, oxidation causes extreme acidic conditions harmful to crops

Available water capacity

- Depends on texture, organic matter, soil depth, gravel content and type of clay minerals
- AWC is expressed as millimetres of water for 100 cm soil depth
- KSLUB (2009) has reported 35 % of soils have high AWC (150 to 200 mm/m), 14 % medium AWC (100-150 mm/m), 38 % low (50 to 100 mm/m) and the rest very low (< 50 mm/m)
- During summer months moisture stress is experienced in soils with low and very low AWC
- Appropriate management practices are essential for improving soil moisture availability

2. Chemical properties – Soil acidity

- Acidic parent rocks dominate under humid tropical environment result in formation of acidic soils
- High rainfall and temperature conditions conducive to rapid removal of bases from soil
- More than 90 % of soils in Kerala have acid reaction
- Fifty per cent of soils are extremely to strongly acidic (pH 3.5 to 5.5)
- Require amelioration with lime to alleviate acidity



Soil acidity

88 % acidic soils of which 50 % are extremely to strongly acidic (pH 3.5 to 5.5)

Iron and aluminium toxicity

- Acidic conditions are also observed in the lower layers of laterite soils
- pH values less than 5.5 causes dissolution of Al toxicity and damage of roots
- Prolonged exposure to high Fe and Al levels causes deficiency of Ca, Mg and P
- Solubilization of clay minerals brings K, Mg, Fe and Al into soil solution
- Increase in the concentration of Fe and Al causes deficiency of P, K and Mg through competition
- Liming to raise soil pH above 5.5 is needed for managing soil acidity

Acid sulphate soils

- Occur in waterlogged problem areas below sea level in Kuttanad, Kole, Pokkali and Kaipad
- Ultra acid soils with pH less than 3.5
- Soils developed mainly from sulphur rich sediments (Jarosite) of marine origin
- Oxidation of soils under aerobic situation in summer results in extreme acidic conditions and thereby formation of acid sulphate soils
- Regular liming is very essential for acidity management

Subsoil acidity

- Occurs mostly in subsoils of sesquioxide rich laterite through Al solubilisation
- Main damage is to the primary root system of plants
- Very crucial for maintaining root health of tree species and plantation crops
- Incorporation of lime to soil neutralizes only the top soil acidity
- Subsoil incorporation of lime is often uneconomic being labour intensive

Subsoil acidity (contd.)

- Application of gypsum ($CaSO_4\ 2H_2O$) and dolomite neutralizes exchangeable Al in subsoil and alleviate deficiency of Ca and Mg

- Gypsum in combination with liming materials under high rainfall conditions facilitate leaching and movement of Ca and Mg to lower layers to correct deficiency (Tessy and Venugopal,1993)

- Highly mobile and stable SO_4^{2-} ions enable movement of Ca and Mg to lower levels

- Gypsum (phospho gypsum), a by-product from fertilizer industry is available in the state

Subsoil acidity (contd.)

- A project on 'Amelioration of subsoil acidity in coconut growing areas in Kerala' has already been completed

- The project was conducted as a multilocational trial under the leadership of NBSS & LUP, Bengaluru in collaboration with CPCRI, Kasaragod and Kayamkulam

- Results are encouraging and the findings hold promise in the midland laterite areas for coconut and other plantation crops

Low nutrient reserves and retention

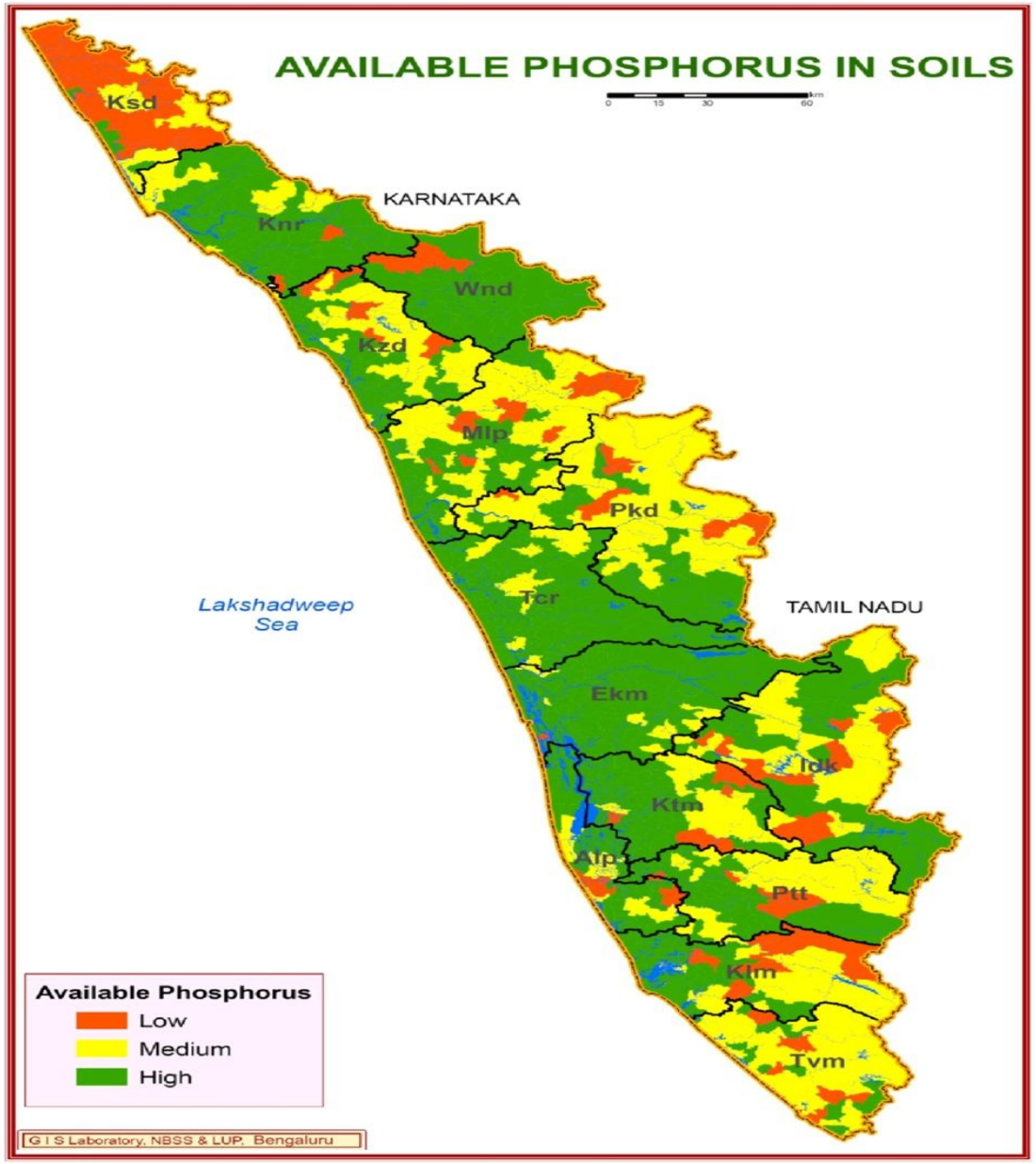
- Soils of the state are highly weathered and dominated by low activity clays with poor retention for nutrients
- Rich in Fe and Al oxides with acidic pH
- Very low cation exchange capacity, base saturation, low nutrient reserves and low water holding capacity
- High rainfall conditions and intense leaching further decrease in nutrient status
- Low soil organic matter content is another critical factor for the poor nutrient and water holding capacity of soils

Phosphorus fixation

- Optimum pH for P availability in soils is between pH 6.0 and 7.0
- Soils have high P fixation due to acidic pH and abundance of sesqioxides
- Available P content is high (>24 kg/ha) in 64 % of soils of the state
- Reduction in P fertilizers is possible and thereby reducing input cost
- Liming to maintain optimum soil pH will minimize P fixation

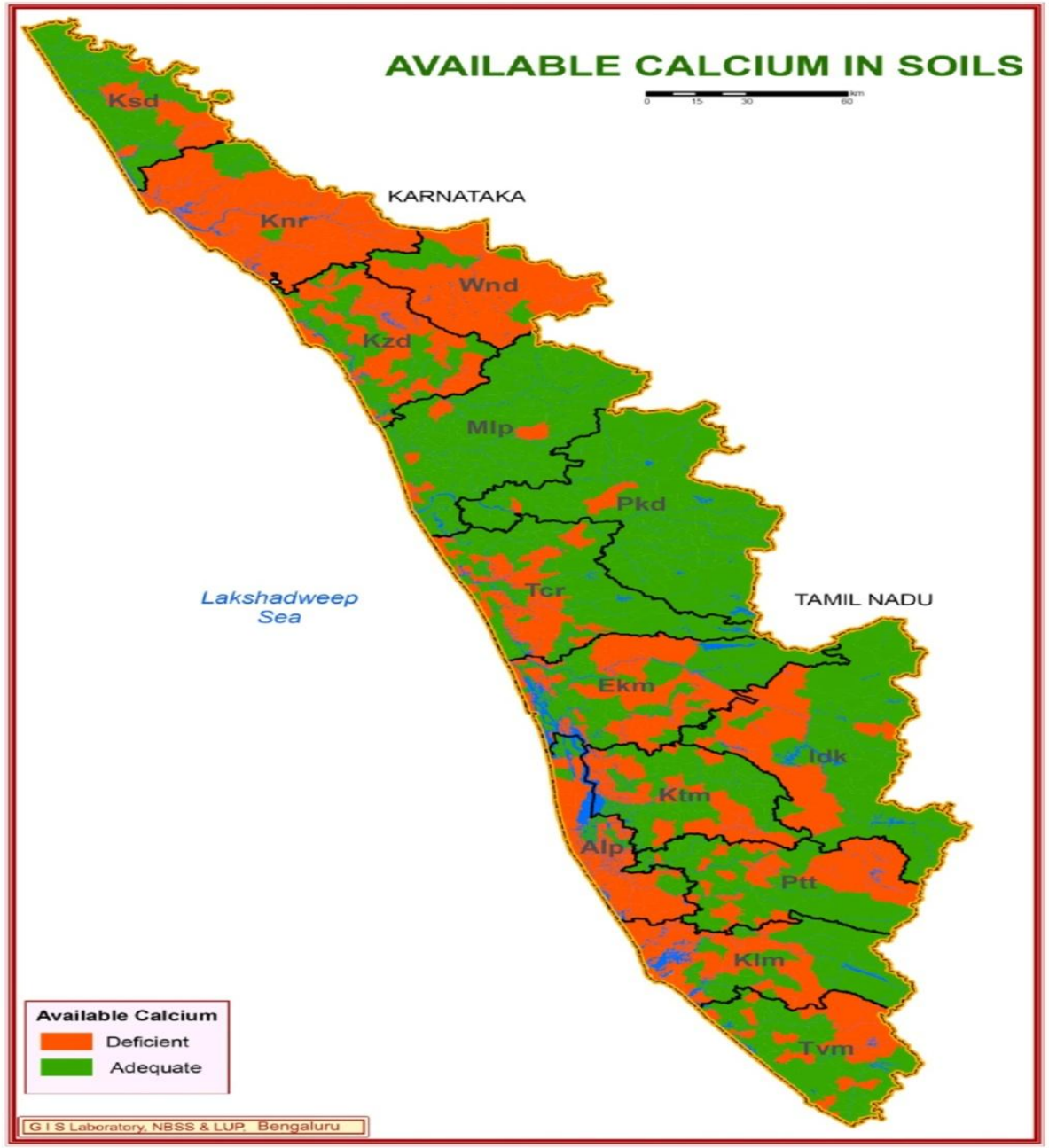
Secondary and micro nutrient status

Extensive deficiencies of secondary nutrients (Ca -36 %) and Mg -71 %) and micro nutrient (boron -60%) have been reported in Kerala soils



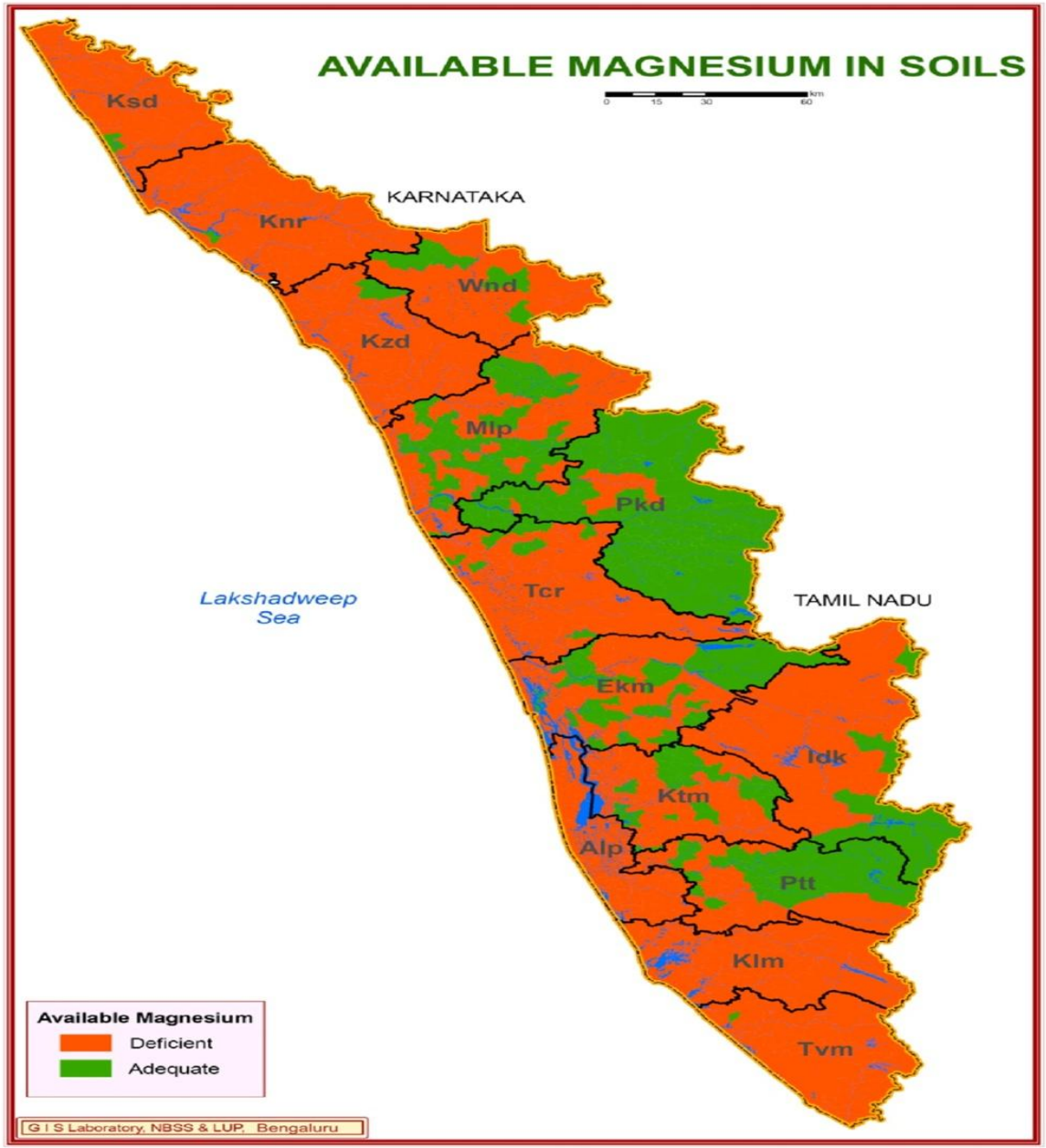
Available P

64 % high in soils



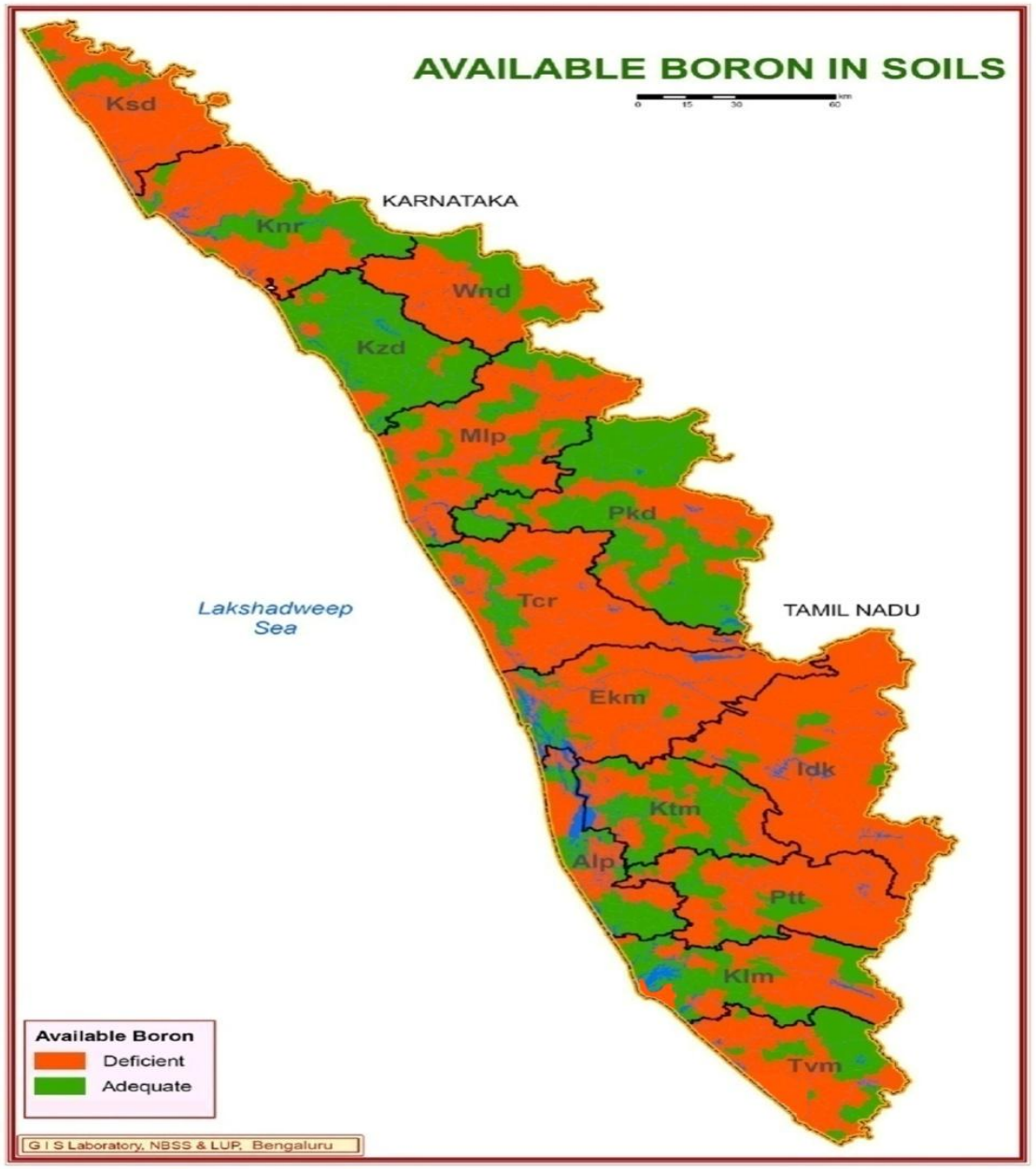
Available Ca

36 % deficient in soils



Available Mg

71 % deficient in soils



Available Boron

60 % deficient in soils

Flood related soil problems

- Kerala is divided into 5 agro ecological zones - coastal plain, midland laterite, foothills, high hills and Palakkad plains
- A combination of distinct altitudinal variations are distinctive features
- Land mass varying from 5 m below sea level to height of 2695 m above MSL in the east
- Nature of the degradation on the soil resources shows varying impact in the AEZ

Flood impact in coastal plains

- Main problem is accumulation of deposited silty and clay materials with contrasting physical properties
- Continued water logging and total destruction of soil structure, aggregate stability, infiltration and disruption in soil air - water relationship
- Crust formation due to ponding of water and consequent drying

Flood impact in coastal plains (Contd..)

- Choking of roots for air causes crop damage
- Increase in acidity due to exposure and drying of sub soil layers in acid sulphate soils
- Water logging and redox changes due to depleted oxygen and altered kinetics of sulphur, iron and manganese causes toxicity
- Disruption of N cycle with enhanced denitrification loss
- Increased EC and salt injury to crops

Flood impact in midland and highland regions

- In the high hills and midland laterite zones, erosion and deposition of materials through landslides and land slips
- Large scale removal of fertile top soil along with organic matter and available nutrients
- Shallow soils and exposure of laterite pan/ gravelly layers make cultivation operations difficult
- Eroded materials deposited in the foot hills and valleys along with the alluvium are often more fertile
- In severely eroded areas deposition of coarser materials like gravels, pebbles and stones over fertile areas results in huge investments in reviving crop cultivation

Reference

- **Department of Agriculture &Farmer's Welfare,2019, Soil Health Management for Sustainable Crop Production in Kerala.** (eds.) **V.K.Venugopal, K.M.Nair, P.Rajasekharan, A.N.Sasidharan** Nair, **Kerala State Planning Board, Thiruvananthapuram, P 1-426**


Thank You