GOVERNMENT OF KERALA

SOIL HEALTH STATUS IN KERALA IN POST FLOOD SCENARIO

DEPARTMENT OF SOIL SURVEY & SOIL CONSERVATION

(for official use only)

Government of Kerala

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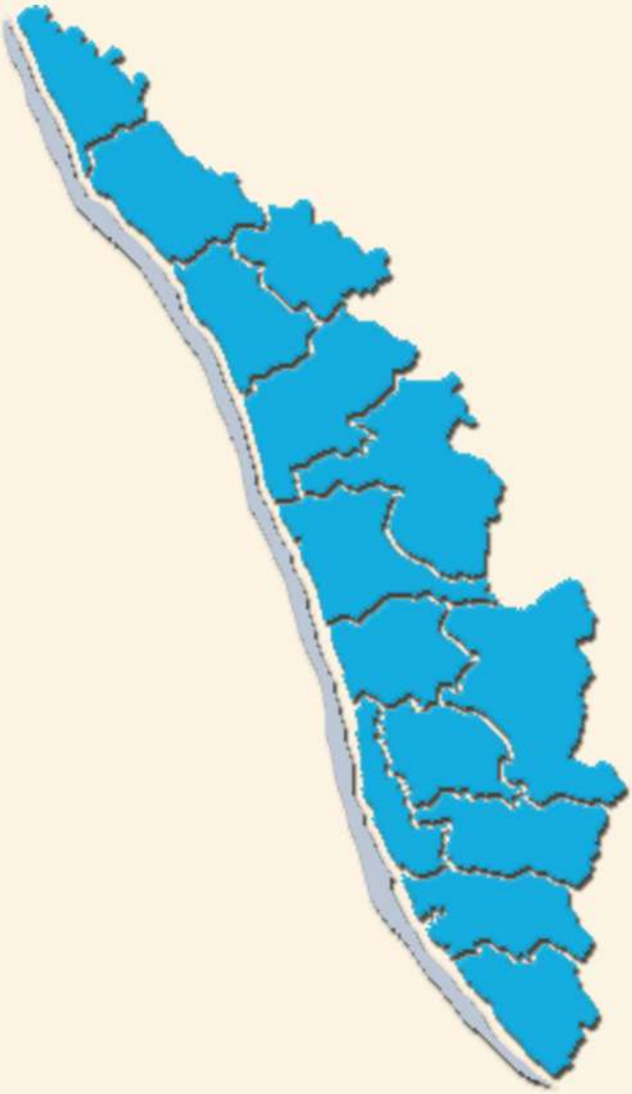
SOIL HEALTH STATUS OF KERALA IN POST FLOOD SCENARIO



Soil Survey

Department of Soil Survey & Soil Conservation

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MESSAGE

The ability of the land to feed its populace depends on soil-water-land interactions, climatic influences and how best mankind sustains productivity through interventions in mother nature. Climate in recent times has been a game changer. The flood that befell Kerala in August 2018 has resulted in destruction of natural ecosystems, soil erosion and landslides, hydrological degradation etc. According to the Kerala Government, one sixth of the total population of Kerala had been directly affected by the floods and related incidents. The flood which caused heavy loss to the agricultural sector has affected the State's food production as well as the livelihood of lakhs of farmers.

Soil degradation constitutes a serious ecological and economic problem. Soil and water must be treated as 'economic good' and should be managed with collective responsibility. The acceptance of interdependence of humans with the environment is recognised in the paradigm of sustainable agriculture.

The department has carried out surveys in the thirteen most affected districts under very challenging circumstances and gathered very valuable data on the aftereffects of the massive deluge and accompanying landslides. For effective management of soil and land resources, we need a strong and reliable soil data base which can be obtained only from the Department of Soil Survey & Soil Conservation.

I am sure that this report will serve as a reference document for the decision makers to plan and formulate programs for ***Rebuilding Kerala***.

I congratulate Department of Soil Survey & Soil Conservation for bringing out this report and wish them all success in their further pursuits.

"Healthy Soils Make Healthy Crops, Healthy People and a Healthy Society."

Yours faithfully

Adv. V.S. Sunil Kumar
Hon'ble Minister for Agriculture

Shri. Devendra Kumar Singh IAS
Principal Secretary &
Agricultural Production Commissioner

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FOREWORD

Soil is one of the most important non-renewable basic natural resources on which the agricultural prosperity depends. Viewing Soil as a living ecosystem reflects a fundamental shift in the way we care for our soils. If we look into history, we see that good quality soil always have enabled civilization to flourish and prosper. The multiple role of soils as the major contributor to attain food security and nutritional goals, to fight climate change and to ensure overall sustainable development often go unnoticed and they remain the silent ally to food production. As a non-replenishable resource, its survival has come under threat due to natural and manmade processes.

The recent flood which thrashed Kerala in August 2018 brought drastic changes in the environment, ecology and economy of Kerala. The landscape itself underwent massive changes, raising concern about the ecosystem in the happening of such unexpected natural calamities.

Knowledge relating to sustainable use of soil is; scarce more so with its spatial diversity. Floods which occur as a result of torrential rains create havoc not only to soil but also to water management systems, wetland ecosystem and pose threat to life of man and animals.

Keeping in view the importance of developing post flood inventory of soil and land resources, Kerala State Department of Soil survey and Soil conservation has taken the initiative to take up a broad based study on the impact of flood and related calamities on the land form and soils of Kerala. Soil survey provides sound soil and land resource information, highlighting soil and water conservation needs for optimising resource utilisation.

I am sure that the details provided in this report would throw light on the changes the flood has brought to ecosystem, soil and land as a whole and would aid as a blue print to the administrators, planners and academicians for evolving policy framework.

Wishing the Department all success in their future endeavours.

Yours Faithfully

Shri. Devendra Kumar Singh IAS
Principal Secretary &
Agricultural Production Commissioner

J. Justin Mohan IFS
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PREFACE

The State of Kerala experienced devastating floods in August 2018. These floods, the worst ever seen in over a century, caused widespread damage to human lives, property and infrastructure. It caused landslides, erosion and has left long lasting effects on the soil and its characteristics not only in the affected areas but also in its immediate surroundings. In particular, these floods have caused severe damage to the soil through widespread deterioration of physical and chemical properties such as stability, pH, composition of microbial fauna, aeration etc.

Although its causes are being debated, experts agree that extreme climatic events such as flooding and other natural disasters are likely to become more frequent as a result of global warming. There is, therefore, an urgent need to understand and take a proactive approach in seeking management solutions to possibly prevent, manage and alleviate the negative effects of such natural disasters.

With this in mind a random study was conducted in thirteen flood affected districts of Kerala (with the exception of Kasaragode) to assess the impact of the flood and landslides on soil quality during August- September 2018 immediately after the flood. The heterogeneity and spatial variability of the soil in Kerala presented significant challenges to the team involved in this study. These challenges required the team to put forth a very dedicated effort to cover and assess the entire area affected by these floods and bring out this report.

I wish to congratulate and thank my entire team of colleagues in our department at field, laboratory, regional and headquarters level for their sincere and dedicated efforts in bringing out an excellent report in a short period of time and in difficult conditions.

I wish to express my sincere gratitude to Hon'ble Minister for Agriculture for his unflinching support for the timely implementations of all such schemes.

I am confident that this report will help planners, administrators and all others involved in the rehabilitation and rebuilding of the affected areas take informed decisions as they develop strategic and sustainable plans to help prevent and manage such environmental catastrophes in the future.

Yours Faithfully

J. Justin Mohan

J. Justin Mohan IFS
Director
Department of Soil Survey &
Soil Conservation

ABSTRACT

Department of Soil Survey & Soil Conservation conducted a random study in the 13 flood affected districts of Kerala to assess the post flood soil quality after the occurrence of "Great Kerala flood 2018". As part of the investigation field traversing and soil sample collection were undertaken from flood/landslide affected areas. The soil analysis was carried out in the labs of the department.

Though trends could not be established with respect to soil physico-chemical properties, soil acidity remains as a major problem to be tackled in the post flood scenario. More than 50% of the soils are coming under the category of extremely acidic to strongly acidic, indicating the need for urgent soil reclamation measures. Widespread deficiency of available nitrogen, available potassium, Calcium, Magnesium and Boron was noticed in the sampled locations. Deficiency of available phosphorus and zinc was also noticed in localised patches. Zinc deficiency noticed mainly in the valleys. Soil compaction, poor aggregate stability, soil textural changes etc. were noticed during field survey. Soil microbial studies were not carried out.

The impact of landslide in soil profile characteristics and soil quality was also studied. Soils of the landslide area are infertile and coarse textured compared to the adjacent landscape. In majority of the landslide areas severe erosion noticed. The "A" horizon was completely lost and 50-75% of the "B" horizon lost in most of the locations studied indicating a poor regrowth of vegetation in these areas.

Apart from slope, vegetation, amount of rainfall etc., soil also has a major role in making a region landslide prone in rainfall triggered landslides. Detailed investigation of soil properties especially soil physical properties need to be undertaken in the affected areas to inventorise the soils prone to the occurrence of landslides.

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INTRODUCTION

Floods are purely environmental hazards of meteorological phenomena, but very often induced by man's improper utilization or abuse of the physical environment. Floods are among the most dramatic forms of interaction between man and its environment. Extreme precipitation events, landslides, and floods are the most common natural disasters that affect human society and economy (Coumou and Rahmstorf, 2012; Crozier, 2010; Hirabayashi et al., 2008; Roxy et al., 2017). Floods occur world wide, often after heavy rains in an area. Frequent extreme precipitation events cause flooding (Fowler et al., 2010), which have become common in India (Mohapatra and Singh, 2003). The frequency of great floods and extreme precipitation events has substantially increased under the Global warming scenario. India has witnessed some of the most unprecedented extreme precipitation events that caused flooding and loss of lives in the recent past. For instance, heavy rain in Mumbai in 2005, flooding in Chennai in 2015, extreme precipitation in Uttarakhand in 2013 had resulted in large flooding in the affected region with the death of more than 5000 people and claiming huge economic loss. Human losses from flooding are projected to increase by 70-80% if the global mean temperature increases above 1.5^{o}C from the pre-industrial level (Dottori 5 et al., 2018). Moreover, Dottori et al., (2018) reported that the future flood impacts are likely to have uneven regional distribution, with the highest losses to occur in Asia.

Soil degradation due to flooding is also a serious concern. Researchers from the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) and other institutes in a study conducted to assess the impact of floods on soil following the 2009 floods in North Karnataka estimated that 13 flood-hit districts lost 287 million tonnes of top soil and soil nutrients across 10.75 million hectares of farmland. A steadfast programme of recovery is needed to recuperate the condition and effect of the floods will be visible on the ground if no comprehensive scheme for recovery undertaken. In 2018, Kerala state has also witnessed a disastrous flood resulted out of continuous heavy rains adding to the list of great natural disasters of the world.

2. BACK GROUND OF THE STUDY

Kerala, commonly referred to as “Gods Own Country” stretches as a narrow belt along the south-western portion of India sandwitched between Western Ghats in the east and Lakshadweep in the west. Lying between 8^0 18' to 12^0 48' north latitude and 74^0 52' to 77^0 22' east longitude, Kerala enjoys a humid tropical monsoon climate. The geographical area is 38863 sq.km accounting to 1.18% of India's total area supporting 3.4% of the national population. The average annual rainfall is 3000 mm and rainfall distribution is bimodal. Rainfall is received from both the Southwest monsoon (June to September) and the Northeast monsoon (October to December) with 60% of the rainfall being from the former.

Kerala witnessed one of the biggest natural disasters that occurred in the past 100 years due to an abnormally heavy rainfall in the south west monsoon season of 2018 starting from June to August. The flood and landslides have caused devastating damage in 13 out of 14 districts of the State, claiming hundreds of lives and destroying hectares of crops, even to the extent of changing the very geographical configuration of the region.

The state received 2346.6 mm of rainfall during this period as against the normal value of 1649.5 mm. Though southwest monsoon began on 1^{st} of June in the state and continued to rain in July, a very severe spell of rainfall started from 14th August and continued till 19th August, resulting in the worst flood situation in the state since the great flood that took place in1924. It is the worst flood in Kerala after the great flood that took place in 1924. All the 13 districts of the State were placed on red alert. The Indian government had declared it a level 3 calamity, or ‘Calamity of severe nature’

The heavy rainfall resulted in enormous landslides in the hilly areas and severe waterlogging in the lowland areas. The water levels in several reservoirs were almost near their maximum storage capacity due to continuous rainfall from 1st June. The intensity of the rainfall in August was so severe that, for the first time in the history of Kerala the gates of 39 out of 54 dams of Kerala were opened to release flood runoff which caused overflowing of rivers and flash flooding. Many rivers began to flow with thrice or more than their usual width, resulting in widespread flood rampant damage and catastrophe in many rural as well as urban areas of the State.

Though all the 14 districts of Kerala had a share of the havoc caused by the disaster, the districts of Alappuzha, Ernakulam, Pathanamthitta, Trichur, Idukki, Kottayam, Wayanad, Kozhikode, Kannur, Palakkad and Malappuram received the major chunk of damage in terms of loss of lives, property and livelihood. The disaster by way of landslides and flooding started affecting the districts Wayanad, Idukki, Kannur, Pathanamthitta, Kottayam, and Palakkad, but spread to other districts also in no time creating hazardous condition in the state. A total of 537 Landslides are reported from districts such as Idukki, Malappuram, Wayanad, Kozhikode, Trichur and Palakkad. Around 483 lives were claimed in floods and landslides. The entire Kuttanad region lying in Alappuzha, Kottayam and Pathanamthitta districts was submerged in the flood water for weeks up to 8 to 15 feet height.

The persistent and extreme rainfall affected all the aspects of human lives including socioeconomic conditions, transportation, infrastructure, agriculture, and livelihood. Rivers have not only overflowed; some of them have changed their course too. The transport and communication systems of the State are also ruthlessly affected.

As per government records more than 483 lives lost, around one million people evacuated from the affected areas and 3,274 Relief Camps opened in the state. The flood caused severe damage to agriculture and plantation sector. Paddy, banana and tuber crops are the most affected crops. Crop loss accounts to 54000 hectares in the state and affected the livelihood of 300000 farmers. The infrastructural facilities like roads, bridges, etc were devastated in the flood. 10000 km of roads and 221 bridges were damaged. Preliminary estimates showed that the economic loss to the state may be higher than 20000 crores.

The devastating floods that have left a trail of destruction will cripple the state's agriculture production in a major way in the current year, especially rice. As per the primary analysis by the state Agriculture department, around 56,844.44 ha of cropped area has been affected by the floods, causing a loss of Rs 1355.68 crore to 3.14 lakh farmers. Among the major crops, paddy and banana were the worst hit by the flood with 26,106 and 6,348 ha of crop damaged in the flood, respectively. Apart from damaging paddy in 26,106 ha of land, the flood has upset or delayed the farming activities in major rice producing districts like Alappuzha, Thrissur and Palakkad, which is expected to bring down the annual paddy production in the state.

Due to the high intensity rainfall soil erosion is rampant in the hilly terrains and flood plains of Kerala. The scouring action of high intensity rainfall eroded the surface and subsurface soils from hilly terrains and rivers transported this sediment load to faraway places and deposited in the low lying flood plains and valleys. The severe erosion and the deposition of sediments have affected the soil quality of Kerala in terms of its physical, chemical and biological properties. Topsoil erosion caused due to rains and overflowing of dams and deposition of silt/sand in the lowlands has brought about changes in the physical and chemical properties of soil, water logging and anaerobic conditions.

There are lot of issues aroused as aftermath of flood such as surface crusting, surface cracking, perishing of fauna such as earthworms, etc in addition to the loss of nutrients due to leaching. Moreover, unusually large number of occurrence of landslide was recorded from the hilly areas of the state during this monsoon season.

In addition to loss of nutrients from leaching, several other issues such as surface crusting, surface cracking of soils and destruction of fauna such as earthworms have occurred due to the floods. Furthermore, an unusually higher than average occurrence of landslides was also reported from the hilly areas of the state during this monsoon season. The devastating impact of flooding on soils include deterioration in soil quality necessitating the need for its study. Soils are the key to food security, biodiversity, protection and to mitigating and adapting to climate change but also the first to pay the price in the happening of natural disaster like flood or drought. Floods often wash away rich, weathered soil. Soil degradation due to flooding is a serious concern. A 2014 review of soil degradation in India shows that an estimated 14 million ha of soil suffer degradation due to flooding annually.

The Department of Soil Survey and Soil Conservation conducted a study in the 13 disaster affected districts of the state to assess the impact of flood and landslides on the properties of soil, extent of damage caused to the quantitative parameters of soil in general and evaluation of soil quality parameters and their effect on soil agricultural purposes in specific, for evolving strategies for flooded soil management.The Department has been functioning towards the development of an authentic soil information system of the State for the cause of providing better understanding of soils to the community formulating developmental plans, research activities etc for the sustainable management of soils and enhanced productivity.

This report is an attempt from the side of the department to assess the extent of damage caused to soil and its quantitative parameters by the flood, areas affected by flood as well as landslides in each district, for finding out possible mitigatory & revamping measures.

3. OBJECTIVES

- To study the impact of flood on soil quality and to assess the changes in the soil quality in terms of physico- chemical properties of the disaster affected areas in the state.
- To assess whether any landscape modification occurred as a result of flooding
- To determine the physico-chemical properties of the sediments silted in the agricultural land
- To assess the changes in soils due to landslide occurrence

Field traversing was conducted in 13 disaster affected districts of the state and soil samples collected from different physiographic positions which were subjected to various physico chemical analyses. The results were interpreted to assess the changes occurred due to the flood 2018.

4. MATERIALS AND METHODS

The Soil Survey wing of the Department of Soil Survey and Soil Conservation has undertaken a study to assess the changes in physico-chemical properties of the soil in the flood and landslide affected districts of the state. The study was carried out after cessation of rainfall in 1st week of September 2018. The materials and methods employed for the study are given below in detail.

4.1. Study area

Flood and landslide affected areas of all districts of Kerala except Kasargode.

4.2. Field traversing and site selection for soil sampling

Field traversing was conducted in the affected catchments of rivers in 13 districts and soil sampling sites were identified based on the destruction. Site characteristics such as sediment deposition, landscape modification etc. were also recorded during survey. The sampling sites were plotted district wise in maps using GPS points taken.

4.3. Soil sample Collection and analysis

With the help of GPS, surface samples were collected from a depth of 0-30 cm.

A composite soil sample of 1kg each was collected from these depths from each of the selected grid points with the help of a stainless steel soil auger. Initially, soil samples were collected at random from different locations which were then mixed up to obtain a composite soil sample separately. The soil samples were then spread on a white sheet of paper and about 1 Kg collected from each point were separated by quartering method. The samples were then transferred to plastic bags, brought to the laboratory and prepared for the analyses.

For soil physical and chemical analysis, a sub sample of each sample was air-dried, ground to powder form and stored in labelled plastic bottles. The soil samples were analyzed and the results are presented on oven dry weight basis.

4.4. Preparation of sample

The soil samples upon arrival at the laboratory were unpacked and spread on a large sheet of paper for air drying under shade. The dried sample was crushed in a wooden mortar with wooden pestle and sieved through a 2 mm sieve until only coarse fragments remained. The sieved soil sample and coarse fragments were weighed to determine coarse fragment content by weight. The volume of coarse fragment was also recorded.

Sub sampling was done to obtain small portions representative of the bulk. The entire 2mm sample was spread evenly by horizontal strokes of a knife on a large sheet of plastic. Small portions were taken at random from all over the sample to obtain a sub sample for each analysis.

The samples were analysed for the following soil quality indicators adopting standard procedures.

1. Soil Reaction / pH
2. Electrical conductivity
3. Organic carbon %
4. Available nutrients like P, K
5. WHC (%)
6. CEC (cmol/kg)
7. Exchangeable bases (Na, K, Ca, Mg) in cmol/kg
8. Available Calcium, Magnesium and Sulphur (ppm)
9. Available micronutrients (Fe, Mn, Cu, Zn, B) in ppm
10. DTPA extractable Heavy metals (Pb, Cd,) in ppm

The methods followed are described below.

4.5.1. Soil reaction

Soil pH is an estimate of the activity of hydrogen ions in the soil solution. The pH was determined in 1:2.5 (Soil/distilled water).

4.5.2 Electrical conductivity

Electrical conductivity of soil is a measure of the concentration of ions in solution. Electrical conductivity was determined from the clear supernatant obtained from a soil: water (1:2.5) suspension (Sharma et al., 1986).

4.5.3 Organic carbon

Soil organic Carbon is a major component of soil organic matter that influences the quality of soils and can be influenced by soil management functions. Organic carbon was determined by the Walkley- Black procedure. The organic carbon was oxidized by dichromate-sulphuric acid and the amount of dichromate remaining was determined by titration against a standard ferrous solution with ferroin as indicator (Sharma et al, 1986).

4.5.4 Available nitrogen

For surface soil fertility investigations an estimate of available nitrogen was made from organic carbon content of the compopoint surface soil samples collected from each grid point. The estimation of plant available nitrogen in soil was made from the organic carbon content of soil assuming C:N of soil organic matter to be 10:1. Organic carbon was determined by the Walkley-Black procedure.

4.5.5 Available potassium

Neutral normal ammonium acetate was used to extract the available potassium which was determined by flame photometry (Black, 1965).

4.5.6 Available phosphorus

Bray's method was used for estimation of available phosphorus. The phosphorus extracted was determined spectrophotometrically as the reduced phosphomolybdate complex at 660 nm (Bray and Kurtz, 1945, Olsen et al 1954).

4.5.7 Available sulphur

Available sulphur in soil was extracted with 0.15 % Calcium chloride solution (Williams and Steinberg 1959). The sulphates were estimated turbidimetrically.

4.5.8 Water holding capacity

Keen Rascowzkii method was employed to determine the Water holding Capacity and Bulk Density. Water holding Capacity is expressed in % and Bulk Density is expressed in g/cc.

4.5.9 Cation exchange capacity

Cation exchange capacity or nutrient retention capacity is a measure of the amount of positively charged nutrients that the soil could hold onto electrochemically and release for plant use. A weighed sub sample was leached with neutral normal ammonium acetate, the leachate being retained for determination of exchangeable bases. The ammonium saturated soil was washed with Ethanol to remove soluble ammonium. The ammonium absorbed on the soil exchange complex was released by distillation with alkali and absorbed in boric acid and titrated against standard acid. (Sharma et al, 1986)

4.5.10. Exchangeable bases

Exchangeable cations are the base cations of calcium, magnesium, potassium and sodium. The ammonium acetate leachate obtained during the determination of cation exchange capacity of soils was made up to volume and used for determination of exchangeable bases through atomic absorption spectrophotometry (Sharma et al, 1986)

4.5.11.Available micronutrients

Micronutrients are essential for plant growth and play an imptant role in balanced crop nutrition. They include boron (B), copper (Cu), iron (Fe), manganese (Mn), Molybdenum (Mo), zinc (Zn),.The available micronutrients were extracted with DTPA (Diethylene Triamine Penta Acetic acid). The extracted Cu, Fe, Mn, Zn were determined using atomic absorption spectrophotometry.

4.5.12.Available boron

Available boron from soil was extracted by refluxing with hot water for a period of 5 minutes with a soil/water ratio of 1:2 (Berger and Truog, 1939). The boron in the extract was determined colorimetrically at 540 nm using Curcumine method.

4.5.13.Heavy metals

Heavy metals are a dangerous group of soil pollutants as they cause serious toxicity problems in plants, animals and human beings. The heavy metals were extracted with DTPA (Diethylene Triamine Penta Acetic acid). The extracted Pb, Cd, were determined using atomic absorption spectrophotometry.

The criteria used for categorizing soils with respect to their reaction and plant available nutrient levels are presented in the following sections.

Soil reaction (pH)

<4.5	Extremely acid
4.5- 5.0	Very strongly acid
5.1- 5.5	Strongly acid
5.6- 6.0	Moderately acid
6.1- 6.5	Slightly acid
6.6- 7.3	Neutral
7.4- 7.8	Slightly alkaline
7.9- 8.4	Moderately alkaline
8.5- 9.0	Strongly alkaline
> 9.0	Very strongly alkaline

EC

Low	<1mmhos/cm
Medium	1-4 mmhos/cm
High	>4mmhos/cm

CEC

Low	<5 cmol/kg
Medium	5-16cmol/kg
High	>16cmol/kg

Water Holding Capacity

Low	<30%
Medium	30-50%
High	>50%

Organic Matter

Low	<1.7g/100g
Medium	1.7-3 g/100g
High	>3g/100g

Exchangeable bases

Rating	*Exchangeable bases cmolkg^{-1}*			
	Na	*K*	*Ca*	*Mg*
Very low	0-0.1	0-0.2	0-2	0-0.3
Low	0.1-0.3	0.2-0.3	2-5	0.3-1.0
Moderate	0.3-0.7	0.3-0.7	5-10	1-3
High	0.7-2.0	0.7-2.0	10-20	3-8
Very high	>2.0	>2.0	>20	>8.0

Plant available nitrogen content

Low	< 0.50% organic carbon
Medium	0.50-1.50% soil organic carbon
High	>1.50% soil organic carbon

Plant available phosphorus

Low	< 10.0 kg P/ha
Medium	10.0- 24.0 kg P/ha
High	> 24.0 kg P/ha

Plant available potassium

Low	< 115 kg K/ha
Medium	115- 275 kg K/ha
High	> 275 kg K/ha

Plant available Calcium

Deficient	< 300.0 ppm
Adequate	>300.0 ppm

Plant available Magnesium

Deficient	< 120.0 ppm

Adequate >120.0 ppm

Plant available sulphur

Deficient < 5 ppm

Adequate 5-10 ppm

Plant available Iron

Deficient < 5ppm

Adequate >5.0 ppm

Plant available Manganese

Deficient < 1.0ppm

Adequate >1 ppm

Plant available zinc

Deficient < 0.60 ppm (when DTPA was used as extractant)

Adequate > 0.60 ppm (when DTPA was used as extractant)

Plant available copper

Deficient < 0.12 ppm (when DTPA was used as extractant)

Adequate > 0.12 ppm (when DTPA was used as extractant)

Plant available boron

Deficient < 0.5ppm

Adequate >0.5 ppm

5. RESULTS & DISCUSSION

Postflood studies were conducted in 13 districts to assess the changes in soil quality as a result of waterlogging, heavy erosion and sediment deposition in the flooded areas and landslide affected highlands. Each affected district was traversed and the results of the physico chemical characteristics of the soil samples collected from identified sites were tabulated and presented districtwise in the report

THIRUVANANTHAPURAM

Total Geographic Area : 2,18,781 Ha

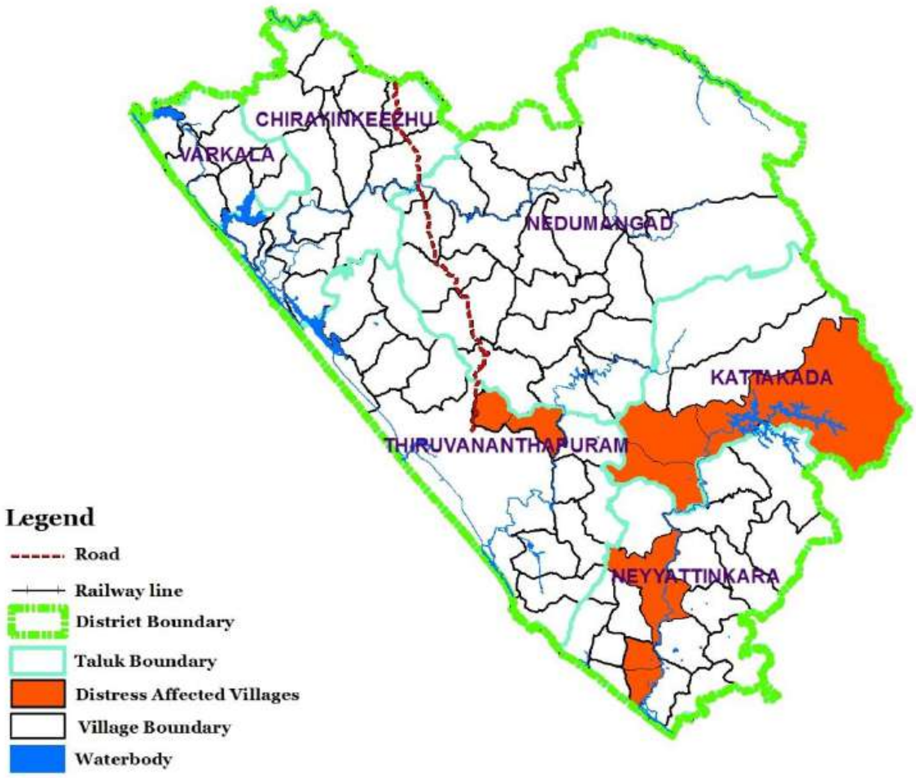
No. of Taluks : 6

No. of Villages : 124

RIVER BASINS

- *Vamanapuram*
- *Karamana*
- *Neyyar*
- *Mamom*

DISTRESS AFFECTED VILLAGES

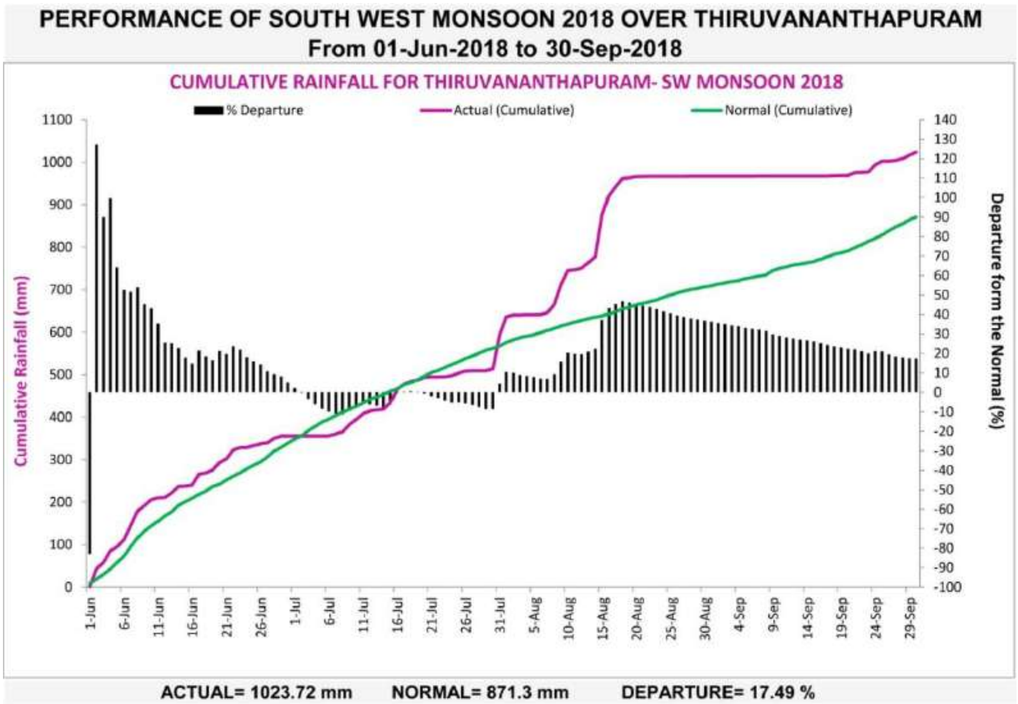


5.1. THIRUVANANTHAPURAM

Thiruvananthapuram district spreads over an area of 2,18,781 ha. Major river basins include Karamana, Neyyar, Mamaom and Vamanapuram. Major physiographic divisions in the district are Lowland, Midland, Mid upland, Upland and Highland.

RAINFALL PATTERN DURING DISTRESS

In the southwest monsoon season, Thiruvananthapuram district received a rainfall of 920.8 mm during the period from June 2018 to 22nd August 2018. This was 45% more than the normal rainfall of 643 mm during the same period. This has caused flooding in some parts of the district. Due to heavy rainfall, the shutters of Neyyar irrigation canal were opened which caused flooding of areas in an around the banks and adjoining areas of Karamana and Neyyar rivers. Compared to other districts in the state except Kasaragod, Thiruvananthapuram was the least affected.



IMPACT OF DISTRESS

Flood in Thiruvananthapuram district occurred as a result of overflow of Karamana and Neyyar rivers and lasted only for 3-4 days. Flood water remained for a period of two days and then receded slowly and after four days water receded completely. The crops mostly affected in the district are banana and tuber crops.

Field traversing and soil sampling

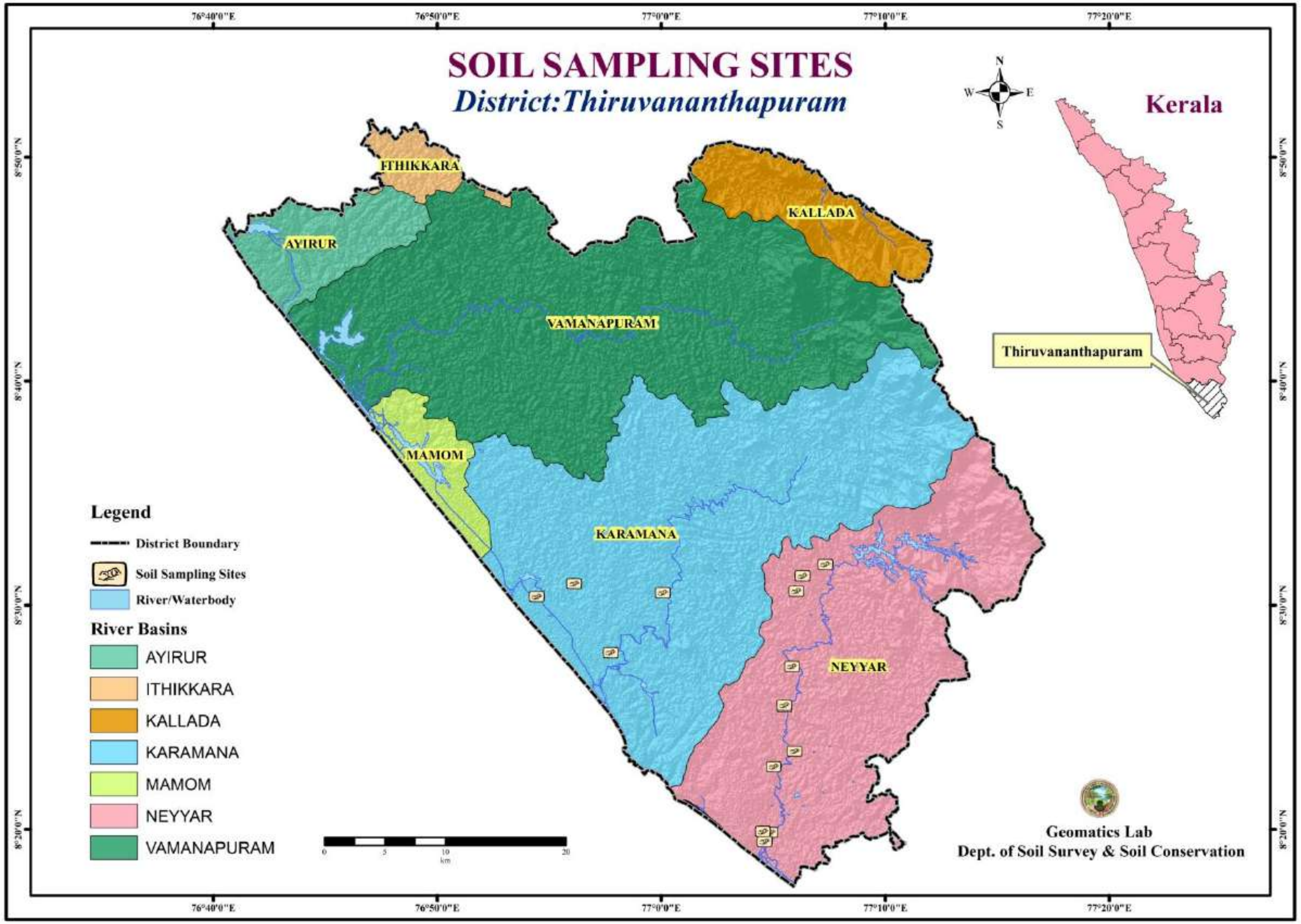
The flood affected areas of the district were traversed and surface soil samples were collected from the selected sites of affected areas under different physiographic units such as lowland valley / flood plain, coastal alluvium, midland laterite and midupland laterite. Altogether 15 soil samples were collected. The sampling locations are depicted in figure 1. The sampling locations and site descriptions are presented in table 5.1.1 and 5.1.2.

List of sampling sites in the district is as follows:

Table 5.1.1

Sampling sites

Sl. no	Sample code	Village/Panchayat	Latitude	Longitude
1	TVM/MNKD/F/1	Manacaud	8^0 27' 55.9"N	76^0 57'45.6''E
2	TVM/KTDA/F/1	Kulathummal	8^0 30' 36.2'' N	77^0 00' 5.47'' E
3	TVM/KLKD/F/1	Kallikkad	8^0 31' 52.3" N	77^0 07' 21.0'' E
4	TVM/PVR/F/1	Thirupuram	8^0 23' 31.8'' N	77^0 05' 58.5'' E
5	TVM/PVR/F/2	Thirupuram	8^0 27' 19.0'' N	77^0 05' 51.3'' E
6	TVM/TPRM/F/1	Thirupuram	8^0 25' 31.6'' N	77^0 05' 31.8'' E
7	TVM/NTA/F/1	Neyyattinkara	8^0 25' 35.3'' N	77^0 05' 30.8'' E
8	TVM/AMVL/F/1	Neyyattinkara	8^0 31' 21.7"N	77^0 06' 19.9'' E
9	TVM/ELVK/F/1	Perumpazhuthoor	8^0 31' 00.8'' N	76^0 56' 08.2'' E
10	TVM/CHVL/F/1	Neyyattinkara	8^0 30' 26.0''N	76^0 54' 27.8'' E
11	TVM/AVPM/F/1	Perumpazhuthoor	8^0 19' 54.9'' N	77^0 04' 53.9'' E
12	TVM/KDPL/F/1	Kadakampalli	8^0 19' 30.3'' N	77^0 04' 38.2'' E
13	TVM/PTM/F/1	Pattom	8^0 19' 57.0'' N	77^0 04' 33.2'' E
14	TVM/VTKY/F/1	Vattiyoorkavu	8^0 22' 50.3'' N	77^0 05' 02.4'' E
15	TVM/PVCL/F/1	Veeranakaavu	8^0 30' 40.5" N	77^0 06' 2.8'' E



SOIL SAMPLING SITES
District:Thiruvananthapuram
Kerala
Thiruvananthapuram
ITHIKKARA
AYIRUR
KALLADA
VAMANAPURAM
MAMOM
KARAMANA
NEYYAR
Legend
District Boundary
Soil Sampling Sites
River/Waterbody
River Basins
AYIRUR
ITHIKKARA
KALLADA
KARAMANA
MAMOM
NEYYAR
VAMANAPURAM
Geomatics Lab
Dept. of Soil Survey & Soil Conservation

Table 5.1.2

Sampling site characteristics

Sl. No.	River basin	Slope %	Physiography	Present land use
TVM/MNKD/F/1	Karamana	0-3%	Lowland	Coconut, Banana
TVM/KTDA/F/1	Neyyar	3-5%	Midupland	Banana, Tapioca
TVM/KLKD/F/1	Neyyar	3-5%	Midland	Banana, Tapioca
TVM/PVR/F/1	Neyyar	0-3%	Lowland	Coconut
TVM/PVR/F/2	Neyyar	0-3%	Lowland	Coconut
TVM/TPRM/F/1	Neyyar	3-5%	Lowland	Coconut, Banana, Tapioca
TVM/NTA/F/1	Neyyar	3-5%	Lowland	Coconut, fruit crops
TVM/AMVL/F/1	Neyyar	3-5%	Midland	Coconut, fruit crops
TVM/ELVK/F/1	Neyyar	3-5%	Midland	Coconut, fruit crops
TVM/CHVL/F/1	Neyyar	3-5%	Midland	Coconut, fruit crops
TVM/AVPM/F/1	Neyyar	3-5%	Midland	Coconut, fruit crops
TVM/KDPL/F/1	Karamana	0-3%	Lowland	Coconut, fruit crops
TVM/PTM/F/1	Karamana	0-3%	Lowland	Coconut,Banana
TVM/VTKY/F/1	Karamana	0-3%	Lowland	Coconut, Fruit crops
TVM/PVCL/F/1	Neyyar	3-5%	Midland	Banana, Tapioca

CHANGES IN SOILS OF DISTRESS AFFECTED AREAS

PHYSICAL PROPERTIES

The physical properties of soils of the sampling locations are presented below.

Table 5.1.3

Physical characteristics

Sample no.	Texture (feel method)	Structure	WHC, %	Porosity, %
TVM/MNKD/F/1	Gravelly sandy loam	Granular	49.00	38.70
TVM/KTDA/F/1	Gravelly sandy clay loam	Sub angular blocky	62.23	30.12
TVM/KLKD/F/1	Gravelly sandy clay loam	Crumb	67.51	50.05
TVM/PVR/F/1	Loamy sand	Single grain	56.46	51.96
TVM/PVR/F/2	Loamy sand	Single grain	33.96	32.59
TVM/TPRM/F/1	Loamy sand	Single grain	40.22	29.65
TVM/NTA/F/1	Gravelly sandy clay loam	Crumb	47.75	41.55
TVM/AMVL/F/1	Gravelly sandy clay loam	Crumb	48.80	40.13
TVM/ELVK/F/1	Gravelly sandy clay loam	Crumb		

TVM/CHVL/F/1	Gravelly sandy clay loam	Crumb	47.13	38.84
TVM/AVPM/F/1	Gravelly sandy clay loam	Crumb		
TVM/KDPL/F/1	Sandy loam	Granular	50.23	40.12
TVM/PTM/F/1	Clay loam	Sub angular blocky	56.97	43.56
TVM/VTKY/F/1	Gravelly sandy loam	Granular	59.19	46.47
TVM/PVCL/F/1	Gravelly sandy clay loam	Crumb	36.35	31.36

There is no notable change in the texture and structure of the soils of the locations. On analysis of the soil samples it is seen that the water holding capacity of samples ranges from 33.96 to 67.51% and porosity ranges from 29.65 to 51.96%. Water holding capacity is the amount of water a soil can hold after being saturated and allowed to drain for a period of one to two days. Generally, a soil with high water holding capacity will provide more plant available water. Field water holding capacity is influenced by soil texture (relative proportion of silt, clay, and sand particles), aggregation, organic matter content and overall soil structure. Clayey soils hold the water most, sandy soils hold the least, and loamy soils hold in-between. However, loamy soils provide more plant available water than clayey soils because much of the water in clayey soils is present in the micropores where water is held so tightly that it is not easily available to plants. Soil porosity indicates the space between soil particles. Coarse textured soils like sandy soils having low porosity holds less water compared to fine textured soils like clayey soils.

CHEMICAL PROPERTIES

The soils were analysed for pH, EC, primary, secondary and micronutrient status. The results were compared with that of pre-flood situation and is given in the table below.

Table 5.1.4
pH, EC and macronutrients

Sample no	Before flood			After flood				
	pH	EC	OC(%)	pH	EC	OC(%)	P (Kg/ha)	K (Kg/ha)
Midland laterite								
TVM/KLKD/F/1	4.9	Trace	0.9	5.3	0.38	1.46	123.20	317.97
TVM/AMVL/F/1	4.9	Trace	0.9	5.8	0.23	1.22	6.72	177.74
TVM/ELVK/F/1	4.9	Trace	0.9	6.1	0.11	1.38	134.40	77.28
TVM/CHVL/F/1	4.9	Trace	0.9	6.2	0.11	0.71	4.48	169.34
TVM/AVPM/F/1	4.9	Trace	0.9	5.2	0.08	1.50	134.40	86.24
TVM/PVCL/F/1	4.9	Trace	0.9	5.5	0.15	1.34	185.06	136.64

Lowland alluvium								
TVM/MNKD/F/1	4.7	0.05	0.7	6.7	0.93	1.42	17.92	128.35
TVM/PTM/F/1	4.7	0.2	2.88	6.3	0.21	1.14	11.20	120.74
TVM/VTKY/F/1	4.7	0.05	0.7	6.4	0.22	3.23	123.20	200.82
Coastal alluvium								
TVM/KDPL/F/1	6.8	0.21	0.3	5.1	0.31	1.53	20.15	138.66
TVM/PVR/F/1	5.6	0.05	0.66	5.5	0.64	2.01	11.20	77.39
TVM/PVR/F/2	5.6	0.05	0.66	4.7	0.28	3.18	123.20	281.68
TVM/TPRM/F/1	5.6	0.05	0.66	6.5	0.1	1.69	134.40	183.12
TVM/NTA/F/1	5.6	0.05	0.66	6.5	0.15	1.93	4.48	504.11
Midupland laterite								
TVM/KTDA/F/1	4.6	0.51	1.33	5.9	0.09	1.50	4.48	91.39

Except in coastal alluvium all sampling locations showed increase in pH compared to preflood samples. For Organic carbon too, coastal alluvium showed a shift from medium to high where as there was no signifcant change in other soils.

Table 5.1.5

Secondary and micronutrients

Sample no	Ca *ppm*	Mg *ppm*	S *ppm*	Fe *ppm*	Mn *ppm*	Zn *ppm*	Cu *ppm*	B *ppm*
Midland laterite								
TVM/KLKD/F/1	725.00	71.78	16.22	215.63	33.09	8.92	4.17	0.72
TVM/AMVL/F/1	782.20	52.38	142.28	156.25	27.94	4.18	3.29	0.95
TVM/ELVK/F/1	986.75	40.48	13.07	26.69	3.77	2.07	2.49	0.80
TVM/CHVL/F/1	1110.15	34.88	16.22	42.88	15.35	2.56	1.58	1.18
TVM/AVPM/F/1	898.93	156.03	28.83	38.91	10.23	2.67	3.10	1.49
TVM/PVCL/F/1	726.45	31.18	35.13	122.83	12.70	5.32	2.33	0.56
Lowland alluvium								
TVM/PTM/F/1	1453.75	45.50	22.52	44.70	15.12	8.74	3.88	1.11
TVM/MNKD/F/1	1197.35	79.88	28.83	55.25	13.17	4.56	3.07	0.65
TVM/VTKY/F/1	989.35	53.53	19.37	58.87	7.43	4.96	5.77	1.03
Coastal alluvium								
TVM/KDPL/F/1	1378.3	37.40	35.13	16.33	3.76	5.94	3.52	1.03
TVM/PVR/F/1	714.95	106.55	366.04	44.87	10.21	4.78	1.85	0.8
TVM/PVR/F/2	735.85	93.20	31.98	157.98	54.63	5.07	2.61	0.95
TVM/TPRM/F/1	1217.4	412.00	16.22	17.70	37.85	2.44	0.93	0.42
TVM/NTA/F/1	880	85.25	13.07	38.75	32.87	4.77	3.26	1.56
Midupland laterite								
TVM/KTDA/F/1	1065.45	41.68	12.44	44.63	15.93	3.41	2.35	1.03

Except two locations, all other locations are deficient in available magnesium. Calcium and sulphur are adequate for crop production though in some samples, sulphur values are very high in the post flood condition.

On analysis, it is seen that all sampling locations have adequate micronutrient status irrespective of sampling location/physiography.

Results of the study in Thiruvananthapuram district can be summarized as below.

- Study area confined to the flood plains of Neyyar and Karamana river basins which include coastal alluvium, riverine alluvium, valleys, laterite of midland and midupland.
- Acidity of the soils except coastal alluvium decreased compared to pre-flood condition. It generally ranges from strongly acidic to slightly acidic and liming can be practised as remedial measure for soils having pH <5.5.
- Organic matter content of the soils is showing medium to high status and Available phosphorus and potassium in soils are in medium to high range.
- Available Magnesium is deficient in almost all the places indicating the need for Magnesium supplementing through fertilizer application. Available Sulphur and calcium are in adequate range.
- All the micronutrients are present in soil in adequate amounts.
- Slight silt deposition is noticed in valleys, no other significant soil changes noticed. No incidence of landslide and hence no landscape modification. No significant change in texture, structure, water holding capacity and porosity except for the presence of gravels in Karamana series.

KOLLAM

Total Geographic Area : 2,48,788 Ha

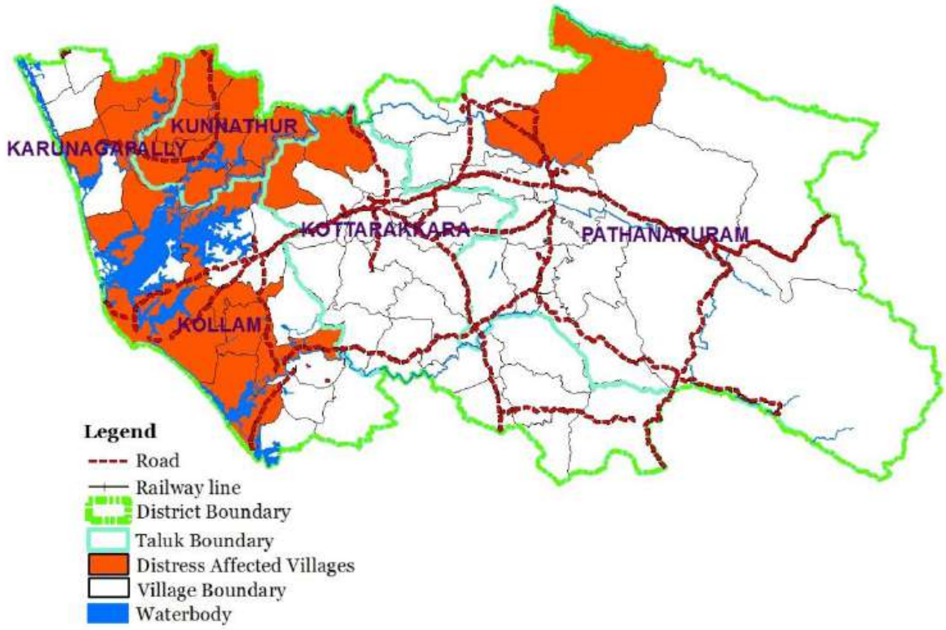
No. of Taluks : 6

No. of Villages : 105

RIVER BASINS

- *Kallada*
- *Ithikkara*
- *Achankovil*
- *Vamanapuram*
- *Pallikkal thodu*
- *Ayirur*

DISTRESS AFFECTED VILLAGES

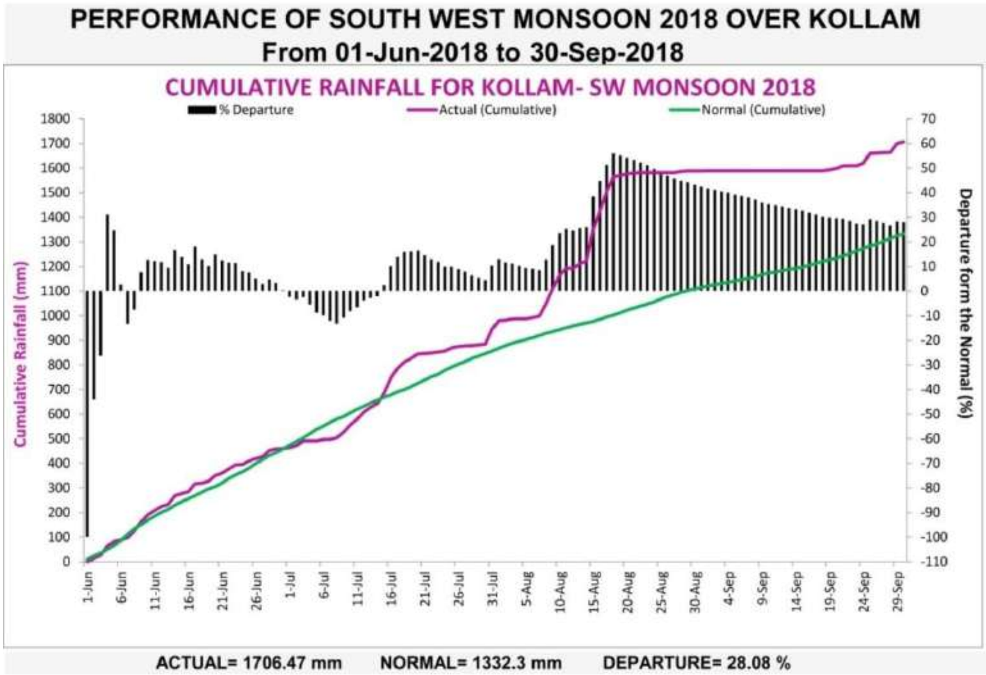


5.2. KOLLAM DISTRICT

Kollam district, an old port town of Arabian sea coast, is located between 8 ^{0}45' and 9^{0}28' north latitude and 76^{0} 28' and 77^{0} 17' east longitude. The district can be physiographically divided into lowland, midland, midupland, upland and highland. The total geographic area is 2,48,788 ha. The major river basins in the district are Kallada and Achankovil.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

On perusal of the rainfall graph, it is seen that the district received 29% more rainfall than normal during the SW monsoon period of 2018. A high peak is seen starting from August 15 onwards.



IMPACT OF DISTRESS IN THE DISTRICT

During the flood occurred in South West monsoon season of 2018, thirty five villages of five thaluks of the district were severely affected by flood calamities. The areas worse affected are Pathanapuram and Punalur. The opening of Thenmala dam shutters has aggavated the situation in Punalur. More than 60%of the affected area come under the flood plains and river banks of the major rivers especially Kallada river. River bank erosion was noted on the banks of the major rivers where as sheet, rill and gully erosion were noticed in mid land to higher elevations. Multiple landslips were reported from Thenmala-Shencottah route of NH 744. Hence all vehicular traffic were temporarily banned in this area. A land slide was reported from Urukunnu forest area of Ariyankavu village. But it did not cause any damage to human life.

FIELD TRAVERSING AND SOIL SAMPLING

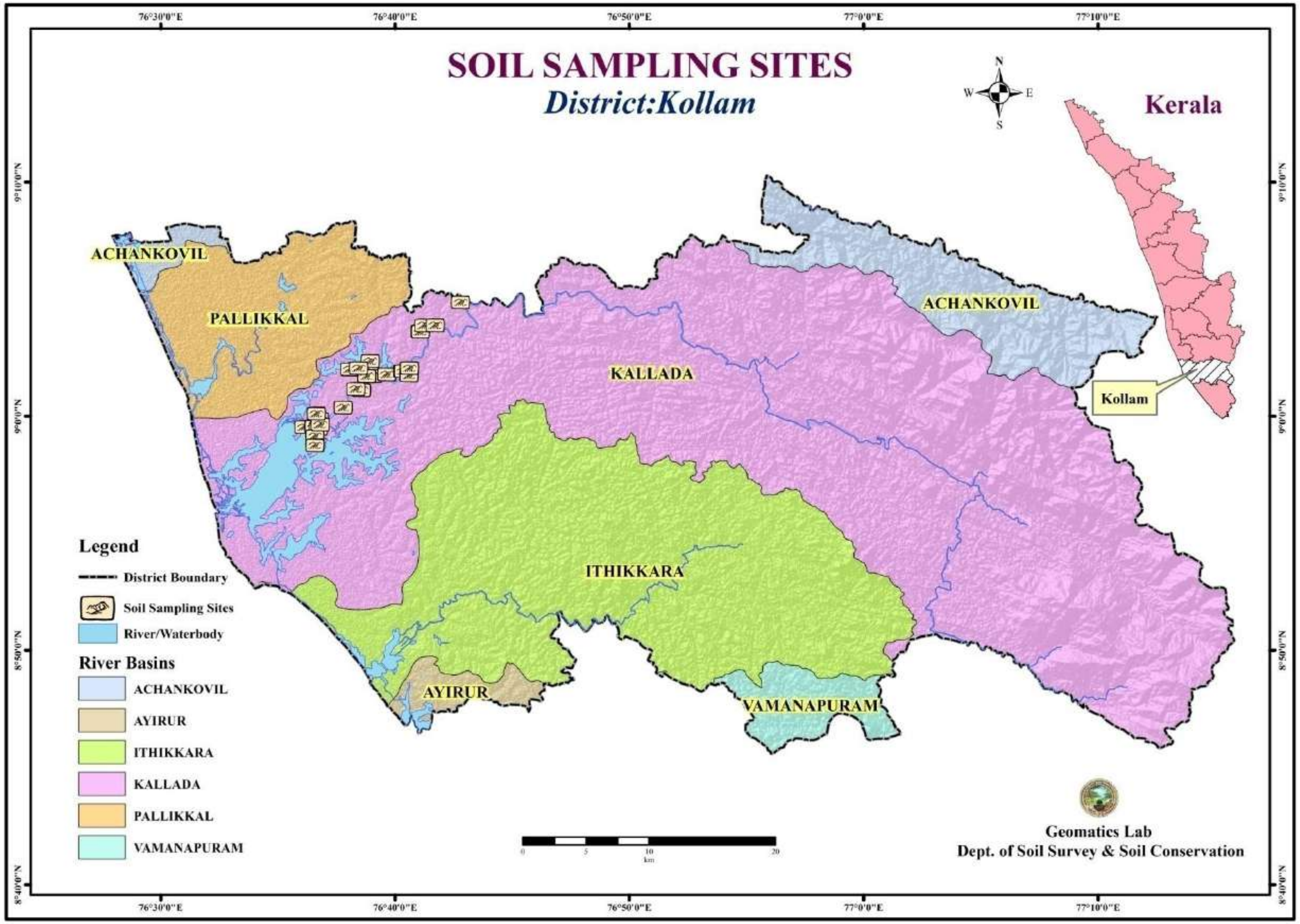
Field traversing was carried out and 30 surface samples were collected from 4 severely affected panchayaths of Kallada river basin. The sampling locations are depicted in map.

Table 5.2.1

Sampling locations

Sl. No.	Sample code	Latitude	Longitude	Slope %	Physiography	Landform	Present land use
Mundrothuruthu panchayat							
1	KL/MT/FS/1	8°59'31.7"N	76°36' 5.2"E	5-10	Lowland	Flood Plains	Coconut
2	KL/MT/FS/2	8°59'32.65"N	76°36'31.66"E	5-10	Lowland	Flood Plains	Coconut
3	KL/MT/FS/3	8°59'52.66" N	76°36'45.18"E	5-10	Lowland	Flood Plains	Coconut
4	KL/MT/FS/4	8°59'27.66"N	76°36'42.84" E	3-5	Lowland	Flood Plains	Coconut
5	KL/MT/FS/5	8°59'8.40" N	76°36'33.57"E	3-5	Lowland	Flood Plains	Coconut
6	KL/MT/FS/6	8°58'45.2" N	76° 36' 33.9"E	3-5	Lowland	Flood Plains	Coconut
7	KL/MT/FS/7	8°59'38.360"N	76° 36' 47.5"E	5-10	Lowland	Flood Plains	Coconut
Sasthamkotta panchayat							
8	KL/SK/FS1	9°1'42.8" N	76° 39' 2.2" E	3-5	Midland	Flood plains /River bank	Rubber, Coconut, Banana
9	KL/SK/FS2	9°1'46.6" N	76°39'37.7" E	3-5	Midland	Flood plains/River bank	Rubber, Coconut, M=
10	KL/SK/FS3	9° 1' 55" N	76°40'18.4" E	3-5	Midland	Flood plains /River bank	Banana
11	KL/SK/FS4	9°1'54.700"N	76°40'21.2"E	3-5	Midland	Flood plains/River bank	Banana, Coconut
12	KL/SK/FS5	9°1' 44.0" N	76°40'34.9"E	3-5	Midland	Flood plains/River bank	Rubber
13	KL/SK/FS6	9°2'2.7" N	76°40' 36.0"E	3-5	Midland	Flood plains/River bank	Coconut, Banana, miscellaneous
14	KL/SK/FS7	9°2'2.6" N	76°40'36.2" E	3-5	Midland	Flood plains/River bank	Coconut, Banana, miscellaneous
15	KL/SK/FS8	9° 2' 20.6" N	76°38'55.5" E	5-10	Midland	Side slope	Coconut, Banana, miscellaneous
Kunnathur panchayat							
16	KL/KNR/FS1	9°3'36.5" N	76°41'2.6" E	1-3	Midland	Valley	Banana (wet land converted)

17	KL/KNR/FS2	9°3'35.7" N	76°41'3.9" E	5-10	Midland	Flood plains /River bank	Rubber, Banana
18	KL/KNR/FS3	9°3' 52" N	76°41' 12.9"E	5-10	Midland	Flood plains /River bank	Rubber, miscellaneous
19	KL/KNR/FS4	9°3'52.2" N	76°41'41.7" E	1-3	Midland	Valley	Wetland converted Banana
20	KL/KNR/FS5	9°0' 6.3" N	76°36'37.1" E	5-10	Midland	Flood plains /River bank	Rubber
21	KL/KNR/FS6	9°4'51.4" N	76°42'47"E	3-5	Midland	Flood plains /River bank	Coconut, Rubber
22	KL/KNR/FS7	9°4'51.4" N	76° 42' 47" E	3-5	Midland	Flood plains /River bank	Rubber, Banana,
23	KL/KNR/FS8	9°2'20.6" N	76°38'55.5" E	3-5	Midland	Flood plains /River bank	Rubber
West kallada panchayat							
24	KL/WK/FS1	9°1' 42" N	76°38'46.3" E	5-10	Midland	Flood plains/River bank	Rubber
25	KL/WK/FS2	9°1'6.2" N	76°38'33.3" E	1-3	Midland	Valley	Converted wetland Coconut,Banana,
26	KL/WK/FS3	9° 1' 9.3" N	76°38'18.7" E	5-10	Midland	Flood plains /River bank	Coconut, Banana
27	KL/WK/FS4	9°0'21.9" N	76°37'46.4" E	5-10	Midland	Flood plains /River bank	Coconut, miscellaneous
28	KL/WK/FS5	9° 0' 6.2" N	76°36'37.1" E	5-10	Midland	Flood plains /River bank	Rubber
29	KL/WK/FS6	9°1'59.5" N	76° 38' 3" E	5-10	Midland	Flood plains /River bank	Rubber
30	KL/WK/FS7	9°2'2.4" N	76°38'26.1" E	1-3	Midland	Valley	wet land



SOIL SAMPLING SITES
District:Kollam
Kerala
Kollam
N
S
E
W
ACHANKOVIL
PALLIKKAL
KALLADA
ITHIKKARA
AYIRUR
VAMANAPURAM
Legend
District Boundary
Soil Sampling Sites
River/Waterbody
River Basins
ACHANKOVIL
AYIRUR
ITHIKKARA
KALLADA
PALLIKKAL
VAMANAPURAM
Geomatics Lab
Dept. of Soil Survey & Soil Conservation
76°30'0"E
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
9°10'0"N
9°0'0"N
8°50'0"N
8°40'0"N

CHANGES IN SOILS OF DISTRESS AFFECTED AREAS

PHYSIOGRAPHY AND LANDSCAPE

No noticeable changes in the physiography and landscape observed while traversing.

Silt deposition with a thickness of up to 10cm was noticed in the estuary in Munrothuruth panchayath. Surface crusting and soil cracks developed on the deposits were noticed in many parts. But it is not evident in upper reaches. In some areas perishing of earthworms and other microfauna were noticed. Major crops affected were banana and tuber crops. Yellowing and root decay was noticed in many panchayats .

PHYSICAL PROPERTIES

The physical properties such as texture, structure and permeability of soils encountered is given in the table below.

Table 5.2.2

Physical characteristics

Sl. no	Sample code	Texture (feel method)	Structure	Permeability
1	KL/MT/FS/1	Gravally sandy clay loam	Subangular blocky	Moderate
2	KL/MT/FS/2	sandy loam	Subangular blocky	Moderate
3	KL/MT/FS/3	sandy loam	Subangular blocky	Moderate
4	KL/MT/FS/4	sandy clay	Subangular blocky	Moderate
5	KL/MT/FS/5	silty clay	Subangular blocky	Moderate
6	KL/MT/FS/6	clay loam	Subangular blocky	Moderate
7	KL/MT/FS/7	Gravally clay loam	Subangular blocky	Moderate
8	KL/SK/FS1	Clay	Subangular blocky	Moderate
9	KL/SK/FS2	Sandy Clay	Subangular blocky	Moderate
10	KL/SK/FS3	Clay	Subangular blocky	Moderate
11	KL/SK/FS4	Sandy Clay	Subangular blocky	Moderate
12	KL/SK/FS5(1)	Clayloam	Subangular blocky	Moderate
13	KL/SK/FS6	Silty Loam	Subangular blocky	Moderate
14	KL/SK/FS7	Sandyclayloam	Subangular blocky	Moderate
15	KL/SK/FS8	Clayloam	Subangular blocky	Moderate
16	KL/KNR/FS1	Clay	massive	slow
17	KL/KNR/FS2	Siltyloam	Subangular blocky	Moderate
18	KL/KNR/FS3	Sandy Clay loam	Subangular blocky	Moderate
19	KL/KNR/FS4	Clay	massive	slow
20	KL/KNR/FS5	Loamysand	Subangular blocky	Moderate
21	KL/KNR/FS6	Sandyclayloam	Subangular blocky	Moderate

22	KL/KNR/FS7	Sandyclay	Subangular blocky	Moderate
23	KL/KNR/FS8	Sandyclay	Subangular blocky	Moderate
24	KL/WK/FS1	Sandyloam	Subangular blocky	Moderate
25	KL/WK/FS2	Clay	Subangular blocky	Moderate
26	KL/WK/FS3	Siltyloam	Subangular blocky	Moderate
27	KL/WK/FS4	Sandyclay	Subangular blocky	Moderate
28	KL/WK/FS5	Sandy Caly	Subangular blocky	Moderate
29	KL/WK/FS6	Sandy Clay	Subangular blocky	Moderate
30	KL/WK/FS7	Sandy Clay	massive	slow

CHEMICAL PROPERTIES

The chemical properties such as pH, EC, macro, secondary and micronutrients of the soil samples collected from the identified flooded locations were analysed. Comparison of data has been done with the available pre flood data.

Table 5.2.3

pH and Electrical Conductivity

Sample code	Before flood		After flood	
	pH	EC dSm^{-1}	pH	EC dSm^{-1}
Lowland flood plain				
KL/MT/FS/1	7.00	0.55	4.60	0.13
KL/MT/FS/2	7.70	0.75	7.70	0.75
KL/MT/FS/3	7.20	0.83	3.40	0.71
KL/MT/FS/4	4.00	2.90	4.20	1.09
KL/MT/FS/5	6.90	0.82	5.10	0.25
KL/MT/FS/6	6.20	1.98	5.90	0.16
KL/MT/FS/7	6.60	0.89	6.50	0.15
Midland flood plain				
KL/SK/FS1	5.20	0.20	4.70	1.29
KL/SK/FS2	4.20	0.70	3.20	0.93
KL/SK/FS3	4.20	0.70	5.10	0.15
KL/SK/FS4	4.20	0.70	6.50	0.13
KL/SK/FS5	4.20	0.70	4.50	0.47
KL/SK/FS6	5.90	0.30	4.90	0.36
KL/SK/FS7	5.90	0.30	5.90	0.10
KL/SK/FS8	5.90	0.30	6.40	0.13
KL/KNR/FS3	6.20	0.70	5.10	0.12
KL/KNR/FS4	6.20	0.70	5.00	0.12
KL/KNR/FS6	4.50	1.00	6.00	0.06
KL/KNR/FS7	4.50	1.00	5.70	0.07

KL/KNR/FS8	4.50	1.00	5.60	0.06
KL/WK/FS1	5.70	1.90	5.10	0.18
KL/WK/FS2	5.70	1.90	4.60	0.30
KL/WK/FS3	5.70	1.90	4.50	1.69
KL/WK/FS4	5.60	0.40	4.70	0.26
KL/WK/FS5	3.70	1.20	5.56	0.29
KL/WK/FS6	3.70	1.20	4.20	0.25
KL/WK/FS7	3.70	1.20	6.20	0.12
Midland valley				
KL/KNR/FS1	6.20	0.70	4.70	0.34
KL/KNR/FS2	6.20	0.70	4.90	0.98
KL/KNR/FS5	4.50	1.00	5.60	0.07

On analysis of soil samples, it is seen that acidity ranges from Extremely acidic to slightly acidic with majority of the samples falling under extremely acidic to very strongly acidic range. The soils need urgent liming measures to restore soil fertility. Lime /Dolomite application and thorough incorporation with soil is necessary. EC values care safe for crop production.

Table 5.2.4

Macronutrients

	Before flood			After flood		
Sample code	OC%	P(Kg/ha)	K(Kg/ha)	OC%	P(Kg/ha)	K(Kg/ha)
Low land flood plain						
KL/MT/FS/1	0.98	178.08	1445.92	2.18	3.36	23.41
KL/MT/FS/2	1.14	21.28	791.84	1.14	21.28	791.84
KL/MT/FS/3	1.51	92.96	100.80	4.04	17.44	251.33
KL/MT/FS/4	4.25	48.16	345.97	3.41	35.03	349.10
KL/MT/FS/5	0.12	17.92	102.70	2.98	8.64	127.68
KL/MT/FS/6	0.83	51.52	120.29	3.68	64.34	58.46
KL/MT/FS/7	2.27	165.76	102.59	2.23	20.37	208.66
Midland flood plain						
KL/SK/FS1	0.42	33.00	190.00	2.09	1.12	163.52
KL/SK/FS2	1.33	42.00	67.00	1.09	11.20	24.03
KL/SK/FS3	1.33	42.00	67.00	0.91	25.76	103.15
KL/SK/FS4	1.33	42.00	67.00	1.34	98.56	252.56
KL/SK/FS5	1.33	42.00	67.00	1.16	62.72	95.76
KL/SK/FS6	0.82	35.00	179.00	1.63	17.92	270.82
KL/SK/FS7	0.82	35.00	179.00	1.63	50.40	144.26
KL/SK/FS8	0.82	35.00	179.00	0.98	10.08	47.94
KL/KNR/FS3	1.23	33.00	134.00	1.59	4.48	62.27
KL/KNR/FS4	1.23	33.00	134.00	1.88	3.36	98.22
KL/KNR/FS6	1.48	34.00	101.00	1.38	57.12	82.43

KL/KNR/FS7	1.48	34.00	101.00	0.79	22.40	56.34
KL/KNR/FS8	1.48	34.00	101.00	1.00	14.56	75.15
KL/WK/FS1	0.46	46.00	112.00	0.69	13.44	36.85
KL/WK/FS2	0.46	46.00	112.00	1.09	23.52	67.98
KL/WK/FS3	0.46	46.00	112.00	2.25	19.04	192.98
KL/WK/FS4	0.46	46.00	112.00	3.62	10.08	245.39
KL/WK/FS5	0.35	36.00	45.00	2.54	61.60	110.66
KL/WK/FS6	0.35	36.00	45.00	1.63	12.32	32.14
KL/WK/FS7	0.35	36.00	45.00	2.00	26.88	50.06
Midland valley						
KL/KNR/FS1	1.23	33.00	134.00	3.09	4.48	80.08
KL/KNR/FS2	1.23	33.00	134.00	2.29	8.96	84.78
KL/KNR/FS5	1.48	34.00	101.00	1.71	26.88	51.97

Organic matter content was medium to high in all post flood samples. 20% of the samples are phosphorus deficient and 60% are potassium deficient. Potassium ranges from low to high with a major portion on low to medium range. Hence potassium fertilization is essential for successful crop production. Available phosphorus also needs to supplement in deficient areas. While comparing pre flood and post flood samples organic carbon content increased. No specific trend could be identified in Phosphorus and potassium content in soil.

Table 5.2.5

Secondary nutrients

Sample code	Before flood (ppm)			After flood (ppm)		
	Avail. Ca	Avail. Mg	Avail Sulphur	Avail. Ca	Avail. Mg	Avail Sulphur
Lowland flood plain						
KL/MT/FS/1	313.60	233.48	35.13	85.90	550.08	82.40
KL/MT/FS/2	504.60	239.08	68.85	717.75	245.38	230.52
KL/MT/FS/3	867.05	504.35	142.28	118.90	144.83	564.53
KL/MT/FS/4	749.40	204.60	646.52	259.50	296.95	482.65
KL/MT/FS/5	598.85	94.73	13.07	116.65	116.65	107.61
KL/MT/FS/6	208.40	98.90	14.01	338.30	198.40	22.52
KL/MT/FS/7	1402.50	1251.75	929.85	361.15	161.60	54.04
Midland flood plain						
KL/SK/FS1	-	-	35.31	79.35	327.13	275.91
KL/SK/FS2	-	-	35.31	189.70	194.35	466.89
KL/SK/FS3	-	-	35.31	773.25	227.15	31.98
KL/SK/FS4	-	-	34.06	780.55	239.25	189.55
KL/SK/FS5	-	-	34.06	371.80	131.25	293.55
KL/SK/FS6	-	-	34.06	349.30	192.75	29.77
KL/SK/FS7	-	-	34.06	913.55	176.25	542.52
KL/SK/FS8	-	-	26.56	1087.50	224.33	463.74

KL/KNR/FS3	-	-	26.56	696.03	108.43	135.98
KL/KNR/FS4	-	-	28.43	167.30	8.25	139.13
KL/KNR/FS6	-	-	28.43	772.75	112.60	79.25
KL/KNR/FS7	-	-	28.43	608.50	86.78	54.04
KL/KNR/FS8	-	-	28.43	490.00	77.48	72.95
KL/WK/FS1	-	-	36.50	463.45	122.90	9.92
KL/WK/FS2	-	-	46.80	912.80	274.75	184.10
KL/WK/FS3	-	-	46.80	147.55	125.00	82.40
KL/WK/FS4	-	-	46.80	768.60	552.50	25.67
KL/WK/FS5	-	-	159.30	493.65	143.30	514.16
KL/WK/FS6	-	-	159.30	98.50	60.50	539.37
KL/WK/FS7	-	-	29.06	414.35	102.03	19.37
Midland valley						
KL/KNR/FS1	-	-	26.56	622.85	121.05	545.68
KL/KNR/FS2	-	-	26.56	736.85	149.93	16.22
KL/KNR/FS5	-	-	46.80	563.90	180.90	158.04

**Preflood values of Calcium and Magnesium are not available

Available Calcium and Magnesium are adequate in majority of the samples analysed. In midland flood plains of Kunnathur and West Kallada panchayats Mg deficiency is seen in localised patches. Sulphur is adequate in all the samples analysed. Postflood samples showed a substantial increase in sulphur when compared with the preflood values.

Table 5.2.6

Micronutrients

Sample code	Pre flood (ppm)					Post flood (ppm)				
	Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
Low land flood plain										
KL/MT/FS/1	75.99	30.79	9.02	5.39	1.30	225.01	4.36	3.92	23.60	1.79
KL/MT/FS/2	78.43	32.21	9.16	5.17	0.86	213.52	8.17	6.67	4.53	3.78
KL/MT/FS/3	43.72	14.62	5.56	4.35	2.35	293.33	6.19	1.95	4.36	3.48
KL/MT/FS/4	19.98	9.84	1.99	1.42	2.56	248.10	9.94	2.15	3.60	3.31
KL/MT/FS/5	29.73	4.49	1.09	1.75	0.65	149.61	5.01	1.58	1.80	1.04
KL/MT/FS/6	48.47	9.19	2.72	3.12	1.43	49.52	8.84	2.12	1.98	0.82
KL/MT/FS/7	250.03	11.88	4.49	4.42	2.50	155.42	20.73	2.48	2.84	0.08
Midland flood plain										
KL/SK/FS1	16.97	10.98	4.41	1.59	1.98	120.98	37.18	3.26	1.30	2.48
KL/SK/FS2	16.97	10.98	4.41	1.59	1.98	176.08	41.25	6.10	1.62	1.79
KL/SK/FS3	16.97	10.98	4.41	1.59	1.98	173.62	8.40	21.23	3.76	2.25
KL/SK/FS4	205.73	2.10	3.02	24.51	0.91	41.13	2.89	4.28	0.77	2.02
KL/SK/FS5	205.73	2.10	3.02	24.51	0.91	146.62	16.74	6.09	2.00	3.63

KL/SK/FS6	205.73	2.10	3.02	24.51	0.91	74.09	39.89	6.89	2.69	1.56
KL/SK/FS7	205.73	2.10	3.02	24.51	0.91	197.12	10.27	8.08	1.89	2.40
KL/SK/FS8	39.48	11.83	3.79	2.30	2.09	203.01	109.93	3.53	4.44	2.71
KL/KNR/FS3	39.48	11.83	3.79	2.30	2.09	37.62	19.44	4.11	2.23	2.25
KL/KNR/FS4	98.02	18.30	2.79	3.47	1.46	76.90	16.49	5.16	2.15	1.33
KL/KNR/FS6	98.02	18.30	2.79	3.47	1.46	35.05	6.50	6.80	1.34	1.56
KL/KNR/FS7	98.02	18.30	2.79	3.47	1.46	72.39	6.92	5.99	1.54	2.17
KL/KNR/FS8	98.02	18.30	2.79	3.47	1.46	80.67	6.69	6.45	1.31	1.87
KL/WK/FS1	361.25	40.37	26.11	8.53	1.20	38.47	2.81	5.10	191.0	0.80
KL/WK/FS2	323.83	37.95	17.55	17.28	1.27	191.63	16.73	4.33	3.97	1.87
KL/WK/FS3	323.83	37.95	17.55	17.28	1.27	133.36	106.19	4.27	4.03	1.49
KL/WK/FS4	323.83	37.95	17.55	17.28	1.27	231.49	113.96	14.64	5.11	1.26
KL/WK/FS5	598.85	3.47	10.69	14.51	1.03	175.29	2.56	7.06	2.99	2.40
KL/WK/FS6	598.85	3.47	10.69	14.51	1.03	162.29	4.36	2.48	0.73	1.26
KL/WK/FS7	13.07	4.33	2.07	2.57	1.50	27.56	2.45	6.22	1.56	1.72
Midland valley										
KL/KNR/FS1	39.48	11.83	3.79	2.30	2.09	187.75	24.78	9.25	3.72	1.87
KL/KNR/FS2	39.48	11.83	3.79	2.30	2.09	62.39	19.66	5.39	2.90	1.26
KL/KNR/FS5	323.83	37.95	17.55	17.28	1.27	159.97	22.78	4.92	3.17	2.33

Micro nutrient status in post flood soils are adequate for crop growth and no deficiency is noticed in any of the sampling locations except for Boron in one location. While comparing preflood and postflood values, definite trend could not be observed.

INTERPRETATION AND RECOMMENDATIONS

Munrothuruth panchayat

In Monrothuruthu panchayat after the flood, silt deposition is noticed in the estuary which has shown sinking for the past few years. Uncontrolled sand and clay mining from river Kallada after 1990, caused sinking of land which was made up by bringing silt from elsewhere. But this year, the flood helped to bring back the equilibrium of Munrothuruth area by depositing silt . On analysis, the soil samples showed drastic reduction in pH and very high organic carbon content.

West Kallada panchayat

In West Kallada panchayat, a silty deposition of 2-3cm thickness was seen on the river banks of Kallada river. The analytical results of the post flood samples showed an increase in OC% and reduction in EC. Postflood pH, Available Phosphorus and potassium exhibited no definite trend. In some locations increasing trend is observed while in others the values decreased when compared to preflood data.

Kunnathoor panchayat

In Kunnathoor panchayat , a silt deposition was noticed on the river banks of Kallada river and the thickness ranging from 2-3cm. Based on the Soil Analytical results of post flood samples in valleys OC increased, P & K decreased generally. In midland flood plains, 40% samples showed increase in OC from medium to high and decrease in P & K with the rest remaining without much change.

Sasthamkotta panchayat

In Sasthamkotta panchayat, a silty patch was seen on the river banks of Kallada river in a thickness ranging from 2-5cm. The analysis of post flood samples showed a reduction in soil pH in some samples.

On analysis, it is seen that acidity of the soils ranges from extremely acidic to medium acidic. The soils need urgent liming measures to restore soil fertility. Apply lime /Dolomite and thoroughly incorporate with soil. EC values are safe for crop production.

The results of post flood sample analysis in Kollam district can be summarized as follows.

- Silt deposition, surface crusting, perishing of earth worms etc. were noticed.
- Soil acidity is a major problem in majority of the soils analysed. Lime/ dolomite application is very essential.
- The availability of potassium reduced after flooding and needs to be supplemented.
- Localized deficiency of Available magnesium is seen
- Micronutrient deficiency is not noticed.

ALAPPUZHA

Total Geographic Area : 1,41,011 Ha

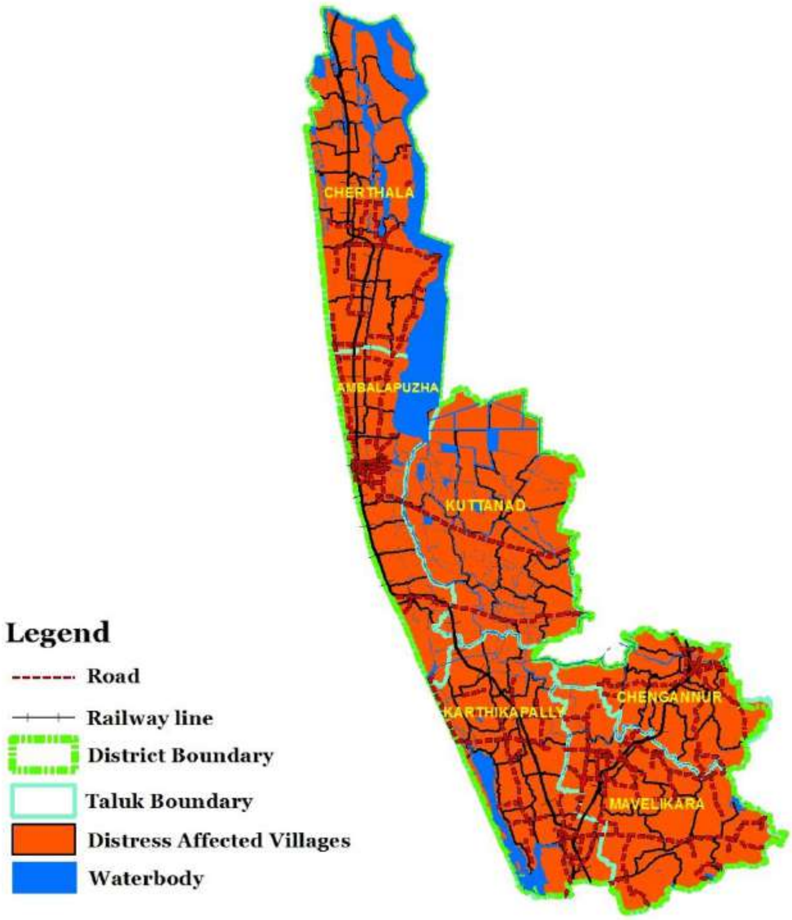
No. of Taluks : 6

No. of Villages : 91

RIVER BASINS

- *Achankovil*
- *Pamba*
- *Muvattupuzha*
- *Manimala*
- *Pallikkal thodu*

DISTRESS AFFECTED VILLAGES



5.3. ALAPPUZHA

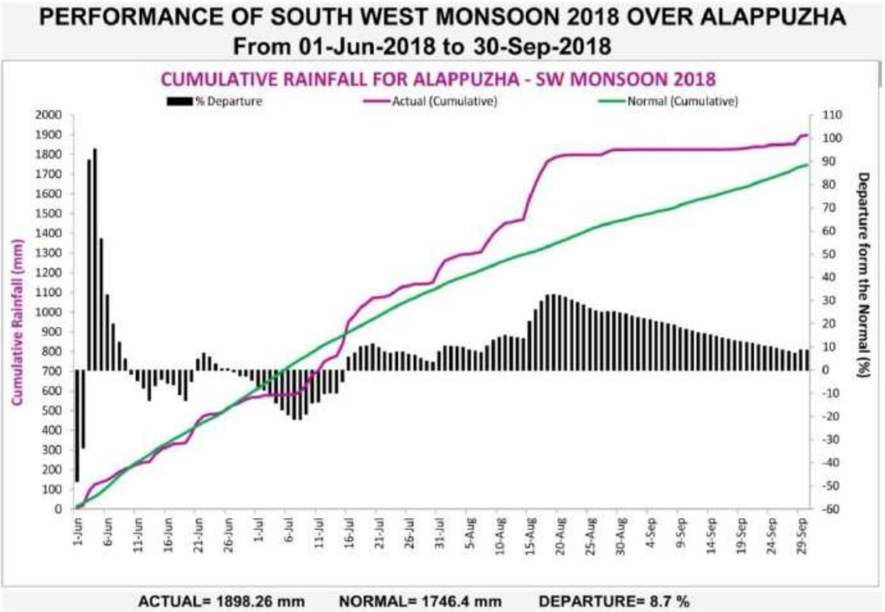
Alappuzha is a veritable maze of bridges and canals, the presence of which has given it the appellation the “Venice of the East”. The district extends between 9 ^{0} 6’ and 9 ^{0} 52’ N latitude and 76 ^{0} 17’ and 76 ^{0} 40’E longitude. The district extends over an area of 1,41,011 ha.

The entire area of the district lies in the low land and the midland divisions and is the only district in Kerala having no area under the high lands. The Low land comprises of beach plains, northern paleo sand ridges with swales and marshes, southern paleo sand ridges with swales and marshes, shallow lagoon lands, lagoon lands adjoining the southern spread of Vembanad lake, submerged deltaic basin, tidal flats, lacustrine plains and transitional plains. Kuttanad, “the rice bowl of Kerala”, one of the very few places in the world where farming is done below sea level is the Alappuzha district. The midland region with an elevation ranging from 20 to 100m above MSL represents undulating regions of laterite soil.

The district is drained by Pampa, Manimala, Muvattupuzha, Pallikkalthdu and Achenkoil rivers

RAINFALL PATTERN DURING THE DISTRESS PERIOD

Alappuzha received 1648.1 mm rainfall during south monsoon period starting from June to August 2018 against the normal rainfall of 1309.5mm which is 29% higher than the normal rainfall received in the district. The rainfall received from Mid July to Mid September was higher than the normal with the maximum in the month of August 2018 which resulted in flooding of Kuttanad and adjoining areas for weeks. Flooding and consequent silt deposition is a common phenomenon in Kuttanad basin enriching the fertility of soil. But during the current year flooding continued for weeks and the increase in water level was much higher than the previous years.



IMPACT OF DISTRESS IN THE DISTRICT

Heavy rain and sea erosion wreaked havoc in different parts of the district causing extensive damage to life and properties. Almost all the villages of Alappuzha district were flood affected. Kuttanad and Chengannur taluks and parts of Mavelikkara, Karthikapally, Ambalappuzha taluks were the worst affected. Low-lying areas in the district have been inundated. Kuttanad, the below sea level area spread across Alappuzha and Kottayam districts, is literally swallowed by rain water disrupting the life and destroying all the paddy, vegetable and fish cultivation. The major rivers Pampa and Manimala draining through Chegannur taluk overflowed and left the area flooded for almost a week.

Post Flood Statistics

Item	Measure/Loss Amount/Nos.
Rainfall	1112.44 mm
No. of injured	2
No. of deceased	12
Houses Damaged	606 nos. (Loss of Rs. 1,49,77,258/-)
Agriculture Loss	Rs. 35,15,00,000/-
PWD(Loss Est.)	Rs.500cr
KSEB	Rs.1,17,00,000/-
Dairy Development	Rs.2,69,84,450/-

(Source: https://alappuzha.nic.in)

FIELD TRAVERSING AND SOIL SAMPLING

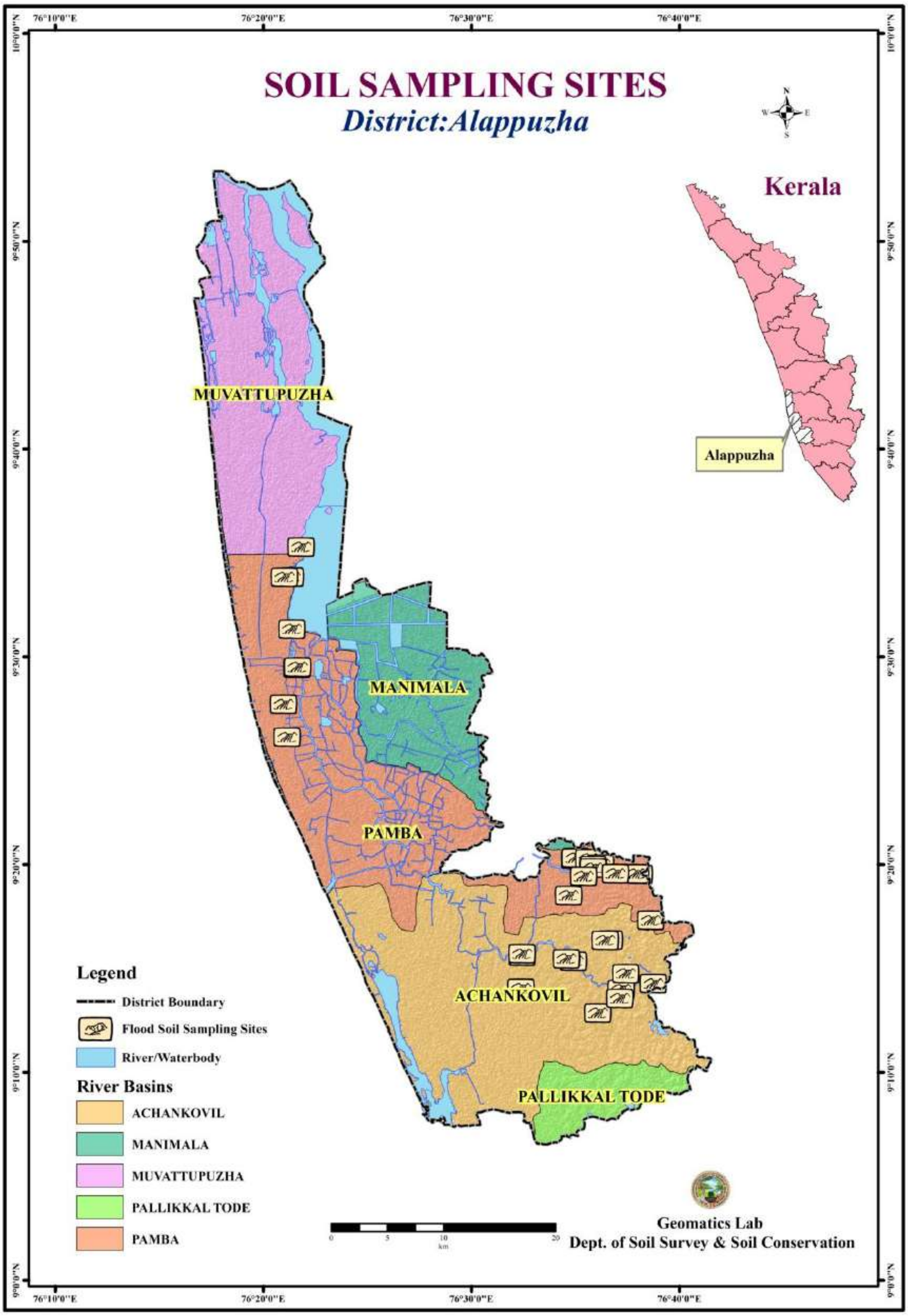
Field traversing of the affected area was carried out and soil samples were collected randomly from sites wherever a change in the texture, colour or deposits was noticed. Surface samples were collected from a depth of 0-30 cm and analysed for various physico-chemical properties. Study area confined to Kuttand basin, coastal alluvium, midland laterite and valleys. Altogether 37 soil samples were collected and the sites selected for sample collection is listed below

Table 5.3.1

Sampling locations

Sample No.	Physiographic unit	Latitude	Longitude	Panchayat
1	Lowland Coastal alluvium	27 9^{0}′ 42.7″N	^{0}20 76′ 59.3″E	Punnapra North
2		26 9^{0}′7.7″N	21 76^{0}′ 10″E	Punnapra South
3	Coastal Plain	^{0}35 9′ 17.2″N	^{0}21 76′ 50.2″ E	Aryad
4	Kuttanad	23 9^{0}′ 20.12″ N	30 76^{0}′ 45.99″E	Muttar
5		23 9^{0}′ 7.47″ N	30 76^{0}′ 15.36″ E	Muttar
6		33 9^{0}′ 50.4″ N	21 76^{0}′ 19.6″E	Mannancherry
7		^{0}33 9′ 49.7″ N	21 76^{0}′ 02.2″E	Mannancherry
8		^{0}35 9′ 17.2″ N	21 76^{0}′ 50.2″ E	Mannancherry
9		29 9^{0}′27.1″N	21 76^{0}′ 38.2″ E	Alappuzha
10		29 9^{0}′ 30″ N	21 76^{0}′ 40″ E	Alappuzha
11		31 9^{0}′ 19.8″N	21 76^{0}′ 24.0″ E	Alappuzha
12	Upper Kuttanad	9 ^{0} 15’ 42.40”N	76 ^{0} 32’27.02”E	Chennithala Thriperumthura
13	Midland	9 ^{0} 20’ 15.70”N	76 ^{0} 34’59.30”E	Thiruvanvandur
14		9 ^{0} 20’ 20.20” N	76 ^{0} 35’ 2.84”E	Thiruvanvandur
15		9 ^{0} 20’ 19.54” N	76 ^{0} 35’ 0.74”E	Thiruvanvandur
16		9 ^{0} 20’ 17.36” N	76 ^{0} 35’39.57”E	Thiruvanvandur
17		9 ^{0} 20’ 1.17” N	76 ^{0} 36’13.34”E	Thiruvanvandur
18		9 ^{0} 19’ 57.01”N	76 ^{0} 35’52.43”E	Pandanad
19		9 ^{0} 19’ 50.92”N	76 ^{0} 35’51.65”E	Pandanad
20		9 ^{0} 19’ 26.16”N	76 ^{0} 35’24.50”E	Pandanad
21		9 ^{0} 19’ 26.16”N	76 ^{0} 35’24.50”E	Mannar

22		9 ^{0} 18’ 31.00”N	76 ^{0} 34’41.38”E	Puliyoor
23		9 ^{0} 16’ 22.32”N	76 ^{0} 36’39.26”E	Ala
24		9 ^{0} 16’ 21.42”N	76 ^{0} 36’26.93”E	Ala
25		9 ^{0} 15’ 21.21”N	76 ^{0} 34’55.04”E	Cheriyanad
26		9 ^{0} 14’ 0.12” N	76 ^{0} 37’13.01”E	Venmony
27		9 ^{0} 14’ 45.38”N	76 ^{0} 37’25.96”E	Venmony
28		9 ^{0} 14’ 16.39”N	76 ^{0} 38’45.58”E	Venmony
29		9 ^{0} 17’ 19.27”N	76 ^{0} 38’38.19”E	Mulakuzha
30		9 ^{0} 19’ 32.63”N	76 ^{0} 38’ 5.42”E	Chengannur (M)
31		9 ^{0} 19’ 33.67”N	76 ^{0} 37’54.79”E	Chengannur (M)
32		9 ^{0} 19’ 34.41”N	76 ^{0} 36’56.51”E	Chengannur (M)
33		9 ^{0} 14’ 2.78”N	76 ^{0} 32’23.72”E	Mavelikkara (M)
34		9 ^{0} 15’ 36.15”N	76 ^{0} 32’27.51”E	Mavelikkara (M)
35		9 ^{0} 15’ 27.99”N	76 ^{0} 34’35.29”E	Thazhakkara
36		9 ^{0} 12’ 51.34”N	76 ^{0} 36’ 5.57”E	Thazhakkara
37		9 ^{0} 13’ 33.34” N	76 ^{0} 37’ 9.23”E	Nooranad


SOIL SAMPLING SITES
District:Alappuzha
Kerala
Alappuzha
MUVATTUPUZHA
MANIMALA
PAMBA
ACHANKOVIL
PALLIKKAL TODE
Legend
District Boundary
Flood Soil Sampling Sites
River/Waterbody
River Basins
ACHANKOVIL
MANIMALA
MUVATTUPUZHA
PALLIKKAL TODE
PAMBA
Geomatics Lab
Dept. of Soil Survey & Soil Conservation
76°10'0"E
76°20'0"E
76°30'0"E
76°40'0"E

CHANGES IN IN SOILS OF DISTRESS AFFECTED AREAS

LAND SCAPE

No notable change was noticed in the landscape, slope or soil depth as a whole in the affected areas.

PHYSICAL PROPERTIES

The changes in physical properties of soils observed were compared to available soil data of the pre flood site characteristics and is given in the table below.

Table 5.3.2

Physical properties and Site characteristics

Sample No.	Panchayat	Site characteristics
1	Punnapra North	Soil series in the area is Kavur with loamy sand texture. Soil texture changed to sandy loam . yrettuB feeling indicate increase in silt %.
2	Punnapra South	The soil series here is Kavur with loamy sand texture. Soil texture changed to sandy clay due to clay deposition
3	Aryad	The soil texture remained loamy sand with no signs of erosion sedimentation & silt deposition.
4	Muttar	In the made up garden lands silt deposited on one side of thodu upto 6”.
5	Muttar	On the river banks, sandy loam deposition was noticed and on traversing 10 m inwards, silty clay and after that pure clay deposits were seen
6	Mannancherry	No distinct sedimentation or silt deposition. Punnamda series with loamy sand to sandy texture got changed to sandy loam texture.
7	Mannancherry	No change in Champakulam series having clayey texture.
8	Mannancherry	No remarkable sedimentation or silt deposition . Texture changed to clay loam
9	Alappuzha	In garden lands the series is Punnamada with loamy sand to sand texture
10	Alappuzha	The wetland soils did not show any change in texture in this area
11	Alappuzha	In garden lands the series is Punnamada with loamy sand to sand texture
12	Chennithala Thriperumthura	Sand and silt deposition found on river banks. Vetticode series with a silty clay texture changed to sandy loam on the banks.
13	Thiruvanvandur	Ayiroor series with a sandy clay loam texture revealed a clay loam texture as a result of the

		sediment deposition thereby decreasing the permeability .
14	Thiruvanvandur	In wet lands the exisiting series Muthur with a clay loam texture revealed an increase in clay content.
15	Thiruvanvandur	Water rose to about 1.5- 2m and all roads and houses were flooded. Sediment deposition noticed on river banks and approaching roads to a height of 0.5 m.
16	Thiruvanvandur	The depositions were more of silt and sand and the texture has changed to sandy loam. Banana dried up. Nutmeg dried up completely
17	Thiruvanvandur	Rice was severely affected which was washed off in the floods.
18	Pandanad	Water rose to above 2 m on both banks and flooded the whole panchayat. In garden lands, sediment deposition to a thickness of 5 cm was seen on the banks of river Pampa. In Ayroor soil series with a sandy clay loam texture, sand and silt depositional changes were noticed.
19	Pandanad	In wetland, Muthur soil series with clay loam texture revealed a silty clay texture due to clay and silt deposition.
20	Pandanad	Not much destruction to the standing crops except drying up of banana, in garden lands.
21	Mannar	Sediment deposition predominately of sand and silt was found to a thickness of about 30cm in pockets. The exisiting series Mannar has sand to loamy sand texture and hence sediment deposition has not brought about much changes to the original texture.
22	Puliyoor	The water lavel has risen to more than 2 m in the panchayat. The soil series is Muthur with clay loam texture. Due to clay and silt deposition the texture appeared to be silty clay. Damage to crops not noticed.
23	Ala	The areas adjacent to Achenkovil river and the canals were flooded to about 1-1.5m height. Adoor series with gravelly sandy clay surface texture shifted to clay loam texture because of silt deposition. Clay deposition also noticed
24	Ala	
25	Cheriyanad	On the river banks deposition is seen to a thickness of 1 cm only. The series existed is Adoor with a gravelly sandy clay surface texture Due to sediment deposition, the texture has changed to sandy loam. No damage to vegetation was seen.

26	Venmony	Water level rose to about 1 m and about 10-15 cm thick sediment deposition occurred which was removed. Textural changes noticed
27	Venmony	
28	Venmony	
29	Mulakuzha	No destruction to crops in the area. Sediment deposition noticed.
30	Chengannur municiplaity	Area worse affected during the floods. Water level rose to more than 3 m in and around Edanad and the area remained flooded for about a week. On the banks of river Pampa, at Arattukadavu, sediment deposition was found to a height of about 1.5 m which was cleared. Banana and Nutmeg were severely affected. Soil series Ayroor with a sandy clay loam texture exhibited a silty clay texture due to silt and clay deposition. In some areas texture remained the same.
31	Chengannur municiplaity	
32	Chengannur municipality	
33	Mavelikkara municipality	The town area was flooded for about a week and the water rose to a height of about 1 m. Not much sediment deposition was found in the area. In garden lands where the series was Palamel with a texture of gravelly clay loam, the texture got shifted to sandy clay loam.
34	Mavelikkara municipality	On river banks, Ayroor soil series with a sandy clay loam texture changed to silty clay. Crops like banana, ginger and turmeric dried up due to water stagnation. On the banks of river, water level rose to about 1 m during the flood. Banana crop was completely withered; there was not much damage to other crops.
35	Thazhakkara	
36	Thazhakkara	The garden lands under Palamel series with gravelly clay loam texture exhibited a sandy clay loam at certain pockets.
37	Nooranad	Water level rose to about 0.5 m near river banks and the resultant sediment deposition to a thickness of 10-15 cm was removed. The garden lands have Palamel series with gravelly clay loam texture which turned into sandy clay loam, due to flood.

CHEMICAL PROPERTIES

The soil samples collected from the sites were analysed for the chemical properties and the results obtained were compared with available soil data which are given below

Table 5.3.3

pH & Electrical Conductivity

Sample no	Panchayat	Before flood		After flood	
		pH	EC dSm^{-1}	pH	EC dSm^{-1}
1	Punnapra North	6.2	trace	5.96	0.19
2	Punnapra South	6.2	trace	6.1	0.23
3	Aryad	6.8	0.14	5.2	0.17
4	Muttar	5.3	0.68	4.52	1.09
5	Muttar	5.3	0.68	3.61	1.89
6	Mannancherry	5.9	0.4	5.48	0.3
7	Mannancherry	4.5	0.17	5.87	0.31
8	Mannancherry	5.9	0.4	6.04	0.29
9	Alappuzha	5.9	0.4	5.6	0.28
10	Alappuzha	4.5	0.17	4.67	0.22
11	Alappuzha	5.9	0.4	5	0.38
12	Chennithala Thriperumthura	4.6	0.08	5.29	0.29
13	Thiruvanvandur	4.9	2	5.9	0.15
14	Thiruvanvandur	5.1	trace	4.7	0.13
15	Thiruvanvandur	4.9	2	5.68	0.09
16	Thiruvanvandur	5.1	trace	5.01	0.07
17	Thiruvanvandur	4.9	2	5.29	0.16
18	Pandanad	4.9	2	5.74	0.64
19	Pandanad	5.1	trace	5.9	0.43
20	Pandanad	4.9	2	6.19	0.28
21	Mannar	5.6	trace	4.88	0.34
22	Puliyoor	5.1	trace	6.9	1.02
23	Ala	4.9	0.05	6.01	0.11
24	Ala	5.7	0.49	4.8	0.14
25	Cheriyanad	4.9	0.05	4.9	0.08
26	Venmony	4.9	2	4.39	0.62

27	Venmony	4.9	2	5.06	0.18
28	Venmony	4.9	2	4.78	0.16
29	Mulakuzha	4.9	0.05	6.81	0.24
30	Chengannur munciplaity	4.9	2	7.2	0.21
31	Chengannur munciplaity	4.9	2	6.9	0.24
32	Chengannur munciplaity	4.9	2	6.8	0.26
33	Mavelikkara muncipality	5.2	0.91	5.42	0.13
34	Mavelikkara muncipality	4.9	2	5.71	0.12
35	Thazhakkara	5.2	0.91	6.56	0.25
36	Thazhakkara	5.2	0.91	5.13	0.13
37	Nooranad	5.2	0.91	5.16	0.12

It is seen that irrespective of the agro ecological zonation, major number of samples analysed showed acidity values generally ranging from very strongly acidic to slightly acidic. In garden lands increase in acidity was noticed in some locations. This may be due to leaching of bases during intense rainfall. Except in some locations in Kuttanad, all other samples showed increase in pH, indicating decrease in acidity. Liming is recommended in areas having pH less than 5.5.The Electrical conductivity values are suitable for crop production in all locations.

Table 5.3.4

Macronutrients

Sample no.	Before flood			After flood		
	OC(%)	**P**(Kg/ha)	**K**(Kg/ha)	OC(%)	**P**(Kg/ha)	**K**(Kg/ha)
1	0.14	30.24	45.92	1.6	103.04	175.84
2	0.14	30.24	45.92	3	112	105.92
3	1.18	Medium to High	Low	1.88	13.44	87.36

4	1.1	3.36	164.64	1.4	6.72	125.44
5	1.1	3.36	164.64	2.8	4.48	156.8
6	0.43	*	*	1.8	8.96	81.76
7	1.2	4.48	161.28	1.2	100.8	100.8
8	0.43	*	*	0.6	87.36	95.2
9	0.43	*	*	4.8	22.4	297.92
10	1.2	4.48	161.28	0.92	8.96	88.64
11	0.43	*	*	4.6	6.72	232.96
12	0.22	*	*	0.36	6.72	58.24
13	0.76	188.16	210.56	1.8	4.48	212.8
14	1.47	*	Medium	2	6.72	118.72
15	0.76	188.16	210.56	1.4	4.48	192.64
16	1.47	*	Medium	4.8	8.96	257.6
17	0.76	188.16	210.56	0.62	44.8	88.48
18	0.76	188.16	210.56	1.63	29.12	141.12
19	1.47	*	Medium	2.88	78.4	168
20	0.76	188.16	210.56	1	67.2	200.48
21	0.64	119.84	107.52	0.91	22.4	113.12
22	1.47	*	Medium	3.12	45.92	364
23	0.05	69.44	253.12	1.2	11.2	176.96
24	1.47	*	Medium	4.8	13.44	86.24
25	0.05	69.44	253.12	1.92	40.32	181.44
26	0.76	188.16	210.56	2.18	7.96	129.92
27	0.76	188.16	210.56	2.36	6.72	63.84
28	0.76	188.16	210.56	1.63	6.72	150.08
29	0.05	69.44	253.12	0.8	51.52	165.76
30	0.76	188.16	210.56	1.27	4.48	153.44
31	0.76	188.16	210.56	1.09	78.4	204.96
32	0.76	188.16	210.56	1.38	4.48	170.24
33	1.13	88.48	187.04	2.36	4.48	71.68
34	0.76	188.16	210.56	2	89.6	301.28

35	1.13	88.48	187.04	1.45	78.4	306.88
36	1.13	88.48	187.04	1.45	6.72	171.36
37	1.13	88.48	187.04	2.9	4.48	164.64

* Values not available

On analyzing the results, it is seen that the organic carbon content of soils showed an increasing trend when compared to preflood values. Except one or two locations, all other samples showed medium to high organic carbon status.

In the case of coastal alluvial soils in majority of the locations showed an increase in available phosphorus but many locations in Kuttanad and midlands of Alappuzha showed comparatively lower values than preflood samples Available phosphorus is deficient in many locations which needs to be supplemented through fertilizers.

Available potassium content values showed no trend while comparing preflood and postflood value. But Kuttanad region and some locations in midlands showed decrease in available potassium after the post flood.

Table 5.3.5

Secondary nutrients(ppm)

Sample no.	Before flood(ppm)		After flood(ppm)	
	Ca	Mg	Ca	Mg
1	**	**	210.2	137.05
2	**	**	208.95	81.175
3	**	1890	228.7	166.05
4	**	110	77.7	81.58
5	**	110	72.7	59.00
6	**	**	149.1	129.05
7	598	290	77.95	77.125
8	**	**	45.45	105.3
9	**	**	67.5	62.63
10	598	290	140.15	68.88
11	**	**	140	118.05

12	140	227.75	75.25	119.98
13	**	960	153.25	18.95
14	**	225	358.85	32.7
15	**	960	245.3	54.025
16	**	225	170.25	55.425
17	**	960	79.95	82.125
18	**	960	55.2	98.475
19	**	225	119.75	172.1
20	**	960	254.3	80.175
21	50	810	82.45	90.7
22	**	225	305.4	41.85
23	**	74.9	165.3	39.95
24	**	225	172.25	18.33
25	**	74.9	40.5	140.15
26	**	960	72.9	77.75
27	**	960	60.35	148.45
28	**	960	53	51.375
29	**	74.9	137.45	42.95
30	**	960	43.9	62.6
31	**	960	119.6	37.4
32	**	960	76.4	119.53
33	**	49.5	78.95	131.73
34	**	960	73.8	89.5
35	**	49.5	37.45	53
36	**	49.5	67.75	126.7
37	**	49.5	61.85	61.93

** Values not available

Available calcium and Magnesium are deficient in majority of the post flood samples analysed

Table 5.3.6

Micronutrients

Sample no	Before flood					After flood				
	Fe ppm	**Mn** ppm	**Zn** ppm	**Cu** ppm	**B** ppm	**Fe** ppm	**Mn** ppm	**Zn** ppm	**Cu** ppm	**B** ppm
1	38.25	7.58	6.65	2.49	0.92	112.46	6.4	4.2	1.3	0.94
2	38.25	7.58	6.65	2.49	0.92	113.05	11.8	24.4	5.00	0.86
3	12.00	3.6	0.62	0.06	1.52	180.21	5.40	6.00	1.30	1.24
4	21.4	1.2	0.18	0.04	1.7	202.61	77.10	5.30	4.60	1.5
5	21.4	1.2	0.18	0.04	1.7	294.88	125.80	9.80	3.60	1.8
6	*	*	*	*	*	89.28	7.40	3.90	3.60	1.32
7	242.0	24.20	1.84	1.62	5.70	84.04	7.30	2.90	6.00	1.3
8	*	*	*	*	*	51.90	4.10	4.40	1.50	0.98
9	*	*	*	*	*	362.10	32.80	14.20	1.40	1.65
10	242.0	24.20	1.84	1.62	5.70	280.30	3.40	2.10	1.30	1.98
11	*	*	*	*	*	401.60	21.40	7.90	12.60	1.85
12	62.00	2.34	0.04	0.76	2.02	40.0	16.4	1.90	1.30	1.42
13	264	22	1.2	0.84	1.62	162.40	12.50	8.50	3.20	0.89
14	56.00	22.00	0.12	0.68	1.22	331.40	23.2	12.3	15.7	1.62
15	264	22	1.2	0.84	1.62	131.50	9.60	14.70	18.30	1.38
16	56.00	22.00	0.12	0.68	1.22	360.70	12.9	8.10	8.20	1.54
17	264	22	1.2	0.84	1.62	50.2	17.3	1.70	1.40	1.65
18	264	22	1.2	0.84	1.62	104.2	18.8	2.5	4.2	1.71
19	56.00	22.00	0.12	0.68	1.22	23.55	1.16	0.52	0.61	0.95
20	264	22	1.2	0.84	1.62	107.7	7.6	4.6	3.8	1.48
21	34.00	18.00	0.16	0.52	9.3	114.5	8.7	8.9	2.3	1.85
22	56.00	22.00	0.12	0.68	1.22	133.4	8.6	10.00	6.60	1.0
23	25.46	2.06	1.36	1.36	0.85	*	*	*	*	0.98
24	56.00	22.00	0.12	0.68	1.22	300.2	11.90	7.6	9.20	1.01
25	25.46	2.06	1.36	1.36	0.85	56.9	10.6	1.80	3.80	0.98
26	264	22	1.2	0.84	1.62	172.30	6.20	1.90	1.80	1.32

27	264	22	1.2	0.84	1.62	52.40	7.97	3.4	2.1	1.24
28	264	22	1.2	0.84	1.62	40.6	9.60	2.50	1.96	1.98
29	25.46	2.06	1.36	1.36	0.85	182.3	9.3	7.9	6.4	1.54
30	264	22	1.2	0.84	1.62	41.9	11.3	5.5	3.8	1.47
31	264	22	1.2	0.84	1.62	30.1	9.9	2.00	3.7	2.0
32	264	22	1.2	0.84	1.62	60.2	8.90	1.5	5.8	1.99
33	16.96	1.56	2.52	0.85	0.16	87.5	16.00	2.50	2.93	0.61
34	264	22	1.2	0.84	1.62	66.95	10.5	3.6	2.6	0.95
35	16.96	1.56	2.52	0.85	0.16	51	3.9	6.4	2.9	0.74
36	16.96	1.56	2.52	0.85	0.16	40.2	6.5	4.3	0.987	0.82
37	16.96	1.56	2.52	0.85	0.16	85.4	14.2	3.00	3.00	0.56

* Values not available

All the samples contain adequate level of micronutrients and there is no considerable changes in the post flood condition. But in some samples Micronutrients like iron and manganese are at toxic level.

The results of the study in Alappuzha district can be summarized as follows

- The study area confined to lowland coastal plain, Kuttanad basin, Midland laterite and valleys.
- In general, soil acidity decreased after flooding but in Kuttanad area, acidity increased in some locations. The electrical conductivity values are suitable for crop production. Liming is recommended for ensuring the availability of nutrients and improving soil structure in the afterflood scenario.
- Organic matter and Available potassium show medium to high rating in soils. Phosphorus deficiency is noticed.
- Available calcium and Magnesium are deficient in majority of the samples analysed
- Micronutrients are in adequate level for crop growth.
- No notable changes noticed as to landscape, slope or soil depth in affected areas
- Textural changes are widely noticed due to sand, silt or clay deposition. River banks had sand and silt deposits. Wetlands exhibited an increase in clay content where as garden lands had silt and sand deposits.

PATHANAMTHITTA

Total Geographic Area : 2,65,277 Ha

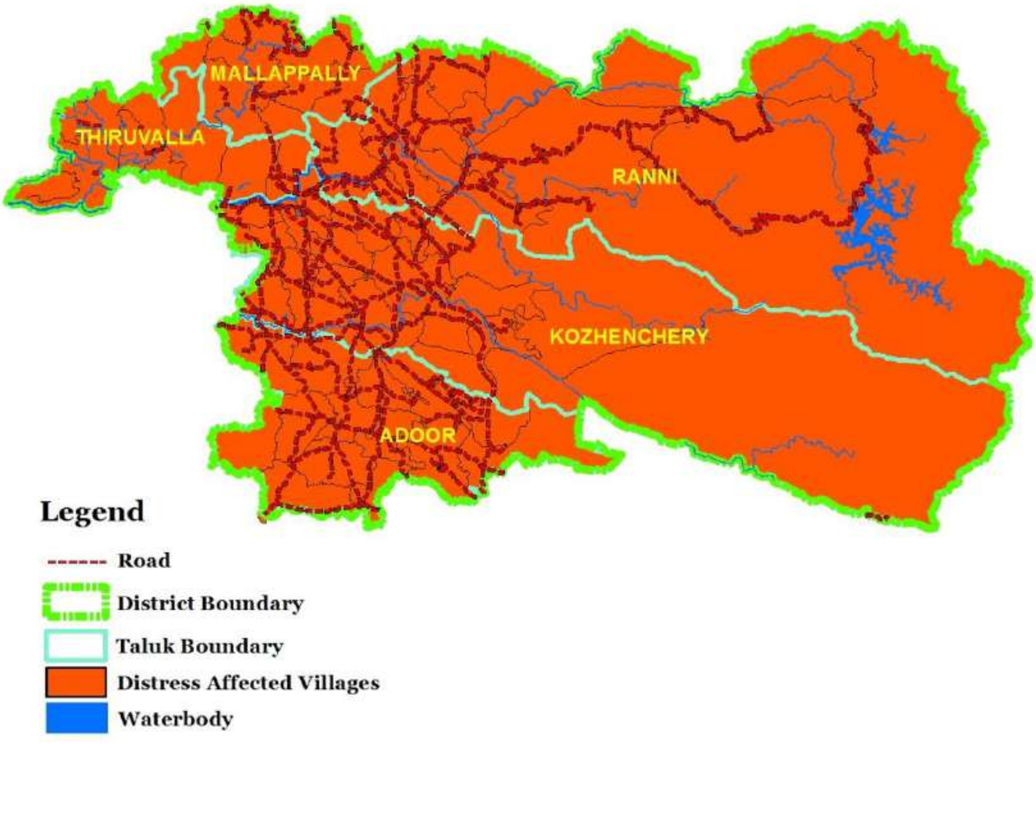
No. of Taluks : 6

No. of Villages : 70

RIVER BASINS

- *Achankovil*
- *Pamba*
- *Kallada*
- *Manimala*
- *Pallikkal thodu*

DISTRESS AFFECTED VILLAGES

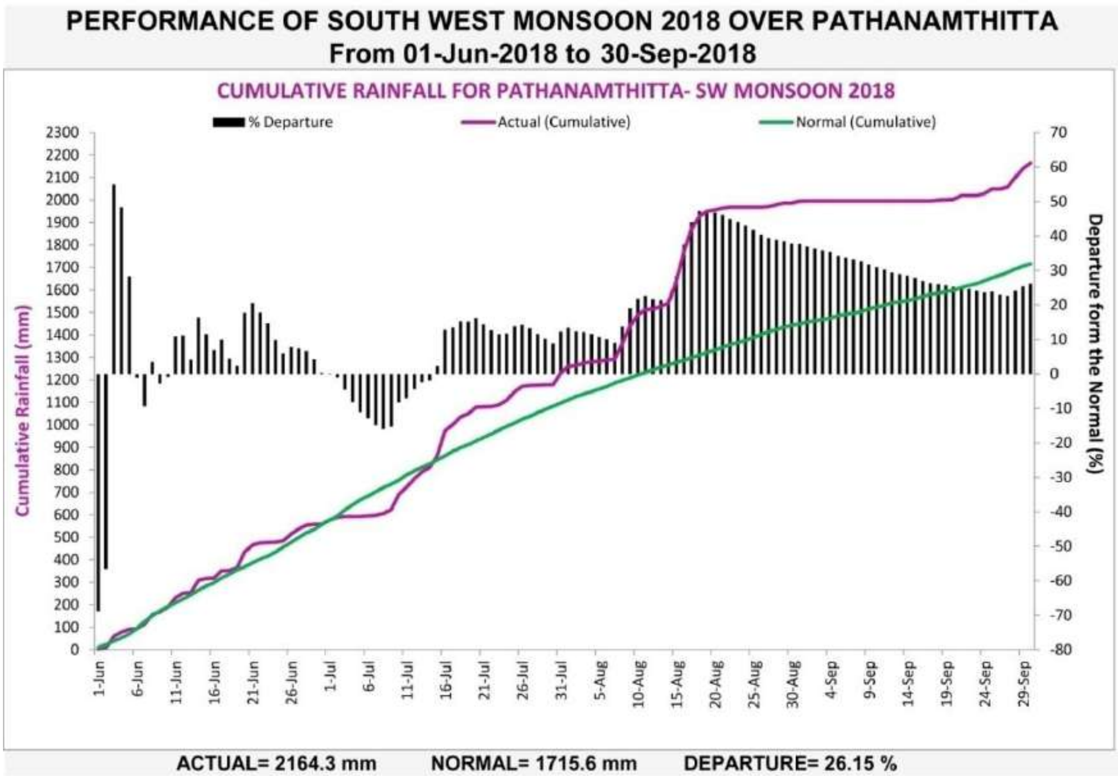


5.4. PATHANAMTHITTA

Pathanamthitta district is situated on the southeastern part of Kerala and extends over an area of 2,65,277 ha. The district lies between 9° 4' and 9° 28' north latitude and 76° 28' and 77° 17' east longitude. Major physiographic divisions of the district are Lowland, Midland, Mid upland, Upland and Highland. The district is mainly drained by Pamba,Achenkovil,Manimala, Kallada and Pallikkathodu rivers.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

From the rainfall pattern in the graph, it can be inferred that the district received 27% more rainfall than the normal during the southwest monsoon period of 2018. The torrential rains received from 5th August to 25th August aggravated the flood situation in the district



IMPACT OF DISTRESS IN THE DISTRICT

Pathanamthitta district was severely affected by the flood and landslide which occurred in August, 2018. Out of 53 panchayats, 18 panchayts were totally affected and 27 panchayats were partially affected. The total estimated loss is Rs. 1810 crores, of which 66.03 Crore is in agriculture sector and 16.89 Crore in Animal Husbandary sector. Three persons were killed in the natural calamity and 1,15,519 people had to be evacuated to relief camps. The unprecedented rainfall which occurred in the district 12th to 17th August forced the opening of Kakki, Kochupampa and Anathode dam to let out raging waters of Pampa and Manimala river which increased the water level up to 15 feet high in Ranni and Vadasserikkara and upto 10 to 13 feet high in Aranmula and Kozhenchery area situated on the banks of Pampa river. Water stagnation continued for 5-6 days in the entire flooded area with thick deposition of silt in Aranmula and villages of Thiruvalla Taluk. Deposition of sand up to 6-8 feet was observed along Pampa River bank in Ranni Taluk. The worstly affected areas in the district are Ranni, Vadasserikkara , Ranni Angadi ,Ranni Pazhavangadi, Ayroor, Thottappuzhassery, Cherukole, Kozhenchery, Mallappuzhassery, and Aranmula panchayat along the Pampa river Bank and Kadapra, Niranam, Peringara, Nedumpuram and Thiruvalla Muncipality area in Thiruvalla taluk which are drained by both Pampa and Manimala River. Vallikkode and Pramadam panchayats and Pandalam Muncipality were severely affected as Achankovil river overflowed from heavy rainfall as well as heavy water flow as a consequence of landslides.

The district also experienced severe landslide in Chittar Panchayat in Meenmutty and Valiyakulangara area due to heavy rain persisting for 4-5 days resulting in loss of human life as well as Agricultural crops. These are steeply sloping areas. Human interventions disturbing the slope stability has increased the vulnerability to erosion. Gneissic soils are observed in the area.

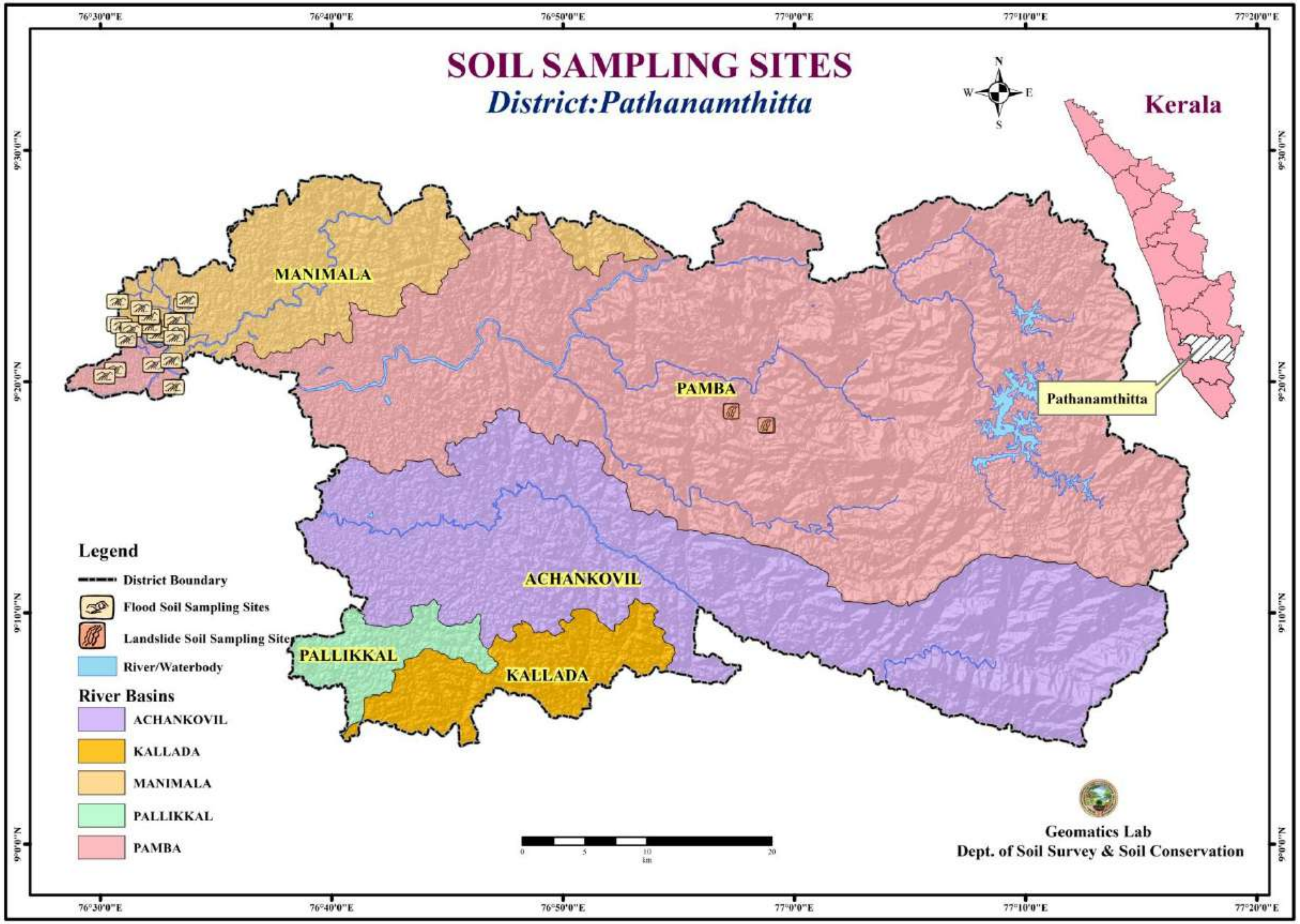
FIELD TRAVERSING AND SOIL SAMPLING

Field traversing was conducted in severely flood affected villages in Thiruvalla Taluk and Chittar Panchayat in Konni Taluk where severe landslide occurred. 23 Soil samples were collected from Nedumpuram, Peringara, Kadapra, Niranam villages and river banks of Manimala Ar and Pamba. The landslide areas were also traversed collecting 4 representative soil samples from Chittar panchayat. The sampling locations are given in Table below. The soil samples were analysed for interpreting the physico chemical and structural changes occurred in soil as a consequence of floods and landslides.

Table 5.4.1

Sampling locations

Sample code	*Latitude*	*Longitude*	*Flood/Landslide affected*
PTA/1	9° 22' 0.721" N	76° 32' 34.836" E	*Flood*
PTA/2	9° 22' 0.980" N	76° 32' 31.920" E	*Flood*
PTA/3	9° 22' 2.320" N	76° 32' 29.004" E	*Flood*
PTA/4	9° 22' 23.800" N	76° 32' 10.680" E	*Flood*
PTA/5	9° 22' 23.000" N	76° 32' 9.996" E	*Flood*
PTA/6	9° 22' 29.285" N	76° 30' 44.133" E	*Flood*
PTA/7	9° 22' 23.870" N	76° 30' 54.000" E	*Flood*
PTA/8	9° 22' 14.550" N	76° 31' 20.172" E	*Flood*
PTA/9	9° 22' 46.390" N	76° 32' 6.720" E	*Flood*
PTA/10	9° 22' 48.570" N	76° 32' 6.720" E	*Flood*
PTA/11	9° 23' 10.250" N	76° 31' 45.552" E	*Flood*
PTA/12	9° 23' 27.519" N	76° 30' 44.581" E	*Flood*
PTA/13	9° 21' 48.402" N	76° 31' 6.930" E	*Flood*
PTA/14	9° 20' 30.190" N	76° 30' 38.268" E	*Flood*
PTA/15	9° 20' 14.000" N	76° 30' 10.008" E	*Flood*
PTA/16	9° 22' 38.000" N	76° 33' 12.996" E	*Flood*
PTA/17	9° 22' 10.000" N	76° 33' 23.004" E	*Flood*
PTA/18	9° 21' 53.000" N	76° 33' 11.988" E	*Flood*
PTA/19	9° 23' 18.000" N	76° 33' 38.988" E	*Flood*
PTA/20	9° 23' 31.450" N	76° 33' 44.964" E	*Flood*
PTA/21	9° 20' 42.930" N	76° 32' 17.736" E	*Flood*
PTA/22	9° 20' 54.224" N	76° 33' 4.204" E	*Flood*
PTA/23	9° 19' 45.680" N	76° 33' 9.864" E	*Flood*
PTA/24	9° 18' 5.600" N	76° 58' 49.584" E	Landslide
PTA/25	9° 18' 7.850" N	76° 58' 45.588" E	Landslide
PTA/26	9° 18' 43.600" N	76° 57' 14.508" E	Landslide depositional zone
PTA/27	9° 18' 42.530" N	76° 57' 16.128" E	Landslide depositional zone


SOIL SAMPLING SITES
District:Pathanamthitta
Kerala
Pathanamthitta
MANIMALA
PAMBA
ACHANKOVIL
PALLIKKAL
KALLADA
Legend
District Boundary
Flood Soil Sampling Sites
Landslide Soil Sampling Site
River/Waterbody
River Basins
ACHANKOVIL
KALLADA
MANIMALA
PALLIKKAL
PAMBA
Geomatics Lab
Dept. of Soil Survey & Soil Conservation
76°30'0"E
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
77°20'0"E
9°30'0"N
9°20'0"N
9°10'0"N
9°0'0"N

CHANGES IN SOILS OF DISTRESS AFFECTED AREAS

LANDSCAPE AND PHYSIOGRAPHY

Large quantity of sand, silt and clay were seen deposited on the surface soils of the affected panchayats. The thickness of deposition varied from 2cm to 10cm. Soil crusting was also reported from these depositional areas. Study was carried out in 5 villages of Thiruvalla Taluk viz:Nedumpuram, Peringara, Kadapra, Niranam and Kavumbhagam. These are low land valley areas under upper Kuttanad with wide stretch of puncha paddy fields, except Kavumbhagam, which is a low land valley. A total of **23** soil samples were collected. Panchayat wise details are as follows.

NEDUMPURAM VILLAGE (Nedumpuram Panchayat**)**

Rivers- Pampa, Manimala

Nedumpuram soil series was the major soil series observed in the area. Silt deposition up to 3-5inches noticed in the area. The depth of silt deposition varied from area to area. 8 soil samples were collected from 4 locations in the village. Soil crusting was observed in many areas. Crops such as Banana and nutmeg withered up after flooding and with development of yellow colour. Nendran variety was the most affected while Poovan, Palyam kodan were not affected.

PERINGARA VILLAGE (Peringara Panchayat**)**

The panchayat is drained by both Pampa and Manimala river. Nedumpuram soil series was the major soil series observed in the area. 4 soil samples were collected. Organic matter content increased than that in available preflood soil data. Nutmeg and banana were affected the most. The depth of silt deposition varied from area to area ranging from 1cm to 10 cm thickness

NIRANAM VILLAGE (Niranam Panchayat**)**

The panchayat is drained by both Pampa and Manimala river. Nedumpuram soil series was the major soil series observed in the area.3 soil samples were collected. Organic matter content increased compared to preflood condition. Nutmeg and banana were affected the most. The depth of silt deposition varies from area to area and it ranges from 5 cm to 15 cm in thickness

KADAPRA VILLAGE (Kadapra Panchayat**)**

The panchayat is drained by both Pampa and Manimala river. Nedumpuram soil series was the major soil series observed in the area.3 soil samples were collected. The depth of silt deposition varies from area to area and it ranges from 15 cm to 25 cm in thickness.

KAVUMBHAGAM VILLAGE (Thiruvalla Muncipality**)**

The area is drained by streams which drain out to both Pampa and Manimala rivers. Nedumpuram soil series was the major soil series observed in the area.5 soil samples were collected. The depth of silt deposition was less and it ranges from 1 cm to 2 cm in thickness.

Sandy loam deposited in the area- with low organic matter and high pH.3.7

Deposited silt

Silt Deposit

Clay deposits

PHYSICAL PROPERTIES

The physical properties such as texture and sediment deposition of the soil samples collected from the flooded soils were analysed and compared with available data as given below.

Table 5.4.2

Pre and Post flood Soil texture

Sl No	Pre flood	Post Flood	Sediment thickness after flood (cm)
Nedumpuram panchayat			
PTA/1	Clay loam	Sandy clay loam	*2*
PTA/2	Clay loam	Sandy clay loam	*4*
PTA/3	Clay loam	Clay loam	*4*
PTA/4	Clay	Sandy loam	*4*
PTA/5	Clay loam	Silt loam	*4*
PTA/6	clay	Silt loam	*8*
PTA/7	Clay loam	Silt loam	*6*
PTA/8	Sandy clay loam	Silty clay loam	*10*
Peringara panchayat			
PTA/9	Clay loam	Sandy clay loam	*2*
PTA/10	Clay	Sandy clay loam	*10*
PTA/11	Clay loam	Sandy clay loam	*>1*
PTA/12	Clay loam	Sandy clay loam	*2*
Niranam panchayat			
PTA/13	Clay loam	Sandy clay loam	*10-15*
PTA/14	clay	sandy loam	*5*
PTA/15	*Clay loam*	sandy loam	*5*
Kavumbhagam panchayat			
PTA/16	Clay loam	Sandy clay loam	*3*
PTA/17	Clay loam	Sandy clay loam	*2*
PTA/18	clay	Sandy clay loam	*>1*
PTA/19	Clay loam	Sandy clay loam	-
PTA/20	Clay loam	Sandy loam	-

Kadapra panchayat			
PTA/21	Sandy Clay loam	Silt loam	*15-25*
PTA/22	Sandy Clay loam	Clay loam	*25*
PTA/23	Sandy Clay loam	Sandy clay loam	*15*

- It can be seen that in all villages except Kadapra there was a shift in texture in general, from *clay loam to sandy clay loam*.
- In Kadapra village due to increased silt % (15-25cm thick silt) and due to decrease in sand and Clay %, there was shift in texture from sandy clay loam to silt loam / clay loam.
- In Kavumbhagam village, there is increase in sand % and decrease in silt % which shifted the texture towards sandy clay loam from clay loam.
- In Peringara, sand % remained almost same in both period but there was increased clay content and decreased silt which caused a shift in texture towards sandy clay loam from clay loam.
- In Niranam panchayat, although sand % and clay % remained same in both period, there was increased silt % which finally caused a shift to sandy clay loam from clay loam.
- In Nedumpuram, although sand and clay % decreased, increased silt % caused a shift in texture from sandy clay loam from clay loam

CHEMICAL PROPERTIES

The chemical properties such as pH, EC, macro, secondary and micronutrients of the soil samples collected from the flood areas were analysed and compared with available data which are given below.

Table 5.4.3

pH and Electrical Conductivity

Sl. no	Location	pH	EC dSm^{-1}
Nedumpuram (Upper Kuttanad region)			
PTA/1	Podiyadi thodu	6.3	0.09
PTA/2	Pampa Link	6.2	0.12
PTA/3	Pampa Link	6.3	0.09
PTA/4	Vaikkathillam thodu	6.3	0.23

PTA/5	Pampa-Manimala link river	3.7	1.43
PTA/6	Pampa-Manimala link river	5.1	0.39
PTA/7	Pampa	3.7	0.63
PTA/8	Pampa-Manimala	3.6	1.04
	Mean	***5.15***	***0.50***
Peringara(Upper Kuttanad region)			
PTA/9	Pamba- Manimala river side	4.4	0.37
PTA/10	Pamba- Manimala river side	4.7	0.23
PTA/11	Pamba- Manimala river side	5.1	0.06
PTA/12	Pamba- Manimala river side	4.9	0.1
	Mean	***4.78***	***0.19***
Niranam(Upper Kuttanad region)			
PTA/13	Pamba- Manimala river side	4.6	0.26
PTA/14	Pamba- Manimala river side	5.4	0.22
PTA/15	Pamba- Manimala river side	5.1	0.14
	Mean	***5.03***	***0.21***
Kavumbhagam			
PTA/16	Ward 28	*5.5*	*0.08*
PTA/17	Ward 26	*5.4*	*0.48*
PTA/18	Ward 31	*5.7*	*0.32*
PTA/19	Ward 31	*4.3*	*0.79*
PTA/20	Ward 31	*6.4*	*0.17*
	Mean	***5.46***	***0.37***
Kadapra(Upper Kuttanad region)			
PTA/21	Ward 3	5.2	0.2
PTA/22	Ward 4	5.6	0.37
PTA/23	Ward 7	5.6	0.4
	Mean	***5.47***	***0.32***

Mean values for post flood and pre flood pH & EC for each village is compared below.

Comparison of Pre and Post flood pH & EC

Village	Preflood		Postflood	
	pH	EC	pH	EC
Nedumpuram	6.0	0.1	*5.15*	*0.5*
Peringara	4.5	0.01	*4.78*	*0.19*
Niranam	6.1	0.1	*5.03*	*0.21*
Kavumbhagam	6.3	0.1	*5.46*	*0.37*
Kadapra	5	0.09	5.47	0.32

In general, there is increased acidity in the post flood period. In Niranam and Kavumbhagam villages, the acidity increased from slightly acidic in the preflood period to strongly to very strongly acidic in the post flood period. There was no change in acidity in Kadapra and Peringara villages where the acidity remained very strongly to strongly acidic and very strongly acidic respectively, during both pre and post flood period. Decrease in acidity in post flood samples was noticed in Nedumpuram village where the acidity shifted from strongly acidic to medium acidic after floods. Except Nedumpuram, in other villages slight increase in EC values seen but it is within safe limit for crop production.

Table 5.4.4

Macronutrients

Sl. no	OC (%)	P kg/ha	K kg/ha
Nedumpuram			
PTA/1	*0.04*	*1.12*	*144.03*
PTA/2	*1.82*	*123.2*	*254.46*
PTA/3	*0.04*	*15.68*	*165.54*
PTA/4	*1.23*	*151.2*	*203.28*
PTA/5	*1.78*	*10.08*	*131.26*
PTA/6	*3.26*	*1.12*	*210.78*
PTA/7	*0.17*	*1.12*	*117.71*
PTA/8	*0.04*	*3.36*	*171.47*
Mean	***1.05***	***38.36***	***174.8***
Peringara			
PTA/9	2.42	180.32	244.27
PTA/10	4.71	22.4	18.14
PTA/11	1.06	215.04	77.06
PTA/12	0.85	21.28	114.46
Mean	***2.25***	***109.76***	***113.48***
Niranam			
PTA/13	2.37	40.32	102.70

PTA/14	1.57	92.96	185.47
PTA/15	0.38	2.24	102.26
Mean	***1.44***	***45.17***	***130.14***
Kavumbhagam			
PTA/16	*0.81*	*197.1*	*196.56*
PTA/17	*2.29*	*182.56*	*303.30*
PTA/18	*3.77*	*126.56*	*290.64*
PTA/19	*4.54*	*7.84*	*172.70*
PTA/20	*4.15*	*14.56*	*48.72*
Mean	***3.11***	***105.72***	***202.38***
Kadapra			
PTA/21	0.04	17.92	86.8
PTA/22	0.47	11.2	109.31
PTA/23	1.40	5.6	178.3
Mean	***0.63***	***11.57***	***124.80***

Mean values for postflood and preflood OC, P & K for each village is compared below

Comparison of Pre and Post flood OC,P&K

Village	Preflood			Postflood		
	OC(%)	P kg/ha	K kg/ha	OC(%)	P kg/ha	K kg/ha
Nedumpuram	1.07	34.5	168	1.05	38.36	174.8
Peringara	0.98	33	511.2	2.25	109.76	113.48
Niranam	1.17	34.5	296	1.44	45.17	130.14
Kavumbhagam	1.63	34.5	50.4	3.11	105.7	202.38
Kadapra	1.58	34.5	291	0.63	11.57	124.80

The organic carbon content remained medium in Nedumpuram and Niranam villages and high in Kavumbhagam village in both pre and post flood period. In Kadapra panchayat the organic carbon content decreased from high to medium and in Peringara, it increased from medium to high.

The phosphorous content remained high in Nedumpuram ,Peringara, Kavumbhagam and Niranam villages in both pre and post flood period. Only in Kadapra Panchayat there was a decreasing trend from High to Medium after floods.

There was a decrease in Potassium content from high to low in Peringara and from high to medium in Niranam and Kadapra, and low to medium in Kavumbhagam. It remained medium in Nedumpuram in both periods.

Table 5.4.5

Secondary & Micronutrients

The secondary and micronutrient status of post flood samples are presented below.

Sample no	Ca ppm	Mg ppm	S ppm	Zn ppm	Fe ppm	Cu ppm	Mn ppm	B ppm
Nedumpuram								
PTA/1	*1003.0*	*139.58*	*14.01*	*3.78*	*32.62*	*3.52*	*14.78*	*1.01*
PTA/2	*627.90*	*170.35*	*22.52*	*5.46*	*48.8*	*5.13*	*20.19*	*1.12*
PTA/3	*635.4*	*90.55*	*33.87*	*10.56*	*172.78*	*4.03*	*22.56*	*1.19*
PTA/4	*1119.15*	*226.3*	*40.80*	*11.46*	*154.2*	*8.42*	*56.2*	*1.09*
PTA/5	*896.35*	*439.75*	*44.27*	*8.41*	*385.63*	*3.01*	*82.52*	*1.87*
PTA/6	*1219*	*355.9*	*237.92*	*5.46*	*203.15*	*6.2*	*45.1*	*0.94*
PTA/7	*479.9*	*271.55*	*128.63*	*3.21*	*345.78*	*5.11*	*53.31*	*1.82*
PTA/8	*713.9*	*435.7*	*263.32*	*4.20*	*120.05*	*8.41*	*15.42*	*1.68*
Mean	**836.82**	**266.21**	**101.04**	**7.06**	**168.01**	**5.27**	**33.07**	**1.34**
Preflood data	**NA**	**NA**	10.43	22.0	2.66	8.0	15.0	1.08
Peringara								
PTA/9	875.45	170.93	36.71	2.72	206.34	3.46	75.64	1.61
PTA/10	732.55	213.93	422.77	14.61	301.66	13.75	89.78	1.21
PTA/11	825.45	196.93	40.80	4.81	264.68	6.13	64.79	0.41
PTA/12	299.80	106.48	70.11	3.16	190.32	5.31	59.61	0.53
Mean	**683.31**	**172.07**	**142.58**	**6.33**	**240.75**	**7.16**	**72.46**	**0.94**
Preflood data	**NA**	**NA**	**13.0**	**4.09**	**85.0**	**2.0**	**91.0**	**0.66**
Niranam								
PTA/13	508.70	174.35	274.64	11.46	289.83	14.48	54.29	1.06
PTA/14	569.20	202.18	28.83	5.67	167.39	6.08	53.06	1.28
PTA/15	401.30	90.00	16.22	4.45	333.2	6.25	40.93	0.99
Mean	**493.06**	**155.51**	**142.58**	**6.33**	**240.75**	**7.16**	**72.46**	**0.94**
Preflood data	**NA**	**NA**	**8.258**	**11.96**	**100.31**	**4.5**	**13.9**	**0.27**
Kavumbhagam								
PTA/16	917.6	252.45	35.13	21.56	123.5	6.13	9.13	1.49
PTA/17	1320.9	293.5	16.22	8.46	59.46	4.89	19.5	1.38
PTA/18	459.7	142.45	22.52	5.49	120.06	6.42	12.45	0.88
PTA/19	816.5	132.65	185.62	8.04	44.64	5.12	10.79	0.98
PTA/20	933.4	88.29	35.13	21.56	123.5	6.13	9.13	1.49
Mean	**889.62**	**181.87**	**16.22**	**8.46**	**59.46**	**4.89**	**19.5**	**1.38**

Preflood data	**NA**	**NA**	9.78	3.0	100.0	6.0	30.0	0.63
Kadapra								
PTA/21	849.15	284.93	22.52	5.49	120.06	6.42	12.45	0.88
PTA/22	850.90	156.40	185.62	8.04	44.64	5.12	10.79	0.98
PTA/23	966.30	441.98	57.19	5.81	89.62	3.12	13.2	1.71
Mean	**888.78**	**294.44**	**63.34**	**9.87**	**87.45**	**5.13**	**12.41**	**1.28**
Preflood data	**NA**	**NA**	**7.84**	**42.0**	**120.0**	**23.0**	**110.0**	**0.126**

Calcium and Magnesium are secondary nutrients. In Peringara Panchayat, 20% of the samples were deficient in Calcium and 40% in Magnesium. All the micronutrients are available in adequate quantity.

In Nedumpuram Panchayat around 12% of the samples showed deficiency of Calcium. Deficiency of Magnesium was noticed in around 25% area in Nedumpuram and Kavumbhagam village.

Micronutrients are available in sufficient quantity in all villages in post flood period which may be due to increased organic matter as a consequence of silt deposition. In Nedumpuram and Peringara, the content of all micronutrients remained high in pre and post flood period. In Niranam, Kadapra and Kavumbhagam villages, the content of Available S and Av B which was either adequate or deficient in pre flood period, showed an increasing trend and was high in post flood period.

LANDSLIDES AND CONSEQUENT CHANGES

Chittar panchayath located in eastern part of the district has been affected by the recent landslides and land slips due to intensive rainfall and changes in the soil moisture level. The area near Vayyattupuzha, Valiaya Kulangara valley has undergone a massive land slide. The Meenmutty area of the panchayath was severely affected resulting in human casualities, loss of agricultural land and houses.

General Observation

Land slide occurred in between the **valley of Valiya Kulangara and Cheriya Kulangara area of Vayyattupuzha, Chittar.**

The top soil of the area had lesser clay content with loamy texture having non elastic, non adhesive nature , with loose boulders in the profile. Lower side of profile is more elastic and more plastic than the upper area due to increased clay content. Due to continuous heavy rain fall, the soil got saturated with water, resulting in increased pore pressure,probably leading to land sliding.

Valiyakulangara Landslide area- site characteristics and inference

- The depth of native soil is 75 to 100cm, slope is 25-33% with gneissic parent material and elevation of area is 216 m
- ***Site details -***

  1) N 9^0 18' 5.6", E 76^0 58' 49.6" 2) N 9^0 18' 7.85", E 76^0 58' 45.6"

  Survey number – 492/4,493/14,497/4
- All top soil eroded revealing the basic parent material underneath. The materials deposited has to be excavated to take up further agricultural activity in the area. The deposited soil had a high proportion of boulders which make agricultural operations difficult. Covering the top soil with grasses like CO-3 or Hybrid Napier is recommended to protect soil and to decrease vulnerability to erosion.
- Entire top soil lost, weathered parent materials seen scattered throughout the way to landslide site.
- Width of soil loss - 30 meters
- Texture – clay loam with gneissic boulders
- Mica, feldspar, Gneissic minerals are distributed throughout the flow area of land slide.
- **Chittar series** (soil series present in the area.)
- ***Texture*** and slope – **clay loam,** with G slope
- Land use- Rubber, banana
- Agricultural area loss**:** Up to 0.5 ha area was lost due to land slide.

Meenmutty Landslide area- site characteristics and inference

Site details –

N 9^0 18' 43.6", E 76^0 57'14.5", N 9^0 18'42.53" ,E 76^0 57'16.12"

General elevation - 120 meters

- Very Severe land slide occurred in the area and more than *75% of the B horizon lost.*

- Eroded and slided soils are seen scattered on the road side. General texture is *sandy loam* (eroded soils of stream bottom). Gneissic boulders and sandy soils seen along the road sides and near by area.
- Gneissic boulders of various sizes are seen distributed along the eroded areas.
- Slope of area is 15-25 %
- More than 5 ha land lost due to severe landslides in this area.

SAMPLING LOCATIONS

The landslide affected areas were traversed and 4 representative samples each from Valiyakulangara valley and Meenmutty were collected and analysed for texture, chemical characteristics which are given below.

Table 5.4.6
Soil texture

Sample no	Geo cordinates	Pre flood	Post flood			
		Texture	Sand(%)	Silt (%)	Clay(%)	Texture
	Valiya kulangara valley (land slide edge)					
24	*N.9 °18'5.6''* *E.76°58' 49.6''*	Clay loam	45.86	48.44	5.70	Sandy clay
	Valiya kulangara valley (Area adjacent to landslide)					
25	*N.9° 18'7.85"* *E.76°58' 45.6''*	Clay loam	47.31	29.29	23.40	Sandy clay loam
	Meenmutty area (Samples collected from soil deposited on road side)					
26	*N.9° 18' 43.6"* *E.76°57'14.5"*	Clay loam	57.31	12.43	30.26	Sandy loam
	Meenmutty area (samples collected from stream channel)					
27	*N 9°18'42.53"* *E 76°57'16.12"*	Clay loam	21.35	68.89	9.76	clay

It can be seen that in Valiyakulangara area there was a shift in texture from Clay loam to Sandy clay and sandy clay loam due to increase in sand content after landslide. This will obviously decrease the water holding capacity. In Meenmutty area the soil deposited o*n roadside* after landslide showed increased sand content where as the soil deposited in the stream channel showed increased clay content .

Table 5.4.7

pH, EC and macronutrients

Sample no	Geo cordinates	pH	EC dSm^{-1}	OC %	P kg/ha	K kg/ha
	Valiya kulangara valley (land slide edge)					
24	*N.9 °18'5.6''* *E.76°58' 49.6''*	4.6	0.08	1.78	1.12	223.10
	Valiya kulangara valley (Area adjacent to landslide)					
25	*N.9° 18'7.85"* *E.76°58' 45.6''*	5.1	0.03	1.36	1.12	327.94
	Mean	4.85	0.06	1.57	1.12	275.52
Preflood	*Mean*	6.3	0.1	1.05	23.46	33.6
	Meenmutty area (Samples collected from soil deposited on road side)					
26	*N.9° 18' 43.6"* *E.76°57'14.5"*	5.3	0.03	0.21	13.44	63.50
	Meenmutty area (samples collected from stream channel)					

27	*N 9°18'42.53"* *E 76°57'16.12"*	4.8	0.02	1.02	1.12	329.50
	Mean	5.05	0.03	0.62	7.28	196.5
Preflood	Mean	5.1	0.1	1.5	6.4	2.58

It can be inferred that the soil continued to be strongly to very strongly acidic in Meenmutty area in post landslide period whereas in Valiyakulangara the acidity increased from slightly acidic to very strongly acidic. Application of lime is very essential to improve soil condition.

In the case of Nitrogen content there was a shift from Medium to high in valiyakulangara and from High to Medium in Meenmutty area.

The phosphorus content was low in post landslide period in both areas and there was decreasing trend.

The Potassium content showed an increasing trend from Low to High in Valiyakulangara and low to medium in Meenmutty area.

Table 5.4.8

Secondary and Micronutrients

Sample no	Secondary nutrients (ppm)			Micronutrients (ppm)				
	Av Calcium	Av Magnesium	Avail. Sulphur	Fe	Mn	Zn	Cu	B
Valiya kulangara area (Land slided area)								
24	*562.75*	*52.30*	54.51	90.52	10.03	2.655	4.08	0.58
Valiya kulangara area (Area adjacent to landslide)								
25	*589.80*	*62.08*	45.53	99.64	10.32	3.08	3.64	0.67
Mean	*576.27*	*57.19*	49.92	95.08	10.18	2.87	3.86	0.63
Pre flood	*NA*	*97.5*	57.81	77.64	8.27	2.85	4.04	0.84
Meenmutty area (Samples collected from soil deposited on road side)								
26	317.6	55.3	15.27	62.34	9.46	3.14	4.19	0.70
Meenmutty area (samples collected from stream channel)								
27	284.7	66.2	135.66	44.89	3.00	2.85	3.59	1.16
Mean	301.15	60.75	75.47	39.45	6.23	2.99	3.89	0.93
Pre flood	NA	97.5	0.86	11.24	22.38	1.785	5.29	0.20

It can be seen that the content of Calcium is high and the content of Magnesium is low in the post landslide period. Although the content of Magnesium was low in pre landslide samples, the value has still decreased in both Valiyakulangara and Meenmutty area. This should be rectified by application of required quantity of Magnesium Sulphate or Dolomite. Magnesium deficiency adversely affect major crops of the area like Coconut, Nendran banana and Rubber. All the micronutrients are available in sufficient quantity in land slide affected areas. The only variation noticed was the increasing trend in Boron and Sulphur in Meenmutty area from Deficient to adequate/High.

SOIL SERIES IN THE LANDSLIDE AREA

CHITTAR SERIES

Soils of Chittar series are moderately deep to deep, well drained with moderately slow permeability. These soils are developed on gneiss and occur on moderately steep to very steep slopes. Surface layers have dark reddish brown to yellowish red, gravelly sandy clay loam to gravelly clay, neutral soils and subsurface soils are reddish brown to yellowish red, slightly acidic, with texture gravelly silty loam to gravelly clay. The high amount of gravel along with reduced soil depth reduces the effective soil volume for the crop reduces moisture holding capacity affecting crop production. The soils are susceptible to erosion. Cultivated with coconut, pepper, tapioca etc.

Results of the study in Pathanamthitta district can be summarized below.

- Textural differences were noticed in flooded wetlands
- Soil acidity decreased after flood and electrical conductivity values are satisfactory for crop production .Acidity ranges from strongly to very strongly acidic in post flood samples
- Organic carbon and available phosphorus showed increase while available potassium showed decrease in post flood samples
- The content of Calcium and Magnesium and sulphur are high in all villages in Thiruvalla Taluk in post flood period.
- Micronutrients are available in sufficient quantity in all villages in post flood period
- Mg deficiency is widespread in landslide affected Chittar Soils and observed in some pockets in flood affected panchayats of Thiruvalla Taluk.

KOTTAYAM

Total Geographic Area : 2,20,442 Ha

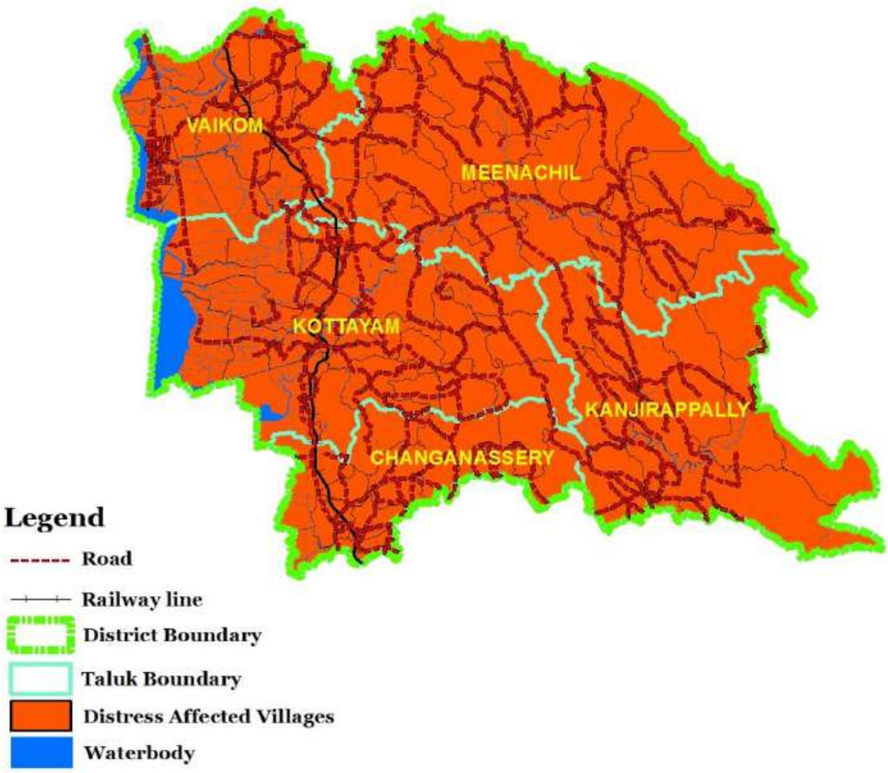
No. of Taluks : 5

No. of Villages : 100

RIVER BASINS

- *Meenachil*
- *Pamba*
- *Muvattupuzha*
- *Manimala*

DISTRESS AFFECTED VILLAGES



5.5.KOTTAYAM DISTRICT

Kottayam district is situated in the southern part of Kerala state between Idukki district in the east, Alappuzha district in the west, Ernakulam district in the north and Pathanamthitta district in the south. It extends between 9°23' and 9°52' north latitude and 76°21' and 77°east longitude. The district comprises of five taluks, viz. Kottayam, Changanacherry, Vaikom, Meenachil and Kanjirapally contributing an area of 2,20,442 ha.

Physiography

Physiographically the area is divided into five natural divisions, viz; the lowland bordering vembanad lake on the west, the midland consisting of undulating area east of the lowland, the midupland consisting of area between midland and upland and the upland as a narrow belt between midupland and highland and high lands on the extreme east.The elevation ranges from below mean sea level lands towards the extreme western portion of Kottayam and Changanassery taluks to 1195m above MSL at Kurisumala of Teekoy panchayath.

Drainage

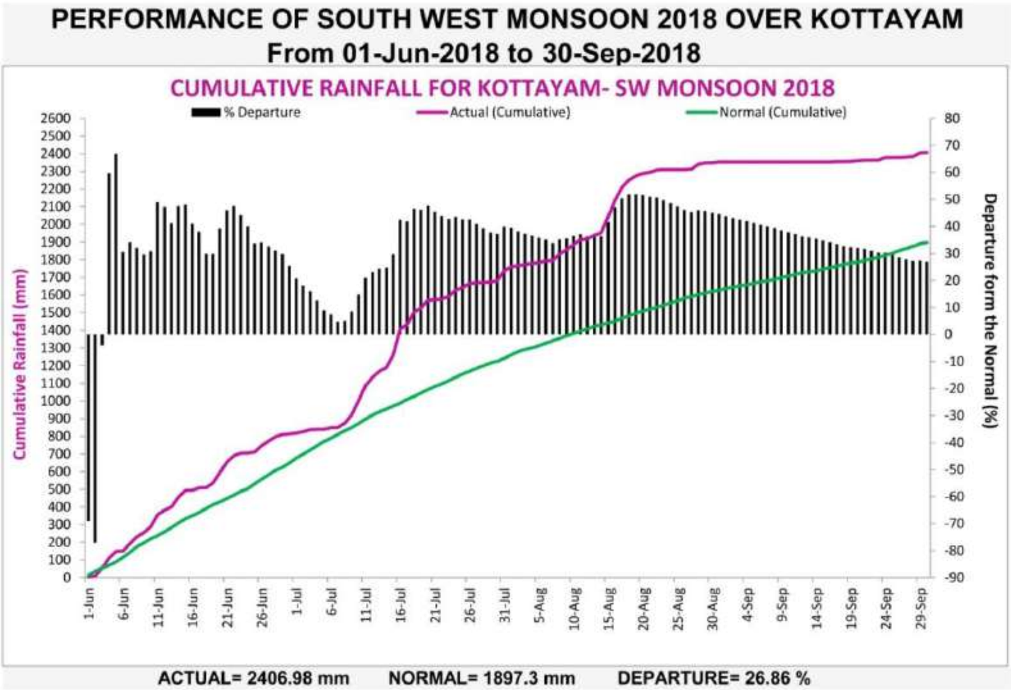
The district is mainly drained by Meenachil, Pamba, Muvattupuzha and Manimala rivers of which major part of the district is under Meenachil river basin. The Meenachil river formed by several streams originates from western ghats and flows through Meenachil, Vaikom and Kottayam Taluks and drains into the Vembanad lake. The total length of the river is about 67.62 Km with a catchment of 1272sq. km.

The Manimala river flows through Kanjirappilly and Changanacherry taluks and drains into Vembanad lake after flowing through Pathanamthitta and Alapuzha districts. The total length of the river is about 91.77km with a catchment of 847sq. km.

The Moovattupuzha river enter Kottayam district at Velloor panchayath of Vaikom Taluk, flows westerly and drains to Vembanad lake.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

The heavy and incessant south west monsoon rains flooded the low land portions twice during this year. Kottayam receives 50% more rainfall than the normal rainfall received from June to mid August wreaked flooding in lowland and landslides in midupland and highland. From the graph it can be inferred that the rainfall in the district is much higher than normal from the very beginning of Southwest monsoon.



IMPACT OF DISTRESS IN THE DISTRICT

Almost 80% of the area of the district is affected by either flood or landslides. Out of 100 villages, 68 are flood affected and 6 are landslide affected. Kottayam, Chanaganassery and Vaikom taluks are affected by floods while the major portion of Meenachil and Kanjirappilly taluks are affected by landslides.

It is estimated that almost 1500 ha of soil is degraded which needs to be rejuvenated for regaining soil fertility and structure. Large gullies are formed of size 300m X 2 m X 1.2m in the severely affected areas of the miduplands and uplands of the panchayat. Moreover these areas are classified under landslide and landslip prone areas which had a record of landslides earlier.

Erattupettah and Kanjirappally blocks are mostly affected by landslides, whereas flood affected blocks are Pala, Madappally, Ettumanoor and Pallom. The flood was due to the overflowing of the Meenachil river from heavy rains as well as landslides in Erattaupetta and Thekoy Panchayats. In Pala Block, the flood affected Panchayaths are Mutholi and Pala. In these Panchayats, the crops under the low-lying areas were damaged mostly. Aymanam Panchayat in Ettumanoor block was also flood affected and tuber crops loss was recorded. In this area, the major crops are rice and banana.

FIELD TRAVERSING AND SOIL SAMPLING

Field traversing of the affected area was carried out to assess the soil loss due to landslides and heavy rain and changes in the physical and chemical properties due to the subsequent floods in the affected areas. It also intends to find out any man made activities has aggravated the conditions for landslides especially in highland areas and also to suggest possible measures for recovering the soil fertility and better management practices. Soil samples were collected randomly from the affected areas based on general observations.

43 soil samples were collected from the paddy fields of 4 representative panchayats of Kottayam and Vaikom Taluks where land was completely submerged for many days.

The flood water intrusion and reversion was fast in midlands with less chance for siltation. Hence drastic changes in soil fertility may not be there due to the occurrence of flood.The midlands are mostly comprised of lateritic soil types . Soil sampling was not done in midland area

Six Surface soil samples were collected from the land slide affected areas of midup land and highland where severe land degradation occurred due to rain, landslides and land slipping etc. The samples were collected at a depth of 15-30cm from the surface.

Surface samples collected were analysed for various physico-chemical properties and the results were compared with that of preflood samples of the same area.

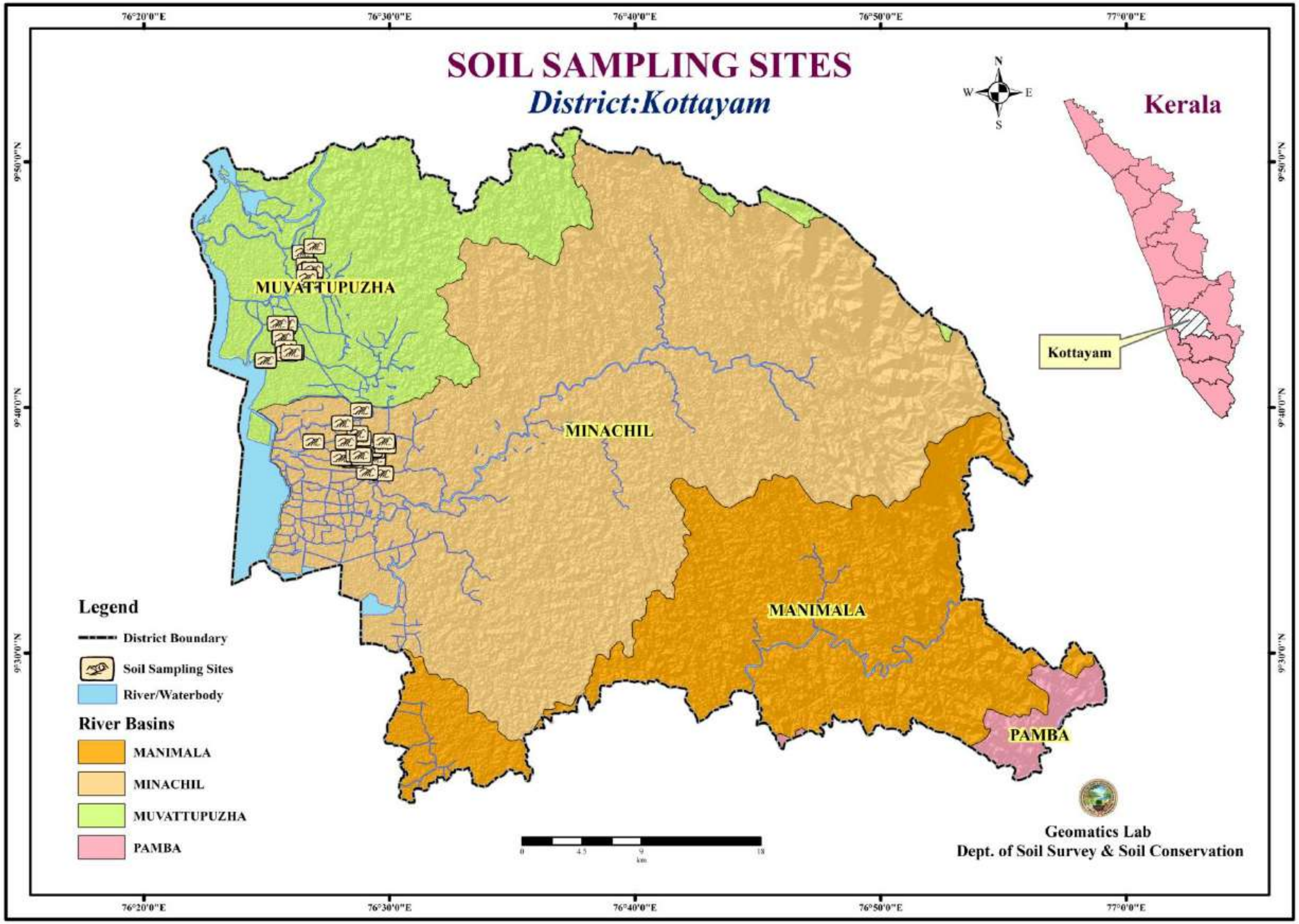
The details of samples collected from flooded areas are as follows

Table 5.5.1

Sampling locations of flooded area

Sample code	Latitude	Longtitude
Arpookkara Panchayat		
KTM/FL/1	9° 41' 54.7"	76° 24' 57.2"
KTM/FL/2	9° 37' 56.0"	76° 29' 25.5"
KTM/FL/3	9° 38' 15.6"	76° 29' 24.5"
KTM/FL/4	9° 38'18.2"	76°.29' 17.3"
KTM/FL/5	9° 38'37.6"	76° 26' 55.5"
KTM/FL/6	9° 38' 44.9"	76° 28' 50.0"

KTM/FL/7	9° 39' 53.8"	76° 28' 51.7"
KTM/FL/8	9° 38' 57.6"	76° 28' 42.7"
KTM/FL/9	9° 39' 22.5"	76° 28' 5.8"
KTM/FL/10	9° 38' 27.2"	76° 29' 50.6"
KTM/FL/11	9° 38' 38.3"	76° 29' 47.9"
Aymanam Panchayat		
KTM/FL/12	9° 37'19.2"	76° 29' 44.2"
KTM/FL/13	9° 37' 22.8"	76° 29' 06.9"
KTM/FL/14	9° 37' 51.9"	76° 28' 32.2"
KTM/FL/15	9° 37''55.9"	76° 28' 19.9"
KTM/FL/16	9° 37' 57 .2"	76° 28' 03.2"
KTM/FL/17	9° 38' 04.9"	76° 28' 40.4"
KTM/FL/18	9° 37' 57.1"	76° 28' 53.9"
KTM/FL/19		
KTM/FL/20	9° 38' 4.2"	76° 28' 50.0"
KTM/FL/21	9° 38' 36.2"	76°.28' 14.5"
Thalayazham Panchayat		
KTM/FL/22	9° 43' 17.7"	76° 25' 43.1"
KTM/FL/23	9° 43' 18.7"	76° 25' 45.6"
KTM/FL/24	9° 43'22.3"	76° 25' 39.7"
KTM/FL/25	9° 43' 24.8"	76° 25' 49.2"
KTM/FL/26	9° 43' 25.5"	76° 25' 28.5"
KTM/FL/27	9° 42' 52.3"	76° 25' 39.3"
KTM/FL/28	9° 42' 51.7"	76° 25' 40.3"
KTM/FL/29	9° 42' 26.8"	76° 25' 47.4"
KTM/FL/30	9° 42' 11.9"	76° 25' 50.1"
KTM/FL/31	9° 42' 15.6"	76° 26' 05.9"
KTM/FL/32	9° 42' 15.1"	76°.26' 01.4"
KTM/FL/33	9° 41' 55.8"	76° 24' 58.4"
Thalayolapparambu Panchayat		
KTM/FL/34	9° 46' 19.8"	76° 26' 28.9"
KTM/FL/35	9° 45' 48.5"	76° 26' 38.9"
KTM/FL/36	9° 45' 48.5"	76 26' 38.8"
KTM/FL/37	9° 45' 33.4"	76° 26' 42.7"
KTM/FL/38	9° 45' 33.6"	76° 26 53.2"
KTM/FL/39	9° 45' 37.5"	76° 26' 53.2"
KTM/FL/40	9° 45' 12.4"	76° 26' 39.9"
KTM/FL/41	9° 45'18.2"	76° 26' 38.9"
KTM/FL/42	9° 46' 34.3"	76° 26' 58.3"
KTM/FL/43	9° 46' 34.3"	76° 26' 58.3"


SOIL SAMPLING SITES
District:Kottayam
Kerala
Kottayam
N
S
E
W
MUVATTUPUZHA
MINACHIL
MANIMALA
PAMBA
Legend
District Boundary
Soil Sampling Sites
River/Waterbody
River Basins
MANIMALA
MINACHIL
MUVATTUPUZHA
PAMBA
Geomatics Lab
Dept. of Soil Survey & Soil Conservation

CHANGES IN SOILS OF THE DISTRESS AFFECTED AREAS

LANDSCAPE AND PHYSIOGRAPHY

No notable changes as noticed to the landscape, slope or soil depth in the affected areas and their characteristics are given below.

Silt deposition

The soil eroded from uplands reached the drains below and get deposited on the banks of Meenachil and Manimalyar. It is reported that almost the entire length of the river bed have silt deposition. Some wells in flooded panchayath have silt and waste deposition upto 2 m . The riverbanks were affected with severe erosion and still there is the threat of sliding of banks. In the midlands there is very less siltation.

PHYSICAL PROPERTIES

The changes in physical properties such as texture of soils encountered by comparing the available soil data with the post flooded site characteristics and is given in the table below.

Table 5.5.2

Soil Texture

Sample code	Total Sand %	Clay %	Silt %	Post flood Texture	Preflood - Texture
1.Arpookkara Panchayat					
KTM/FL/1	33.73	27.38	38.88	Clay loam	Clay loam
KTM/FL/2	23.96	39.37	36.67	Clay loam	Clay loam
KTM/FL/3	29.98	5.79	64.24	Silt loam	Sandy clay loam
KTM/FL/4	35.63	6.25	58.12	Silt loam	Sandy clay loam
KTM/FL/5	26.23	7.15	58.12	Silt loam	Sandy clay loam
KTM/FL/6	27.23	6.25	66.62	Silt loam	Sandy clay loam
KTM/FL/7	30.25	5.25	66.52	Silt loam	Sandy clay loam
KTM/FL/8	32.15	6.15	64.70	Silt loam	Sandy clay loam
KTM/FL/9	21.44	26.01	61.70	Silt loam	Sandy clay loam
KTM/FL/10	14.00	5.07	80.93	Silt	Sandy clay loam
KTM/FL/11	27.40	22.10	50.50	Silt	Sandy clay loam
2. Aymanam Panchayat					
KTM/FL/12	18.23	33.25	48.52	Silty clay loam	Silty clay loam
KTM/FL/13	16.49	39.26	44.25	Silty clay loam	Silty clay loam
KTM/FL/14	22.70	46.08	31.22	Clay	Silty clay loam
KTM/FL/15	15.99	43.81	40.20	Silt clay	Silty clay loam
KTM/FL/16	12.42	40.73	46.84	Silt clay	Silty clay loam

KTM/FL/17	20.68	26.18	53.14	Silt loam	Silty clay loam
KTM/FL/18	20.50	16.18	63.32	Silt loam	Silty clay loam
KTM/FL/19	49.25	26.25	24.50	Sandy clay loam	Silty clay loam
KTM/FL/20	18.25	41.25	40.50	Silty clay	Silty clay loam
KTM/FL/21	52.35	12.35	35.30	Sandy loam	Silty clay loam
3.Thalayazham Panchayat					
KTM/FL/22	20.12	35.75	44.13	Clay loam	Sandy clay loam
KTM/FL/23	15.85	32.57	51.57	Silty clay loam	Sandy clay loam
KTM/FL/24	17.20	49.29	33.52	Clay	Sandy clay loam
KTM/FL/25	18.25	12.35	69.40	Silty loam	Sandy clay loam
KTM/FL/26	52.35	23.56	24.09	Sandy clay loam	Sandy clay loam
KTM/FL/27	54.87	16.25	28.88	Sandy clay loam	Sandy clay loam
KTM/FL/28	19.44	47.02	33.54	Clay	Sandy clay loam
KTM/FL/29	35.51	15.31	49.18	Loam	Sandy clay loam
KTM/FL/30	39.25	16.25	44.50	Loam	Sandy clay loam
KTM/FL/31	54.25	14.16	31.59	Sandy loam	Sandy loam
KTM/FL/32	58.05	15.69	26.26	Sandy loam	Sandy clay loam
KTM/FL/33	59.23	18.24	22.53	Sandy loam	Sandy clay loam
4. Thalayolapparambu Panchayat					
KTM/FL/34	55.54	31.38	13.08	Sandy clay loam	Sandy clay loam
KTM/FL/35	54.28	16.47	29.25	Sandy clay loam	Sandy clay loam
KTM/FL/36	18.35	45.11	36.54	Clay	Sandy clay loam
KTM/FL/37	56.23	28.23	15.54	Sandy clay loam	Sandy clay loam
KTM/FL/38	59.59	26.65	13.75	Sandy clay loam	Sandy clay loam
KTM/FL/39	73.85	20.92	5.23	Sandy clay loam	Sandy clay loam
KTM/FL/40	56.16	14.25	29.59	Sandy loam	Sandy loam
KTM/FL/41	59.21	5.20	35.59	Sandy loam	Sandy loam
KTM/FL/42	51.51	10.38	38.11	Loam	Sandy clay loam
KTM/FL/43	41.22	45.69	13.10	Clay	Sandy clay loam

Texture pertinent to post flood samples and pre flood samples of the above locations showed that in Arpookara, Aimanam, Thalayazham silt or clay is deposited on the wetlands and in the case of Thalayolaprambu panchayat, much difference is not seen in the soil of post flood samples though an increase in sand content is noted. It can be inferred that waterholding capacity of these samples might have been improved by silt or clay deposition.

CHEMICAL PROPERTIES

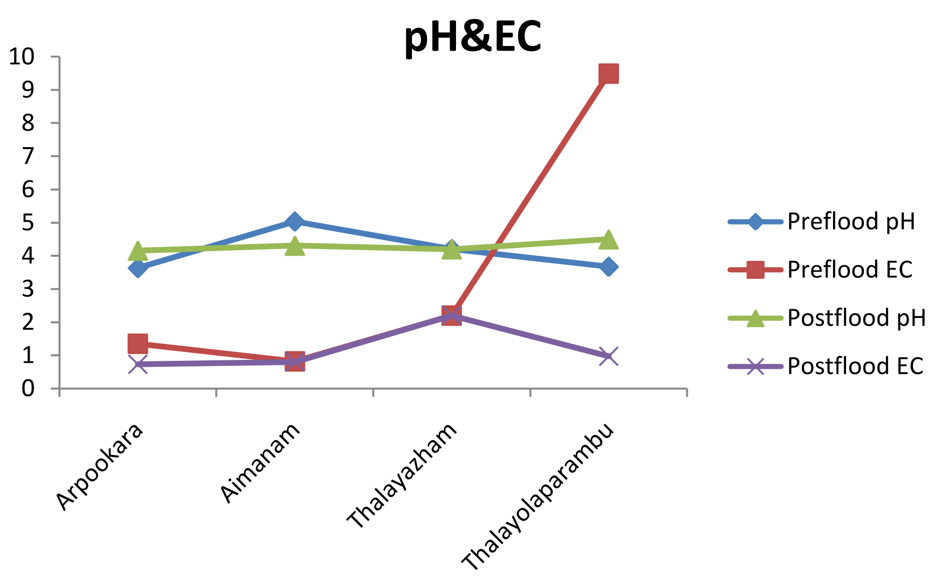
The chemical properties such as pH, EC, macro, secondary and micronutrients of the soil samples collected from the flooded soils were analysed and compared with available data and are as follows.

Table 5.5.3

pH & Electrical Conductivity

Soil Sampling point	Post flood		Pre flood	
	pH	EC dSm-1	pH	EC dSm-1
1.Arpookkara Panchayat				
KTM/FL/1	4.05	0.67	4.20	0.53
KTM/FL/2	4.20	0.43	4.00	0.58
KTM/FL/3	4.22	0.70	3.80	0.48
KTM/FL/4	3.95	0.60	3.70	0.82
KTM/FL/5	4.23	0.40	3.90	0.45
KTM/FL/6	4.20	0.30	4.00	2.06
KTM/FL/7	4.37	0.59	3.94	2.08
KTM/FL/8	4.27	0.61	3.81	2.25
KTM/FL/9	4.45	0.54	4.45	0.54
KTM/FL/10	4.10	1.16	3.10	1.78
KTM/FL/11	3.87	0.81	2.80	2.15
Mean	**4.16**	**0.73**	**3.63**	**1.35**
2. Aymanam Panchayat				
Soil Sampling points	**Post flood**		**Pre flood**	
	pH	**EC**	**pH**	**EC**
KTM/FL/12	3.97	0.79	4.86	0.48
KTM/FL/13	4.14	0.60	4.21	0.81
KTM/FL/14	4.33	0.61	5.15	0.72
KTM/FL/15	4.50	1.10	4.85	0.44
KTM/FL/16	4.40	1.30	4.82	1.52
KTM/FL/17	4.18	1.01	4.69	1.15
KTM/FL/18	4.22	0.59	4.02	0.875
KTM/FL/19	4.50	0.40	3.6	1.29
KTM/FL/20	4.65	0.32	4.91	0.94
KTM/FL/21	4.63	0.30	4.79	0.99
Mean	**4.31**	**0.80**	**5.03**	**0.82**
3. Thalayazham Panchayat				
Soil Sampling points	**Post flood**		**Pre flood**	
	PH	**EC**	**PH**	**EC**
KTM/FL/22	4.18	1.20	3.48	3.97
KTM/FL/23	3.76	2.40	3.78	2.03

KTM/FL/24	3.85	1.20	3.36	3.52
KTM/FL/25	4.17	1.90	2.31	5.30
KTM/FL/26	3.53	2.50	3.38	4.75
KTM/FL/27	3.97	2.00	3.3	2.96
KTM/FL/28	3.67	2.05	3.39	2.08
KTM/FL/29	4.13	2.08	3.54	4.88
KTM/FL/30	3.98	1.01	3.39	2.18
KTM/FL/31	4.40	0.98	3.02	3.45
KTM/FL/32	3.95	1.79	2.68	4.29
KTM/FL/33	4.41	0.99	3.87	2.5
Mean	**4.20**	**2.20**	**3.09**	**3.67**
4. Thalayolapparambu Panchayat				
Soil Sampling points	**Post flood**		**Pre flood**	
	pH	**EC**	**pH**	**EC**
KTM/FL/34	4.48	0.44	3.84	3.17
KTM/FL/35	4.19	0.73	3.7	2.17
KTM/FL/36	4.21	0.84	3.35	4.73
KTM/FL/37	4.00	1.26	3.81	2.65
KTM/FL/38	4.30	1.10	3.64	4.07
KTM/FL/39	5.00	0.54	3.66	3.26
KTM/FL/40	4.55	0.60	3.9	3.26
KTM/FL/41	4.20	0.83	3.85	2.73
KTM/FL/42	4.07	1.32	3.58	16.81
KTM/FL/43	4.32	1.51	3.99	3.08
Mean	**4.50**	**0.97**	**3.67**	**9.49**

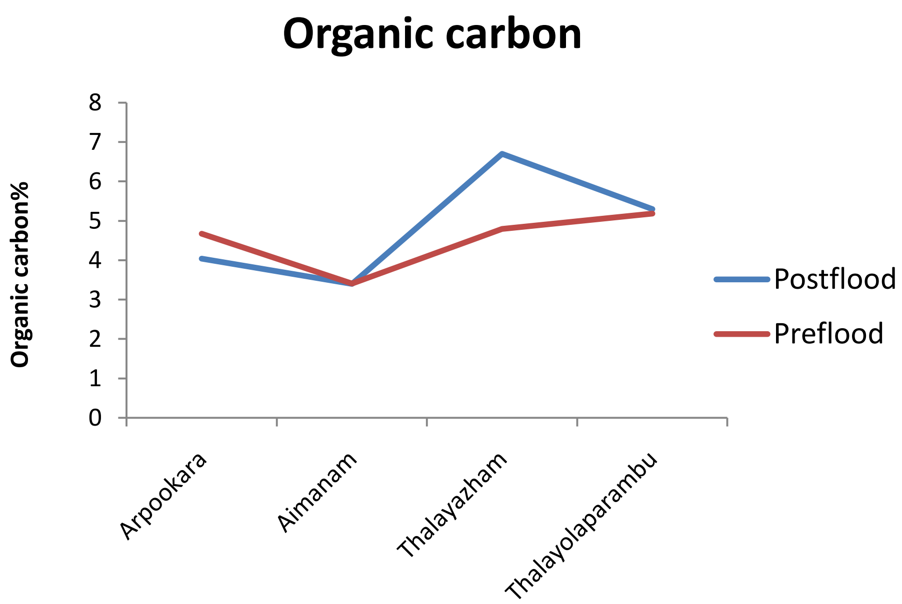


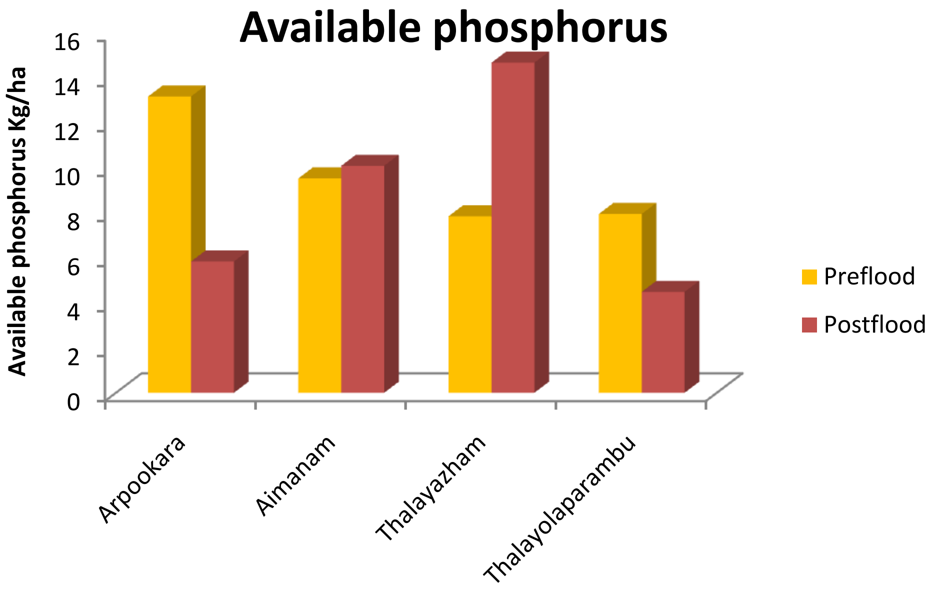
In majority of the samples acidity as well as . Electrical conductivity values reduced in post flood samples when compared to preflood samples.

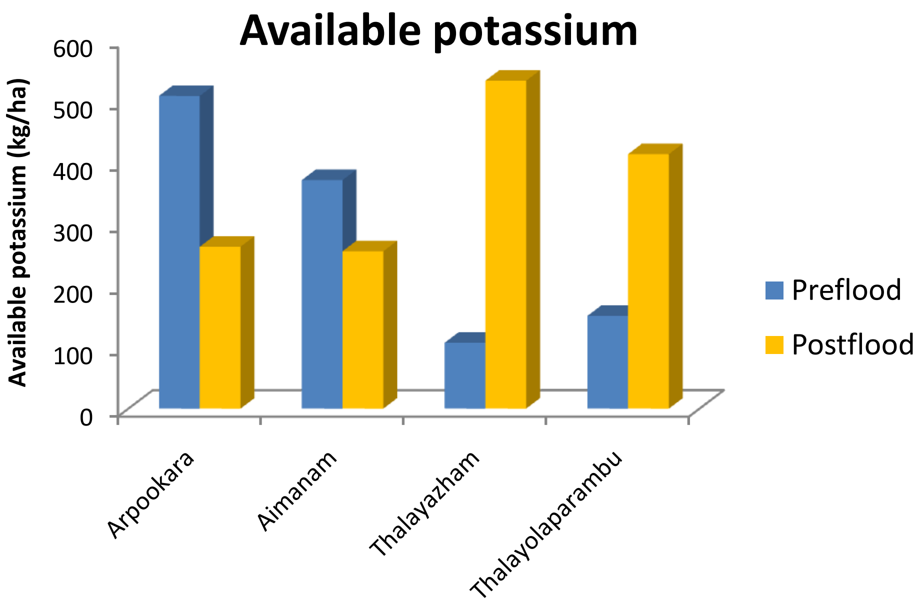
Table 5.5.4
Macro Nutrients

Soil Sampling points	Post flood			Preflood		
	OC %	**P kg/ha**	**K kg/ha**	**OC %**	**P kg/ha**	**K kg/ha**
1. Arpookkara Panchayat						
KTM/FL/1	2.60	4.48	321.44	3.90	15.57	15.57
KTM/FL/2	4.20	6.72	226.24	2.79	15.90	293.44
KTM/FL/3	4.92	4.70	230.72	5.16	15.79	647.36
KTM/FL/4	4.88	4.93	243.04	5.57	8.85	1001.28
KTM/FL/5	4.80	5.60	241.92	4.31	18.7	973.28
KTM/FL/6	5.00	4.48	260.96	3.49	17.02	636.16
KTM/FL/7	5.32	6.72	204.96	6.56	4.48	295.36
KTM/FL/8	5.48	6.94	253.12	6.33	4.48	351.08
KTM/FL/9	5.00	7.17	267.68	5	4.48	267.68
KTM/FL/10	4.40	5.04	255.36	5.20	20.16	670.88
KTM/FL/11	4.20	4.70	260.96	6.31	21.84	478.24
Mean	**4.04**	**5.83**	**263.20**	**4.68**	**13.16**	**508.43**
2. Aymanam Panchayat						
Soil Sampling points	**Post flood**			**Preflood**		
	OC %	**P kg/ha**	**K kg/ha**	**OC %**	**P kg/ha**	**K kg/ha**
KTM/FL/12	3.80	2.24	253.12	1.30	11.20	205.41
KTM/FL/13	3.40	4.48	216.16	2.37	8.96	536.48
KTM/FL/14	4.60	8.96	248.64	4.1	2.24	319.33
KTM/FL/15	3.60	4.48	282.24	4	1.12	395.25
KTM/FL/16	4.60	2.24	352.80	4.74	4.27	326.83
KTM/FL/17	4.60	4.48	230.72	4.25	7.84	397.75
KTM/FL/18	3.20	4.70	237.44	4.48	8.96	373.33
KTM/FL/19	2.40	4.93	164.64	2.3	17.92	537.6
KTM/FL/20	2.20	17.92	161.28	4.85	7.84	279.25
KTM/FL/21	2.40	2.69	159.04	5.52	2.24	308.6
Mean	**3.40**	**10.08**	**255.92**	**3.41**	**9.52**	**371.51**
3.Thalayazham Panchayat						
Soil Sampling points	**Post flood**			**Preflood**		
	OC %	**P kg/ha**	**K kg/ha**	**OC %**	**P kg/ha**	**K kg/ha**
KTM/FL/22	6.60	4.48	344.96	5.43	5.82	100.16
KTM/FL/23	7.20	2.24	526.40	6.49	8.51	128.13
KTM/FL/24	6.60	7.84	295.68	6.77	8.96	137.01

KTM/FL/25	7.40	6.72	626.08	6.72	4.48	81.76
KTM/FL/26	6.60	2.24	394.24	6.8	7.84	114.24
KTM/FL/27	3.40	4.48	244.16	7	8.96	163.52
KTM/FL/28	5.40	4.48	285.60	6.8	6.72	134.4
KTM/FL/29	3.40	6.72	395.36	5.53	6.72	124.69
KTM/FL/30	2.40	6.72	343.84	2.6	8.96	50.4
KTM/FL/31	6.00	6.94	672.00	6.28	8.51	70.34
KTM/FL/32	3.60	20.38	308.00	4.4	6.72	52.64
KTM/FL/33	3.60	26.88	432.32	2.83	11.2	155.31
Mean	**6.70**	**14.66**	**533.12**	**4.80**	**7.84**	**106.96**
4.Thalayolapparambu Panchayat						
Soil Sampling points	**Post flood**			**Pre flood**		
	OC %	**P kg/ha**	**K kg/ha**	**OC %**	**P kg/ha**	**K kg/ha**
KTM/FL/34	4.40	2.24	341.60	6.17	14.76	107.55
KTM/FL/35	4.40	6.72	389.76	3.28	2.13	86.24
KTM/FL/36	5.20	2.24	533.12	5.09	1.12	118.5
KTM/FL/37	4.20	3.36	303.52	6.36	3.36	94.08
KTM/FL/38	6.20	4.48	358.40	3.28	1.12	85.12
KTM/FL/39	5.00	4.93	394.24	4.93	2.24	100.82
KTM/FL/40	5.60	4.70	309.12	5.29	1.12	115.5
KTM/FL/41	5.60	4.70	427.84	3.39	3.36	109.2
KTM/FL/42	6.40	6.72	296.80	7.1	1.46	216.16
KTM/FL/43	5.00	2.24	294.56	5.36	2.24	104.31
Mean	**5.30**	**4.48**	**413.84**	**5.19**	**7.94**	**150.64**







A definite trend could not be inferred while analyzing the results. Majority of the samples showed increase in organic carbon content in postflood samples. Available phosphorus was low in majority of the samples and post flood samples showed lower values for phosphorus than preflood samples

Table 5.5.5

Secondary nutrients

Soil Sampling points	Post flood *(ppm)*			Pre flood *(ppm)*		
	S *ppm*	Ca *ppm*	Mg *ppm*	S *ppm*	Ca *ppm*	Mg *ppm*
1. Arpookkara Panchayat						
KTM/FL/1	48.57	671.40	133.75	133.75	--	--
KTM/FL/2	31.98	209.55	153.23	153.23	--	--
KTM/FL/3	48.57	793.95	301.03	301.03	--	--
KTM/FL/4	52.98	738.90	146.60	146.60	--	--
KTM/FL/5	41.94	338.70	204.03	204.03	--	--
KTM/FL/6	38.76	657.25	303.50	303.50	--	--
KTM/FL/7	59.84	776.95	319.25	319.25	--	--
KTM/FL/8	47.11	255.15	342.23	342.23	--	--
KTM/FL/9	35.21	916.90	246.43	246.43	--	--
KTM/FL/10	43.63	411.50	155.65	155.65	--	--
KTM/FL/11	56.29	417.20	159.65	159.65	--	--
Mean	**45.91**	**563.23**	**237.99**	**237.99**	**--**	**--**
2. Aymanam Panchayat						
Soil Sampling points	**Post flood**			**Preflood**		
	S	**Ca**	**Mg**	**S**	**Ca**	**Mg**
KTM/FL/12	51.52	404.00	131.90	395.38	--	--
KTM/FL/13	41.99	488.10	158.98	350.88	--	--
KTM/FL/14	52.91	656.50	261.65	359.50	--	--
KTM/FL/15	25.40	800.78	281.28	365.00	--	--
KTM/FL/16	24.01	806.50	376.95	526.25	--	--
KTM/FL/17	56.87	525.80	172.63	367.25	--	--
KTM/FL/18	47.69	659.80	183.60	2.02	--	--
KTM/FL/19	29.16	574.45	191.75	306.6	--	--
KTM/FL/20	31.63	160.05	144.00	63.39	--	--
KTM/FL/21	25.32	385.05	150.68	248	--	--
Mean	**40.44**	**483.28**	**254.43**	327.8	--	--
Thalayazham Panchayat						
Soil Sampling points	**Post flood**			**Preflood**		
	S	**Ca**	**Mg**	**S**	**Ca**	**Mg**
KTM/FL/22	62.56	1303.90	425.38	1263	--	--
KTM/FL/23	65.08	810.15	468.75	1288	--	--
KTM/FL/24	60.04	549.90	239.90	1300	--	--
KTM/FL/25	57.52	869.65	293.68	1316	--	--
KTM/FL/26	52.48	1317.30	126.68	1088	--	--
KTM/FL/27	47.44	521.15	199.60	1261	--	--

KTM/FL/28	44.91	765.80	342.93	1271	--	--
KTM/FL/29	34.58	710.10	203.48	1313	--	--
KTM/FL/30	35.33	656.55	401.65	241	--	--
KTM/FL/31	37.10	637.40	406.23	1175	--	--
KTM/FL/32	50.46	576.15	437.85	1263	--	--
KTM/FL/33	52.48	837.10	445.98	1288	--	--
Mean	**49.83**	**919.23**	**297.71**	**778.50**	--	--
4. Thalayolapparambu Panchayat						
Soil Sampling points	**Post flood**			**Preflood**		
	S	**Ca**	**Mg**	**S**	**Ca**	**Mg**
KTM/FL/34	37.48	550.65	136.50	1376	--	--
KTM/FL/35	38.44	708.55	323.85	1317	--	--
KTM/FL/36	38.91	561.00	540.18	526	--	--
KTM/FL/37	36.04	687.40	278.25	581	--	--
KTM/FL/38	51.19	631.95	388.48	1318	--	--
KTM/FL/39	39.42	883.45	342.83	789.3	--	--
KTM/FL/40	21.32	582.10	306.23	633.4	--	--
KTM/FL/41	24.42	862.80	291.63	1317	--	--
KTM/FL/42	41.76	912.40	194.20	1319	--	--
KTM/FL/43	62.82	782.10	232.50	313.9	--	--
Mean	**42.07**	**731.53**	**338.34**	**845. 13**	--	--

** preflood values of Available calcium and magnesium are not available

Postflood values for Available sulphur showed comparatively lower values than preflood values. Available calcium, magnesium and sulphur in postflood soils are adequate for agricultural production.

Table 5.5.6

Micronutrients

Soil Sampling points	**Post flood** (*ppm*)					**Pre flood** (*ppm*)				
	Fe	**Mn**	**Zn**	**Cu**	**B**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
1. Arpookkara Panchayat										
KTM/FL/1	514.25	10.81	9.45	13.41	0.62	253.56	8.57	2.76	0.69	0.46
KTM/FL/2	485.45	15.42	10.9	11.85	0.88	213.14	10.54	1.97	5.42	0.38
KTM/FL/3	541.7	17.57	10.85	10.07	1.05	211.31	10.63	1.02	1.06	0.14
KTM/FL/4	656.85	24.79	15.75	13.36	0.72	203.31	9.56	2.31	2.58	0.58
KTM/FL/5	557.5	15.12	10.4	10.78	0.79	216.44	12.52	1.34	2.55	2
KTM/FL/6	472.5	6.54	10.6	9.51	0.83	119.52	6.59	1.22	2.63	0.28
KTM/FL/7	754.85	18.65	10.3	11.75	1.16	41.96	1.99	6.33	0.99	0.78
KTM/FL/8	766.85	18.25	9.55	11.87	0.91	55.96	4.66	8.23	2.85	1.2
KTM/FL/9	725.2	23.89	9.9	13.27	0.89	41.96	4.63	5.21	2.99	0.9

KTM/FL/10	586.05	29.34	9.25	12.51	0.65	353.16	10.82	2.43	7.83	0.5
KTM/FL/11	619.9	12.18	6.75	11.56	0.69	338.73	8.61	1.84	5.02	1.04
Mean	472.50	35.88	11.25	11.46	0.84	197.56	7.26	4.63	4.26	1.07
2. Aymanam Panchayat										
	Post flood (*ppm*)					**Pre flood (*ppm*)**				
	Fe	**Mn**	**Zn**	**Cu**	**B**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
KTM/FL/12	545.15	13.74	7.15	11.15	0.74	112.03	14.27	1.90	8.36	0.27
KTM/FL/13	531.1	14.42	5.25	11.73	0.61	334.53	13.79	4.74	4.54	1.24
KTM/FL/14	494.6	17.40	4.8	10.67	0.98	192.68	12.40	4.18	18.90	0.61
KTM/FL/15	331.1	12.87	3.35	11.25	1.01	202.88	19.26	3.55	18.20	0.91
KTM/FL/16	389.95	15.71	6.1	10.73	0.86	226.62	202.04	3.01	10.36	9.89
KTM/FL/17	457.4	60.21	11.6	11.50	1.04	251.25	24.59	4.16	20.25	0.14
KTM/FL/18	442.05	41.41	11.75	13.64	0.97	300.52	21.16	4.96	2.85	1.5
KTM/FL/19	454.1	12.16	9.45	10.51	0.74	475.36	5.18	4.88	2.64	1.62
KTM/FL/20	440.45	12.12	8.2	10.17	0.82	121.09	20.09	4.28	18.30	0.45
KTM/FL/21	457.75	18.67	7.75	10.40	0.77	191.44	23.48	6.28	21.48	1.4
Mean	438.13	36.16	7.55	11.90	0.89	293.70	103.61	4.09	12.06	5.02
3.Thalayazham Panchayat										
Soil Sampling points	**Post flood (*ppm*)**					**Pre flood (*ppm*)**				
	Fe	**Mn**	**Zn**	**Cu**	**B**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
KTM/FL/22	783.65	5.65	3.15	8.74	1.27	320.00	9.80	2.45	4.20	1.39
KTM/FL/23	875.5	5.48	3.35	8.60	3.09	311.00	8.64	3.10	4.13	1.61
KTM/FL/24	772.45	4.54	1.95	8.17	1.08	319.00	8.80	2.10	6.40	1.24
KTM/FL/25	777.1	14.95	3.4	7.84	3	26.3	2.6	2.90	4.01	1.32
KTM/FL/26	760.55	8.46	6	8.21	1.24	301	7.48	3.3	4.87	1.49
KTM/FL/27	602.9	9.64	1.35	8.61	1.43	287	5.63	3.1	3.99	1.27
KTM/FL/28	755.15	10.80	1.75	8.82	1.06	296	6.52	2.83	4.23	1.28
KTM/FL/29	711.98	5.46	1.65	8.72	1.27	278	6.13	3.2	4.96	1.24
KTM/FL/30	486.85	6.89	1.45	7.51	0.82	295	7.32	2.9	4.82	1.17
KTM/FL/31	722.45	9.23	11.63	8.82	1.75	305	8.79	2.68	4.26	1.12
KTM/FL/32	452.49	19.94	13.05	8.67	1.9	320	9.8	2.45	4.2	1.39
KTM/FL/33	424.85	11.91	16.55	8.99	1.89	311	8.64	3.1	4.13	1.61
Mean	815.33	14.58	9.95	8.83	1.96	173.15	6.20	2.70	5.20	1.37
4. Thalayolapparambu Panchayat										
Soil Sampling points	**Post flood (*ppm*)**					**Pre flood (*ppm*)**				
	Fe	**Mn**	**Zn**	**Cu**	**B**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
KTM/FL/34	661.85	8.48	9.6	13.10	0.82	341	31	5.1	5.94	0.98
KTM/FL/35	500.7	8.97	1.7	11.74	1.08	287.9	29.13	6.7	5.2	1.44
KTM/FL/36	556.9	11.39	4.25	11.91	1.17	287.6	16.62	3.8	4.9	0.86
KTM/FL/37	618.8	7.52	6.45	12.77	1.56	256.6	12	3.3	6.4	1.08
KTM/FL/38	537.65	7.31	3.7	12.19	0.96	446.7	26.12	3.3	5.3	0.78

KTM/FL/39	706.85	7.54	6.15	21.55	1.22	250.7	17.5	4.7	5.9	0.88
KTM/FL/40	671.35	8.67	8.05	12.39	0.83	350	19.56	5.2	5.4	0.72
KTM/FL/41	605.4	74.18	7.9	11.94	1.34	300.2	23.4	3.9	3.9	0.88
KTM/FL/42	668.3	97.18	28.2	13.07	0.91	386	29	6.6	5.89	0.88
KTM/FL/43	579.35	9.91	25.25	12.96	1.46	463.8	19.8	5.3	6.2	0.88
Mean	603.78	52.24	14.95	16.64	1.19	357.25	21.50	5.00	5.15	1.08

The lowlands of the panchayath were flooded for many days and samples were taken from 4 panchayaths for comparison with the samples taken before floods. It was observed that the samples from paddy fields of Kottayam taluk (Arpokkara and Aymanam panchayath), showed a slight reduction in acidity, considerable reduction in EC, reduction in OC and considerable reduction in available K. At the time of sampling the field was fallow. In the case of Vaikom Taluk, the panchayaths Thalayazham and Thalayolapparambu, showed a slight reduction in acidity, considerable reduction in EC but the organic carbon content and the available K increased when compared to the preflood samples. It was inferred that there was a standing crop in the area at the time of flood and the decayed straw might have contributed to the high K in these area.

LANDSLIDE AFFECTED AREAS IN UPLANDS AND MID UPLANDS

The detailed description of sites where landslides occurred is detailed below

Table 5.5.7

<table>
<tr><th>Sl. no</th><th>Panchayat</th><th>Location &Elevation</th><th>Soil series identified</th><th>Site description & inference</th></tr>
<tr><td>1</td><td rowspan="2">Teekoy</td><td>Vellimala : (516 m)</td><td rowspan="4">Vellikulam</td><td rowspan="4">Very steep lands with 33-50% slope. The soil rests on granitic rock below and the soil layers are non gravelly with weak structure especially in the top layers of soil. It is observed that the soil characteristics, slope gradient of the site and the landuse have direct influence on the landslide occurrence. The heavy incessant rain aggravated the situation. The nearby areas of the eroded land are also under threat of erosion in the forthcoming rainy season.</td></tr>
<tr><td>2</td><td>Ottaeetti (380m)</td></tr>
<tr><td>3</td><td>Poonjar Thekkekara</td><td>ward 6, chattambik kavala, 290m</td></tr>
<tr><td>4</td><td>Koruthode</td><td>ward 3 (341m)</td></tr>
</table>

5	Koottikkal (Around 12 severe and minor landslides occurred in the panchayath area	Ramachamparabu area of Melethadam (ward 6) 778m,	Vazhikkadavu	During the first phase of the south west monsoon, an area of around 3 acres was found to be sunken down up to 2 meters and cracking was noticed in the Ecologically Sensitive Area (ESA) at Ramachamparabu by the side of Elamkadu-Vagamon road. The heavy rains eroded the land to almost 2 km distance including roads and agricultural crops. The soils are sandy clay in texture(>35% clay and 45% or more sand) in texture with weak subangular blocky soil structure and very deep soil column. Weak structure and weak aggregation of soil along with the slope of the land is very favourable for sliding of soil. On profile examination, the soil layers are found to be saturated with water and water currents are seen in the cracks. There are large number of micropores in clay which absorbs and hold the water like a sponge. When the soil become heavy due to saturation of water , it accelerate sliding of the soil. Also low organic matter content in the subsurface layers results in weak soil aggregation. The high and intense rainfall in the area aggrevated the situation.
5		Plapally – njarkkadu area(324 m) 9^0 29'26.1''N $76^0$58'10'' E	Plapally	The soil texture is gravelly clay loam, developed over gneissic parent material on steep slopes. These deep gneissic soils with gneissic boulders at different stages of weathering in steep slopes are susceptible to soil erosion. It is recommended to avoid cultivating annual crops like ginger, turmeric or soil eroding crops like tapioca in the area. Soil conservation measures to be taken to prevent further degradation of the soil. In areas were severe erosion has occurred leaving the land into gullies ,covercropping with leguminous crops is recommended to prevent further exposure of soil and also to increase the organic matter content.
		Plapally – njarkkadu area(304 m) 9^0 36'51.4''N $76^0$52'41.2''E		
		Plapally – njarkkadu	Thalumkal	These are deep soils with gravelly clay loam texture developed over gneissic

		area(200 m) $9^0 38'9.3''$N, $76^0 53'23.4'$ E		parent material on steep slopes. Gneissic boulders at different stages of weathering are seen in the profile. Thalumkal series seen in lower elevations of the miduplands. It is recommended to avoid any annual crops like ginger, turmeric or soil eroding crops like tapioca cultivating in the area. Soil conservation measures to be taken to prevent further degradation of the soil. In areas were severe erosion has occurred leaving the land into gullies ,covercropping with leguminous crops is recommended to prevent further exposure of soil and also to increase the organic matter content.
		Plapally – njarkkadu area(206 m) $9^0 38'16.7''$N $76^0 53'13.4''$E		


Land slide affected Area in Kanjirapilly Taluk

ENVIRONMENTAL POLLUTION DUE TO MAN MADE ACTIVITIES AND HEAVY RAINS

TABLE 5.5.8

Sl. no	Panchayat	Location &Elevation	Site description & inference
1	Mundakkayam	vettukallamkuzhi ; 318 m elevation 9^0 33' 39.31''N	Huge amounts of degradable and non degradable waste dumped in the location are slided downstream due to heavy rains similar to the sliding of soil. The leachates of the waste materials are drained into the

		76^0 52' 28.51''E	nearby drain below- Nenmeni river which finally drains into Manimalayar. The land is having a slope of more than 30%. The heavy rains along with the sliding of waste material has blocked the road transport other than polluting the water bodies below.

CHEMICAL CHARACTERISTICS OF LANDSLIDE AFFECTED AREAS

The soil samples from the area adjacent to landslided areas were collected from the land close to the slided portion(landslide edge). A and B horizons were lost in almost all the slided areas except in Koruthode where the A horizon was lost. The soil samples were subjected to analysis in the labs and results are presented below in table.

Table 5.5.9

pH, Electrical Conductivity and macronutrients

SERIES	Panchayat	pH	EC	OC %	P kg/ha	K kg/ha
Vellikulam	Teekoy	5.10	0.09	1.52	32.68	139.66
Vellikulam	Teekoy	4.80	0.09	2.90	2.78	132.05
	Mean	4.95	0.09	2.21	17.73	135.86
Vazhikkadavu	Koottikkal	5.20	0.08	2.34	3.95	186.48
Plappally	Koottikkal	5.30	0.03	0.48	0.14	97.66
	Mean	5.25	0.06	1.41	2.05	142.07
Vellikulam	Koruthode	4.90	0.11	3.42	17.44	276.86
Vellikulam	Poonjar	5.20	0.02	0.39	0.14	233.86

Table 5.5.10

Secondary and micronutrients

SERIES	Panchayat	Secondary nutrients (ppm)			Micro nutrients (ppm)				
		Ca	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
Vellikulam	Teekoy	74.55	61.68	21.89	38.03	4.55	1.84	10.02	2.18
Vellikulam	Teekoy	35.45	43.88	20.32	39.95	6.00	0.95	2.87	2.12
Vazhikkadavu	Koottikkal	107.30	169.70	98.79	39.84	8.68	1.20	27.26	0.26
Plappally	Koottikkal	46.50	66.73	248.49	29.53	5.12	0.72	24.52	0.49
Vellikulam	Koruthode	185.00	247.38	18.11	44.49	12.69	1.31	28.77	0.33
Vellikulam	Poonjar	70.60	71.88	56.24	28.08	8.15	0.41	9.57	1.37

On reviewing the results, It is seen that all the samples were very strongly to strongly acidic. The electrical conductivity values not affected by the landslide. Except two areas one at Koottikkal and other at Poonjar all other areas showed medium to high organic carbon status. Available calcium is deficient in all locations. Phosphorus and Magnesium are deficient in some locations.

SOIL SERIES ENCOUNTERED IN LANDSLIDE AREAS

VELLIKULAM SERIES

Vellikulam soils are very deep, well drained, medium-textured, brownish and acidic. They have developed over gneissic parent material on moderately steep to very steep slopes in uplands. The thickness of the solum is more than 150 cm. The ‘A’ horizon is 20-30 cm thick. Its colour is dark brown in hue 7.5 YR, value 3 ,chroma 2 to 4. The texture is sandy clay loam to clay loam. The soils are very strongly acidic. The ‘B’ horizon is more than 150 to 180 cm thick. Its colour ranges from dark brown to strong brown in hue 5 YR to 7.5 YR, value 3 to 5 and chroma 3 to 6 and the texture varies from clay loam to clay. Gravel percentage is very less in subsoil. Clay percentage increases with depth. These soils are well drained with rapid to moderately rapid permeability. These soils have medium nitrogen(OC -0.56-1.56%), medium phosphorus and medium potassium. These soils have low CEC . The soils are susceptible to severe erosion.

PLAPALLY SERIES

Plappally soils are very deep brownish moderately fine to fine soils. ‘A’horizon underlain by dark brown to brown gravelly clay loam to gravelly clay ‘B’ horizon. These soils have developed in gneissic parent material on steep slopes, at an elevation of 300 to 600m above MSL. The thickness of the solum is 100-150cm. The ‘A’ horizon is 15-20 cm thick. Its colour is in hue 7.5 YR, value 2.5 and chroma 2-4. The texture is gravelly clay loam gravelly clay. The ‘B’ horizon is more than 100cm thick. Its colour is in hue 7.5 YR, value 3-5 and chroma 3 to 4 and texture varies from gravelly clay loam to gravelly clay. Gravel % ranges from 10-15%. Soil profile contain gneissic boulders of different stages of weathering. Organic carbon content ranges from0.49-1.64. These soils are very strongly to strongly acidic.

VAZHIKADAVU SERIES

Vazhikkadavu soils are very deep, occur on steep to very steep slopes of highlands, 600m above MSL . They have developed over weathered gneissic rocks. Moderately well drained with moderately rapid permeability. Vazhikkadavu soils have dark reddish brown to very dark brown, medium acid, sandy clay loam to gravely sandy clay loam ‘A’ horizon and yellowish red to strong brown, medium acid, gravelly clay loam to gravelly clay ‘B’ horizons. These soils are moderately well drained with moderately rapid permeability. The thickness of the solum is 100-150 cm. The ‘A’ horizon is 20-40 cm thick. Its colour is in hue 7.5 YR, value 2.5 and chroma 2 and texture is sandy clay loam to gravelly sandy clay loam. The ‘B’ horizon is more than 100cm thick. Its colour is in hue 5 YR to 7.5 YR, value 3 to 4 chroma 3 to 6 and the texture is gravelly clay loam.

These soils are susceptible to severe soil erosion. Gravel content ranges from 20-30% Soils are strongly acidic, have low CEC. Cultivated to tea in some areas

THALUNKAL SERIES

Thalunkal soils have dark brown gravelly clay loam to gravely clay. ‘A’horizon underlain by dark reddish brown to yellowish red gravelly clay loam to gravelly clay ‘B’ horizon. These are deep soils developed on gneissic parent material on foothills, at an elevation of 100-300 m above MSL. The thickness of the solum is 100-150cm. The ‘A’ horizon is 15-20 cm thick. Its colour is in hue 5 YR, value 3 and chroma 3-4. The texture is gravelly clay loam to clay. The ‘B’ horizon is more than 90cm thick. Its colour is in hue 5 YR, value 3-4 and chroma 4 to 6 and texture varies from gravelly clay loam to gravelly clay. Gneissic boulders of size 3 cm-5cm present from 3rd layer onwards. These soils are moderately well drained with moderate permeability. Distributed in the midupland and lower areas of upland of Kottayam district. These soils are susceptible to soil erosion. Gravel content in this soils ranges from 10-20%. Extremely to very strongly acidic and have low CEC

The results of the study can be summarized as follows

- Except in Aimanam panchayat, Soil acidity reduced in postflood samples but in other places it does not show much change.
- Electrical conductivity values reduced drastically in Thalayolaprambu panchayat in other places showed not much variation.
- Available phosphorus values showed deficiency of phosphorus in soil.
- Available potassium and organic carbon status is satisfactory for crop growth.
- Liming is recommended before rice cultivation.
- Available calcium, magnesium and sulphur in post flood soils are adequate for agricultural production .
- Micronutrient deficiency is not seen.
- Textural changes occurred in wetland consequent to flooding. Depending on the material deposited changes occurred in Texture.
- Except acidity & Soil phosphorus all other parameters are satisfactory for crop production.
- In landslide areas - in majority of the sites, A horizon completely & B horizons partly lost.
- In landslide affected areas more detailed study has to be conducted to identify the soil susceptibility to landslides.

IDUKKI

Total Geographic Area : 4,36,328 Ha

No. of Taluks : 5

No. of Villages : 83

RIVER BASINS

- *Periyar*
- *Pambar*
- *Muvattupuzha*
- *Manimala*
- *Pamba*
- *Meenachil*

DISTRESS AFFECTED VILLAGES

5.6. IDUKKI

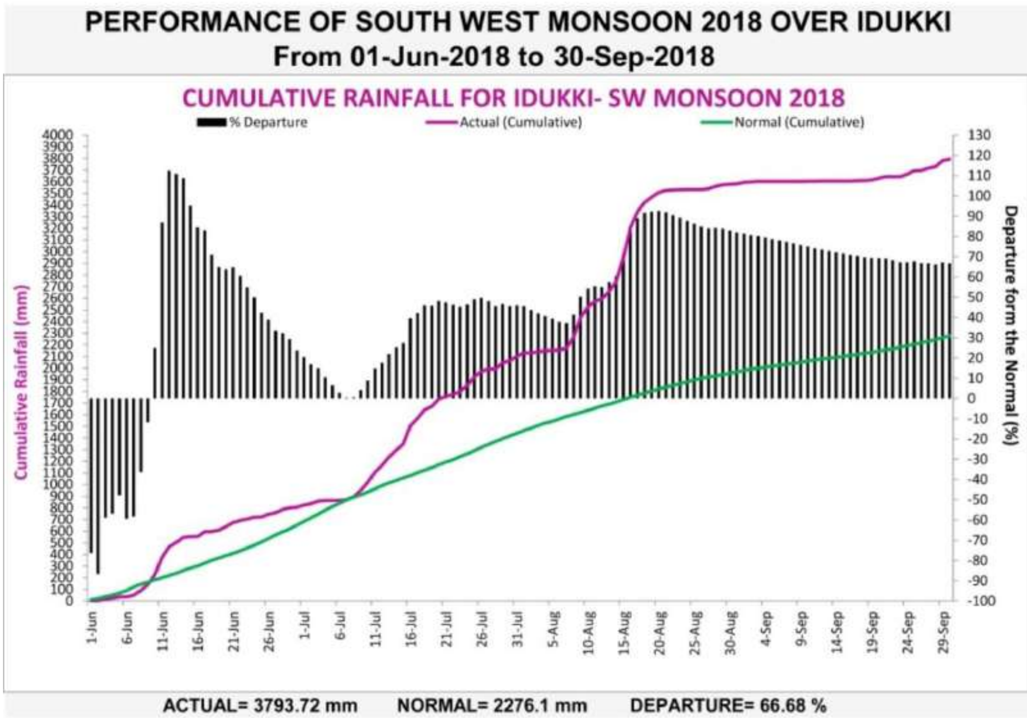
Idukki district which lies in the Western Ghats of Kerala is the second largest district in area (436328 ha) but has the lowest population density. Idukki has a vast forest reserve area and more than half of the district is covered by forests. The urban areas are densely populated whereas villages are sparsely populated. Idukki is also known as the spice garden of Kerala. The total population is 1108974.

The major river basins in the district are Periyar, Pamba, Pambar, Meenachil, Manimala and Muvattupuzha of which, Periyar river basin is the largest.

Lowland, midland, midupland, upland, highland and mountainous regions are the physiographic divisions identified in the district with major portion lying in upland and highland.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

The highest of the rainfall in the State was recorded in Idukki. Very intensive localized rainfall was received in some locations. While comparing with normal rainfall, Idukki received 66% more rainfall during the southwest monsoon season of 2018.



IMPACT OF DISTRESS IN THE DISTRICT

Devikulam, Udumbanchola, Idukki and Thodupuzha were the affected taluks of which, Devikulam and Idukki taluks were the worst affected. As per revenue records, 66 out of 67 villages were either affected by landslides/land slips or flood. High land areas were the physiographic division,severely affected.

For the first time in 26 years, the shutters of the Idukki dam were opened, causing a deluge. The waters gushing out from the Idukki dam spread out far and wide, damaging everything that came in its way. 89 people were killed, 1030 houses were fully damaged, 7527 houses were partially damaged, and 33,635 people were forced to flee their homes to the relief camps. Soil degradation, top soil loss, debris deposition etc impaired 3100 Ha land in the district.

Munnar known as the Kashmir of Kerala, experienced the worst flood since 1924. The devastating monsoon completely destroyed the town and upended its green tea valleys with boulders, mud and uprooted tea shrubs. Residential areas, as well as famous tourist destinations, including Mattuppetty, Kunthala and Rajamala were inundated. Munnar and Cheruthoni in Idukki were isolated and completely cut off from the rest of the places with no power supply. Roads leading to Munnar were broken. In Munnar, the most affected areas are Eravikulam, Kunthala and Mattupetti.

Landslips triggered by the rains have destroyed Idukki. Since all the roads were damaged due to landslips and landslides, the transportation network was completely jammed in this region. Vehicular traffic was disrupted in National Highway 85 due to landslides. Though Kerala Road Transport Corporation resumed bus services to Idukki, it was restricted till Adimaly for weeks. The areas near dams were devastated and flooded for 5-6 days continuously. Silt deposition to a height of 2-3 metres was observed in low lying areas.

FIELD TRAVERSING AND SOIL SAMPLING

Field traversing of the affected area was carried out to evaluate the changes in soil health due to landslides and heavy rain with special reference to distress affected panchayats.

Soil samples were collected from landslide affected areas and flood affected areas. 5 soil profiles were studied in this area to identify the changes in soil profile. Surface, subsurface, sediment deposits and profile samples were collected and analysed. In the case of surface samples, depth of sampling was 15 to 30cm.The details of samples collected from panchayats are mentioned below.

Munnar Panchayath

Surface samples and silt deposition samples were collected from Munnar. In order to study the change occurred in soil profile, four profiles were also studied in Landslide area.

Vellathooval and Konnathady Panchayath

Two surface samples each were collected from the land slide areas.

Rajakkad Panchayath

From the Panniyarkutty land slide area, 2 silt deposited samples, surface samples from areas adjoining landslide areas, profile samples from the landslide areas etc were collected. One profile was studied in the flood prone area.

The whole town was devastated due to heavy landslide in Panniyarkutty. Opening of shutters of Ponmudi and Mattupetty dams and heavy rainfall caused severe flooding in the panchayath. From the landslide areas, debris happened to fall in the river downstream, flooding the areas near the river bank.

Senapathy panchayath

One surface sample was collected from the areas adjacent to land slide area of Udumbanchola village.

Vazhathope Panchayath

Surface samples were collected from areas adjacent to different land slide areas of the Panchayath. From the land slide areas of Thanikadom, Perumkala, Manjapara and Gandhinagar colony surface samples were collected. Thadiyambadu and Karimban areas were severely flooded due to the raising of the shutters of Idukki and Mullaperiyar dams. Surface sample and silt deposited sample from Thadiyambadu were collected.

Vathikudy Panchayath

From the Rajapuram land slide area, one surface sample was collected.

Kanjikuzy Panchayath

From the land slide areas in Keerithode, one surface sample was collected.

Details of surface samples collected are given in the table below

Table 5.6.1

Sampling locations

Sl. no	Sample	Latitude	Longitude	Panchayat
1	LS/KDH/1	10° 4' 4.4" N	77° 6' 22.1" E	Munnar

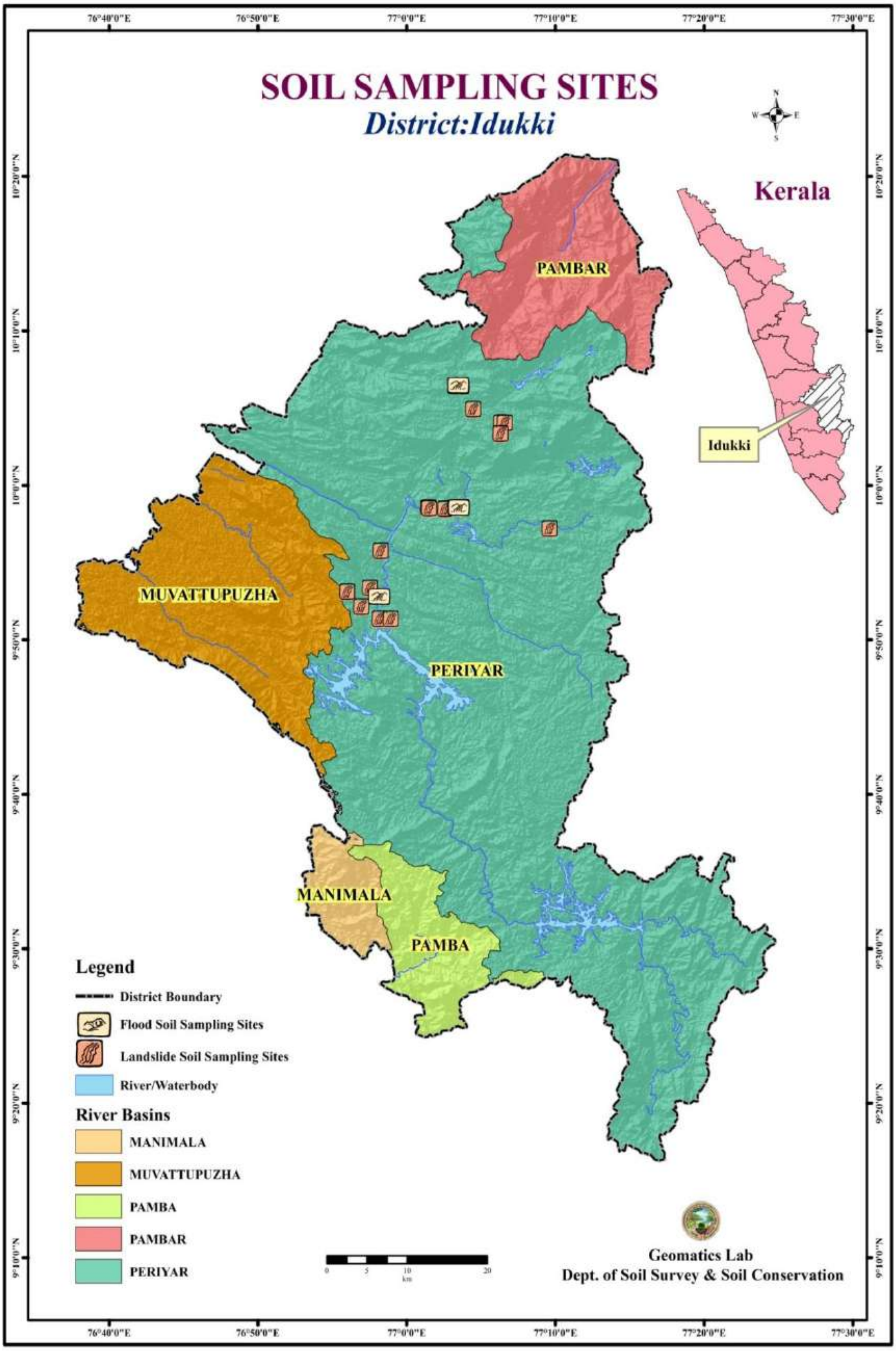
2	LS/KDH/2S	10° 4' 2.8" N	77° 6' 34.9" E	Munnar
3	LS/KDH/3-S	10° 4' 3.7" N	77° 6' 35.4" E	Munnar
4	LS/KDH/4	10° 3' 22.2" N	77° 6' 19.2" E	Munnar
5	LS/KDH/5-S	10° 3' 22.4" N	77° 6' 19.3" E	Munnar
6	LS/MNR/1-S	10° 4' 56.4" N	77° 4' 28.3" E	Munnar
7	SD/MNR/1	10° 6' 26.6" N	77° 3' 30.2" E	Munnar
8	RB/MNR/1	10° 6' 29.7" N	77° 3' 30" E	Munnar
9	LS/VLTL/1	9° 58' 34.1" N	77° 1' 26.4" E	Vellathooval
10	LS/VLTL/2	9° 58' 31.8" N	77° 1' 29.8" E	-do-
11	LS/KNTD/1	9° 58' 29.6" N	77° 2' 35.1" E	Konnathady
12	LS/KNTD/2	9° 58' 34.9" N	77° 3' 29" E	-do-
13	SD/RJKD/1	9° 58' 36.2" N	77° 3' 31.9" E	Rajakkad
14	RB/RJKD/1	9° 58' 36.2" N	77° 3' 31.9" E	-do-
15	FP/RJKD/1	9° 58' 36.2" N	77° 3' 31.9" E	-do-
16	FP/RJKD/RC-1	9° 58' 34.3" N	77° 3' 31.8" E	-do-
17	LS/UDCL/1	9° 57' 13.3" N	77° 9' 37.1" E	Senapathy
18	LS/VZTP/7	9° 53' 50.7" N	77° 57' 10.4" E	Vazhathope
19	LS/TNKM/1	9° 52' 10" N	76° 56' 57.8" E	-do-
20	LS/PMKA/1	9° 53' 8" N	76° 56' 0.6" E	-do-
21	LS/MNPR/1	9° 53' 22.7" N	76° 57' 32" E	-do-
22	LS/GANR/1	9° 51' 22.3" N	76° 58' 10.9" E	-do-
23	FP/TDPU/1	9° 52' 48.9" N	76° 58' 10.9" E	-do-
24	LS/RJPM/1	9° 51' 21.6" N	76° 58' 56.1" E	Vathikudy
25	LS/KTDE/1	9° 55' 46.7" N	76° 58' 14.8" E	Kanjikuzhy
26	LS/DVKM1	10° 4' 56.6" N	77° 4' 28.3" E	Munnar

Table 5.6.2

Site characteristics

Sl. no	Sample	Slope %	Physiography	Topography	Present land use
1	LS/KDH/1	33-50	Mountainous region	Side slopes	Miscellaneous trees and grasses
2	LS/KDH/2S	33-50	-do-	Side slopes	-do-
3	LS/KDH/3-S	25-33	-do-	Side slopes	-do-
4	LS/KDH/4	>50	-do-	Side slopes	-do-
5	LS/KDH/5-S	25-33	-do-	Side slopes	-do-
6	LS/MNR/1-S	33-50	-do-	Side slopes	Tea plantation
7	SD/MNR/1	3-5	-do-	valley	Grass

8	RB/MNR/1	3-5	-do-	valley	Grass
9	LS/VLTL/1	15-25	High land	Side slopes	Cocoa, coffee, pepper
10	LS/VLTL/2	15-25	-do-	Side slopes	-do-
11	LS/KNTD/1	15-25	-do-	Side slopes	-do-
12	LS/KNTD/2	15-25	-do-	Side slopes	-do-
13	SD/RJKD/1	3-5	-do-	valley	Banana
14	RB/RJKD/1	3-5	-do-	valley	grass
15	FP/RJKD/1	10-15	-do-	Side slopes	Banana, pepper etc
16	FP/RJKD/RC-1	10-15	-do-	Side slopes	-do-
17	LS/UDCL/1	25-33	High land	Side slopes	Banana, pepper etc
18	LS/VZTP/7	25-33	-do-	Side slopes	-do-
19	LS/TNKM/1	25-33	-do-	Side slopes	-do-
20	LS/PMKA/1	25-33	-do-	Side slopes	-do-
21	LS/MNPR/1	25-33	-do-	Side slopes	-do-
22	LS/GANR/1	25-33	-do-	Side slopes	-do-
23	FP/TDPU/1	1-3	Up land	Side slopes	-do-
24	LS/RJPM/1	33-50	-do-	Side slopes	Nutmeg, Pepper etc
25	LS/KTDE/1	25-33	-do-	Side slopes	Nutmeg,Pepper etc.
26	LS/DVKM1	25-33	Mountainous region	Side slope	tea


SOIL SAMPLING SITES
District:Idukki
Kerala
Idukki
PAMBAR
MUVATTUPUZHA
PERIYAR
MANIMALA
PAMBA
Legend
District Boundary
Flood Soil Sampling Sites
Landslide Soil Sampling Sites
River/Waterbody
River Basins
MANIMALA
MUVATTUPUZHA
PAMBA
PAMBAR
PERIYAR
Geomatics Lab
Dept. of Soil Survey & Soil Conservation

CHANGES IN SOILS OF DISTRESS AFFECTED AREAS

LANDSCAPE / SLOPE MODIFICATION

- In Munnar Panchayth, in Mattuppetty series the entire A horizon and part of B horizon was found to be eroded. In Periyavarum area in Munnar village. silt deposition to a height of 198 cm was observed.
- In Panniyarkutty land slide area of Rajakkad Panchath, the entire soil washed off, exposed the rock underneath and debris finally deposited in the river beneath causing flood in nearby area. In flooded area Kunjithanni series was found, and silt deposition to a thickness of 2m was found over the top soil.
- In areas severely affected by landslides, intermixing of the soil horizons and sand-silt depositions were observed.

Landslide at Munnar

Landslide in Panniyarkutty

Subsurface soil piping

Land subsidence Mavady, Idukki

PHYSICAL PROPERTIES

Soil Texture

Due to erosion, change in surface as well as subsurface texture was noticed in many areas. On the surface, clay was more prominent while sand and silt particles accumulated in the sub surface layers. Silt accumulation observed at different depths near the land slide depositional areas.

Soil Structure

Due to the impact of heavy rain, soil structure was destroyed in most of the areas. Loss of soil aggregation affects agriculture by decreasing soil quality and crop production. As soil aggregates breakdown due to flooding, the soil particles plug pores and voids that would otherwise help the soil to dry and return to normal after flooding. Soil aggregation after flooding was found to be weak.

Water Holding Capacity and Porosity

Change in texture and organic matter content led to changes in water holding capacity. Due to the accumulation of clay particles drainage was impaired and increasing the water holding capacity. But in areas where sand got accumulated, water holding capacity decreased.

OTHER GENERAL OBSERVATIONS

Yellowing and wilting of crops in the flood affected areas. Wilting of nutmeg is common in the entire region.

CHEMICAL PROPERTIES

The chemical properties such as pH, EC, macro, secondary and micronutrients of the soil samples collected from the flooded soils were analysed and compared with available data and are as follows.

Table 5.6.3

pH & Electrical Conductivity

Sl. no	Sample Code	Before flood		After flood	
		pH	EC	pH	EC
	Mountainous region				
1	LS/KDH/1	4.9	trace	5.31	0.16
2	LS/KDH/2	4.9	trace	5	0.98
3	LS/KDH/3	4.9	1.11	5.5	0.25
4	LS/KDH/4	4.9	trace	6.2	0.12
5	LS/KDH/5-S	5.0	trace	5.7	0.13
6	LS/DVKM/1	4.9	trace	5.11	0.06
7	LS/MNR/1	4.9	trace	5.36	0.15
8	RB/MNR/1	4.6	trace	5.36	0.15
	Highland				
9	LS/UDCL/1	5.1	trace	5.59	0.14
10	LS/UDCL/2	5.1	trace	5.15	0.10
11	LS/TNKM/1	4.5	0.2	5.29	0.14
12	LS/PMKA/1	6.3	0.95	5.15	0.12
13	RB/RJKD/1	5.1	Trace	5.24	0.11
14	FP/RJKD/1	5.1	Trace	5.95	0.15
	Upland				
15	LS/VLTL/1	5.1	Trace	6.00	0.12
16	LS/VLTL/2	5.1	-do-	5.07	0.17
17	LS/KNTD/1	6.3	0.95	5.36	0.13
18	LS/KNTD/2	6.3	0.95	5.65	0.14
19	LS/VZTP/7	4.5	0.2	5.60	0.16
20	LS/MNPR/1	4.2	0.2	4.95	0.15
21	LS/GANR/1	5	0.05	5.51	0.16
22	LS/RJPM/1	4.2	0.2	5.93	0.12
23	LS/VJKY/1	4.2	0.2	5.90	0.14
24	LS/KTDE/1	5.3	Trace	5.58	0.98
25	LS/KJKY/1	5.3	Trace	5.45	0.12
26	FP/TDPU/1	6.3	0.95	6.40	0.16

It is seen that in majority of the sampling locations, pH of the soil has increased and acidity has reduced when compared to preflood data. The soils are strongly to slightly acidic. Electrical conductivity values are suitable for agricultural production.

Table 5.6.4

Macronutrients

Sl.no	Sample Code	Before Flood			After Flood		
		OC %	P kg/ha	K kg/ha	OC %	P kg/ha	K kg/ha
Mountainous region							
1	LS/KDH/1	3.86	H	78	0.78	4.48	107.52
2	LS/KDH/2	3.86	H	78	1.2	14.51	214.48
3	LS/KDH/3	1.99	H	608.4	3.28	8.64	177.07
4	LS/KDH/4	3.86	H	78	0.7	6.72	39.2
5	LS/KDH/5	2.1	H	79	2.20	5.71	43.34
6	LS/DVKM/1	3.86	H	78	2.34	5.60	80.64
7	LS/MNR/1	3.86	H	78	3.71	6.72	150.08
8	RB/MNR/1	2.3	H	31.2	3.71	6.72	150.08
Highland							
9	LS/UDCL/1	1.18	M	327.6	2.15	20.16	801.92
10	LS/UDCL/2	1.18	M	327.6	2.34	31.36	524.16
11	LS/TNKM/1	1.63	M	101.4	3.74	44.8	88.48
12	LS/PMKA/1	1.26	M	78	2.85	17.92	169.12
13	RB/RJKD/1	1.18	M-H	327.6	1.37	7.62	199.36
14	FP/RJKD/1	1.18	M	327.6	1.37	4.70	252.00
Upland							
15	LS/VLTL/1	2.7	M-H	54.6	0.20	6.94	147.84
16	LS/VLTL/2	2.7	M-H	54.6	0.39	5.6	160.16
17	LS/KNTD/1	1.26	M-H	78	1.29	7.17	651.84
18	LS/KNTD/2	1.26	M-H	78	2.22	6.5	672.00
19	LS/VZTP/7	1.63	L-H	101.4	1.56	8.6	551.04
20	LS/MNPR/1	2.19	L-H	171.6	2.54	8.96	160.16
21	LS/GANR/1	1.46	L-H	210.6	3.32	6.94	492.80
22	LS/RJPM/1	2.19	M-H	171.6	1.09	8.51	10.08
23	LS/VJKY/1	2.19	M-H	171.6	0.39	6.27	86.24
24	LS/KTDE/1	2.57	M	140.4	1.17	7.84	138.88
25	LS/KJKY/1	2.57	M-H	140.4	1.56	6.5	199.36
26	FP/TDPU/1	1.26	L-H	78	0.78	22.40	171.36

L – Low M- Medium H-High

On reviewing the analytical results, a reduction in the fertility status of soils was found. Organic carbon content increased in most of the locations whereas phosphorus and potassium availability was reduced in many locations. In areas where available nitrogen, phosphorus and potassium are low, these nutrients are to be supplemented based on soil test results.

Table 5.6.5

Secondary and micro nutrient status

Since pre flood soil data for secondary and micronutrients are not available, the results could not be compared with preflood values.

Sl. no	Sample Code	Micronutrients (ppm)					Secondary nutrients (ppm)		
		Fe	Mn	Zn	Cu	B	S	Ca	Mg
Mountainous region									
1	LS/KDH/1	17.30	9.20	1.50	2.00	3.52	1.99	146.20	76.72
2	LS/KDH/2	29.49	4.07	1.23	1.75	0.80	23.15	363.45	129.18
3	LS/KDH/3	142.11	17.17	7.62	2.42	0.49	47.74	780.85	267.93
4	LS/KDH/4	12.30	6.30	1.20	1.9	1.20	15.50	125.00	85.00
5	LS/KDH/5-S	67.17	13.87	1.64	1.48	0.88	21.89	121.9	66.60
6	LS/DVKM/1	60.20	2.80	1.40	2.40	1.50	16.25	58.20	62.10
7	LS/MNR/1	37.73	20.47	2.08	1.43	0.72	9.92	358.2	34.90
8	RB/MNR/1	95.80	7.10	3.60	4.10	2.27	2.25	99.20	79.32
Highland									
9	LS/UDCL/1	29.63	14.23	2.13	2.99	6.96	2.45	152.00	74.00
10	LS/UDCL/2	64.50	28.00	1.50	2.30	3.52	2.13	166.40	68.82
11	LS/TNKM/1	26.32	18.69	2.96	3.42	1.89	2.13	11.30	29.63
12	LS/PMKA/1	37.10	9.20	1.70	3.30	3.60	24.50	62.75	58.67
13	RB/RJKD/1	36.10	10.20	1.00	3.00	8.56	2.00	185.05	72.75
14	FP/RJKD/1	20.10	5.26	3.20	2.30	1.60	2.00	212.00	106.00
Upland									
15	LS/VLTL/1	35.23	4.10	2.30	3.10	10.20	12.58	63.00	123.00
16	LS/VLTL/2	21.70	16.50	2.00	1.70	7.80	2.00	152.75	127.30
17	LS/KNTD/1	18.30	10.32	2.20	1.96	5.60	15.71	100.00	154.00
18	LS/KNTD/2	22.00	7.40	2.40	2.30	1.20	6.13	226.05	202.80
19	LS/VZTP/7	45.30	2.18	2.96	2.20	2.80	2.13	115.00	56.32
20	LS/MNPR/1	65.10	15.60	1.60	3.10	3.90	2.50	273.90	79.52
21	LS/GANR/1	48.50	30.80	7.10	3.10	2.63	2.25	268.00	119.47
22	LS/RJPM/1	68.00	20.70	1.60	2.60	2.45	2.34	220.30	134.47
23	LS/VJKY/1	51.70	24.00	1.50	2.80	12.63	3.25	216.75	130.00

24	LS/KTDE/1	56.40	27.00	1.50	2.90	3.20	2.00	195.35	83.47
25	LS/KJKY/1	65.70	22.70	1.20	2.60	10.52	1.88	220.60	77.17
26	FP/TDPU/1	35.63	11.60	2.96	3.20	12.45	2.25	185.00	132.00

Localised deficiency of available calcium, magnesium and sulphur is noticed. In some locations, high boron content is noticed indicating boron toxicity in soil.

PROFILE STUDIES CONDUCTED IN LANDSLIDE AND FLOODED AREAS

Five profile studies were conducted in landslide/ flooded areas of Idukki district to understand the changes in depth and horizon characteristics. Four profiles were studied in landslide areas of Munnar panchayat and one in flooded area of Rajakkad panchayat. The results of the study are presented below. Profile KDH-2 is studied from the edge of landslide, KDH-3&5, MNR-1 are from the landslide scar mid way. The profile FP/RJKD/RC1 was taken from the flooded river bank. Of these, the soil series in KDH-3 was Amrithmedu series and in all other landslide profile it was Mattupetty series. The soil series in flooded riverbank is Kunjithanni series. The analytical results are presented below

Table 5.6.6

Water Holding capacity and Particle size distribution

Sample code	Depth cm	WHC	Particle size distribution %			
			Sand	Clay	Silt	Texture
LS/KDH/2/1/3	0-30	45.17	65.48	14.78	17.33	Sandy Clay Loam
LS/KDH/2/2/3	30-82	36.94	70.8	23.1	6.1	Sandy Clay Loam
LS/KDH/2/3/3	82-180	36.94	54.78	25.48	19.74	Sandy Clay
LS/KDH/3/1/3	0-43	54.09	75.76	21.07	3.16	Sandy Clay Loam
LS/KDH/3/2/3	43-60	39.11	65.41	18.89	15.7	Sandy Loam
LS/KDH/3/3/3	60-190	-	47.71	38.6	13.69	Sandy Clay
LS/KDH/5/1/3	0-30	47.21	59	39.84	1.17	Sandy Clay
LS/KDH/5/2/3	30-75	50.70	60.12	14.79	25.09	Sandy Loam
LS/KDH/5/3/3	75-184	57.32	69.89	15.17	14.94	Sandy Loam
LS/MNR/1/1/3	0-30	-	55.2	26.4	18.4	Sandy Clay Loam
LS/MNR/1/2/3	30-60	69.96	56.25	20.49	23.26	Sandy Clay Loam
LS/MNR/1/3/3	60-198	-	54.78	24.78	20.44	Sandy Clay Loam
FP/RJKD/RC1/1	0-30	55.44	43.65	52.08	4.27	Clay
FP/RJKD/RC1/2	30-55	57.32	58.46	28.96	12.58	Sandy Clay Loam
FP/RJKD/RC1/3	55-124	48.23	51.13	29.81	19.06	Sandy Clay Loam
FP/RJKD/RC1/4	124-130	57.01	54.13	22.45	23.42	Sandy Clay Loam
FP/RJKD/RC1/5	130-148	41.08	58.49	24.18	17.33	Sandy Clay Loam

The soils collected from landslide areas were predominantly sandy clay loam or sandy clay textured and showed medium to high water holding capacity. In general, the soils in landslide area are coarser textured.

Table 5.6.7

PH, EC and macronutrients

Sample code	Depth cm	pH	EC	Macro nutrients		
				OC %	P Kg/ha	K Kg/ha
LS/KDH/2/1/3	0-30	5.6	0.19	1.32	11.58	210.67
LS/KDH/2/2/3	30-82	5.1	0.16	0.12	11.58	106.74
LS/KDH/2/3/3	82-180	5	0.08	0.2	14.51	116.48
LS/KDH/3/1/3	0-43	5.5	0.18	3.99	8.64	151.09
LS/KDH/3/2/3	43-60	5.2	0.11	3	5.71	79.74
LS/KDH/3/3/3	60-190	5	0.09	1.72	5.71	55.89
LS/KDH/5/1/3	0-30	5.4	0.13	0.68	8.64	45.7
LS/KDH/5/2/3	30-75	6.4	0.13	0.12	5.71	27.66
LS/KDH/5/3/3	75-184	6.8	0.18	0.2	8.64	22.96
LS/MNR/1/1/3	0-30	6.4	0.24	0.4	5.71	124.77
LS/MNR/1/2/3	30-60	6.6	0.2	0.92	5.71	88.14
LS/MNR/1/3/3	60-198	6.3	0.18	0.6	2.78	64.96
FP/RJKD/RC1/1	0-30	4.9	0.07	1.20	8.64	246.29
FP/RJKD/RC1/2	30-55	5	0.09	0.12	5.71	312.82
FP/RJKD/RC1/3	55-124	4.7	0.07	0.20	5.71	228.26
FP/RJKD/RC1/4	124-130	4.8	0.08	0.80	5.71	216.05
FP/RJKD/RC1/5	130-148	5.4	0.08	0.48	2.78	320.54

The soils collected from landslide scar and depositional zone showed increased pH and low organic carbon content than the samples collected from areas adjacent to landslide area. The soils are low in available phosphorus and low to medium in Available potassium. The profile collected from Rajakkad showed low to medium Organic carbon and deficiency in available phosphorus.

Table 5.6.8

Secondary and micronutrients

Sample code	Depth cm	Micronutrients (ppm)					Secondary nutrients (ppm)		
		Fe	Mn	Zn	Cu	B	S	Ca	Mg
LS/KDH/2/1/3	0-30	50.52	8.39	1.77	2.06	0.88	22.52	249.85	164.9
LS/KDH/2/2/3	30-82	46.27	3.87	1.41	1.62	0.95	2.04	129.25	129.55
LS/KDH/2/3/3	82-180	24.81	14.07	1.12	1.29	0.8	6.77	73.7	102.1
LS/KDH/3/1/3	0-43	135.52	5.07	5.96	2.72	1.03	50.89	847	76.15

LS/KDH/3/2/3	43-60	75.26	7.71	1.39	2.76	1.18	60.34	133.7	291.43
LS/KDH/3/3/3	60-190	71.75	9.09	2.14	2.51	1.26	28.83	102.55	161.03
LS/KDH/5/1/3	0-30	39.03	6.38	2.73	1.61	1.18	22.52	77.75	83.25
LS/KDH/5/2/3	30-75	20.9	9.1	2.84	1.27	0.8	4.87	93.85	54.13
LS/KDH/5/3/3	75-184	14.27	13.9	2.98	1.29	1.03	2.98	63.5	38.93
LS/MNR/1/1/3	0-30	19.21	9.04	2.51	1.58	1.11	6.77	78.5	34.5
LS/MNR/1/2/3	30-60	32.73	18.36	2.3	1.64	0.8	9.92	102.09	87.18
LS/MNR/1/3/3	60-198	18	7.41	2.12	1.51	1.26	16.22	130.9	54.75
FP/RJKD/RC1/1	0-30	69.26	17.36	2.44	2.00	0.95	3.61	242.4	157.20
FP/RJKD/RC1/2	30-55	55.99	17.38	2.34	1.44	0.88	176.95	243.7	89.75
FP/RJKD/RC1/3	55-124	27.95	16.66	1.88	1.47	0.88	69.80	207.75	98.00
FP/RJKD/RC1/4	124-130	43.75	11.51	1.68	1.83	0.42	57.19	185.25	126.70
FP/RJKD/RC1/5	130-148	28.195	7.78	1.87	1.52	0.27	41.43	235.2	136.45

In general the soils from landslide areas are rich in micronutrient and sulphur though in 4 samples sulphur is deficient.The profile samples collected from flood affected Rajakkad panchayat, except available calcium all others are sufficient.(Available magnesium is deficient in two subsurface samples.)

Table 5.6.9

Exchangeable acidity, Base saturation and Cation Exchange Capacity

Sample code	Depth	Exchangeable bases ($cmolkg^{-1}$)				CEC
		K	Ca	Mg	Na	
LS/KDH/2/1/3	0-30cm	0.32	3.90	3.24	0.08	0.6
LS/KDH/2/2/3	30-82	0.24	1.75	6.39	0.06	0.4
LS/KDH/2/3/3	82-180	0.24	1.75	6.39	0.06	0.4
LS/KDH/3/1/3	0-43	0.24	1.35	4.20	0.11	1
LS/KDH/3/2/3	43-60	0.18	3.24	5.30	0.17	0.3
LS/KDH/3/3/3	60-190	0.38	3.10	4.82	0.14	0.7
LS/KDH/5/1/3	0-30	0.48	3.99	4.20	0.06	0.3
LS/KDH/5/2/3	30-75	0.37	1.37	3.29	0.11	0.1
LS/KDH/5/3/3	75-184	0.43	1.60	3.38	0.04	0.8
LS/MNR/1/1/3	0-30	0.90	2.18	3.28	0.08	0.8
LS/MNR/1/2/3	30-60	0.43	2.32	3.77	0.02	0.5
LS/MNR/1/3/3	60-198	1.02	4.05	2.18	0.04	0.9
FP/RJKD/RC1/1	0-30	0.16	1.14	2.78	0.04	2
FP/RJKD/RC1/2	30-55	0.56	1.37	1.70	0.11	0.7

FP/RJKD/RC1/3	55-124	0.42	3.89	4.05	0.06	2.3
FP/RJKD/RC1/4	124-130	0.25	2.54	2.38	0.03	0.7
FP/RJKD/RC1/5	130-148	0.40	3.17	4.03	0.02	0.5

All the soils have low CEC . The soils were totally intermixed and were found in such a state that characteristics were highly variable throughout the horizons. The changes in soil morphological features caused by landslide deposition observed in this study indicated that landslides destroy the original soil profiles.

Sl.no	Sample code	Series	Remarks
1	LS/KDH/2	Mattupetty	As per profile description, in Mattupetty series surface texture is clay loam to silty clay loam and subsurface texture is clay loam to clay. But as per the textural analysis of the site it is seen that surface soil was totally eroded and sand content has increased in all depths indicating intermixing of different horizons/soils from elsewhere.
2	LS/KDH/3	Amritamedu	As per the series description silt loam in surface and clay loam or clayey texture is observed down the profile, but in the study area increased sand content is noticed and texture observed is outside the range in characteristic of Amrithamedu series. Moreover Amrithamedu soils are moderately deep resting on gneissic parent material at a depth of 60-90cm. But in this Increased soil depth of 180cm was noticed indicating the deposition of soils from elsewhere. Intermixing of diffent horizons were also noticed.
3	LS/KDH/5	Mattupetty	There is change in texture, colour when compared to typical profile; sand content increased in all horizons studied and the surface and subsurface texture noticed is outside the range in characteristics of Mattuppetty series. This indicates deposition of soil from elsewhere and intermixing of horizons.
4	FP/RJKD/RC1	Kunjithanni	The surface texture ranges from clay loam to sandy clay loam and that of the subsurface is clay loam to silty clay loam in typical profile but in the profile studied, But as per analytical result surface texture is clay. Instead of increasing clay down the profile, sand content increased.Textural change and increased profile Depth indicating sediment

			deposition . soils showed poor CEC
5	LS/MNR/1-RC 1	Mattupetty	Sandy clay loam texture was observed through out. Surface soil was totally eroded and intermixing of soils from different places and different depth was observed.

The description of soil series studied are given below.

KUNJITHANNI SERIES

Kunjithanni series are deep, well drained soils, developed from gneissic parent material, which occurs on steeply to very steeply sloping hills and mounds at an elevation 600-1200m above MSL. They have a dark brown to reddish brown, clay loam to sandy clay loam surface and yellowish red to red, clay loam subsurface. Fine gravels (10 to 20%) are distributed in the subsoil. Weathering gneissic material occupies more than 50% of the solum below 125cm.

Taxonomic classification : fine loamy, mixed isohyperthermic Oxic Dystrustepts.

Typifying pedon: Kunjithanni – sandy clay loam-cultivated.

Ap	0-13cm	Dark brown (7.5YR 3/2M); sandy clay loam; weak fine subangular blocky; friable, slightly sticky and non plastic; many fine and medium roots; many fine and medium pores; moderate permeability; pH 4.9; clear smooth boundary.
AB	13-27cm	Reddish brown (5YR 4/4M); clay loam; weak, fine, subangular blocky; friable, slightly sticky and non plastic; fine gravels 14%; many fine and medium roots; many, fine and medium pores; moderate permeability; pH 4.9; clear smooth boundary.
BA	27-47cm	Reddish brown (5YR 4/4M); gravelly loam; weak fine subangular blocky; friable slightly sticky and non plastic; fine gravels 25%; common fine roots; many fine and medium pores; moderate permeability; pH 4.9; clear smooth boundary.
Bw_1	47-74cm	Red (2.5YR 4/6M); clay loam; weak medium subangular blocky; friable, slightly sticky and plastic; many fine and medium pores; moderate permeability; pH 4.7; clear smooth boundary.
Bw_2	74-90cm	Yellowish red (5YR 4/6M); clay loam; weak medium subangular blocky; friable; slightly sticky and slightly plastic; 17% fine gravels; weathering gneissic material 15%; many fine and

		medium pores; moderate permeability; pH 4.7; clear smooth boundary.
Bw_3	90-115cm	Yellowish red (5YR 4/6M); clay loam; weak medium subangular blocky; friable, slightly sticky and slightly plastic; 15% fine gravels; weathering gneissic material about 30%; many fine and medium pores; moderate permeability; pH 4.8; clear wavy boundary.
BC	115-141cm	Yellowish red (5YR 4/6M); clay loam; weak medium subangular blocky; friable, slightly sticky and slightly plastic; 13% fine gravels; weathering gneissic material about 50%; moderate permeability; pH 5.0.

Range in Characteristics:

The surface texture ranges from clay loam to sandy clay loam and that of the subsurface is clay loam to silty clay loam. The colour of the surface is reddish brown to dark brown in hue 5 YR and 7.5YR value 3 to 4 chroma 2 to 4, and that of the subsurface ranges from yellowish red to red in hue 2.5 YR to 5YR value 4 and 5 and chroma 6 to 8.

Associated series

Principal associated series is Mullanthandu series which is Typic Kanhaplustults.

Drainage and permeability

Well drained with moderate permeability.

Land use

Pepper, arecanut, banana etc are cultivated.

Type Location:

Irupathu acre along Kunjithanni – Pottenkadu route, Santhanpara panchayat, UdumbancholaTaluk.

Series proposed by : Soil survey Organization, Kerala

Interpretative grouping

Land capability class :-IIIe, IVe, IVes

Land Irrigabilityclass :- 3t, 4t

Nutrient status

Nitrogen – Medium

Phosphorus – Low

Potassium - High

General Recommendation

Proper management practices may be adopted while growing crops. Contour bunding may be done to prevent erosion. Proper drainage must be provided during rainy season.

ANALYTICAL RESULTS OF KUNJITHANNI SERIES

Depth (cm)	Gravel (%)		Total sand (%)	Clay (%)	Silt (%)	Sand fractions (%)					pH	
	/wt	/Vol				vc	c	mc	f	vf	1:1	1:2.5
0-13	-	-	54.08	30.10	13.82	21.86	13.95	10.08	6.77	1.42	4.9	5.1
13-27	32	14	34.93	35.07	30.0	10.20	9.63	4.67	8.8	1.63	4.9	5.1
27-47	35	25	40.92	26.08	33.0	16.18	5.40	3.31	15.08	0.95	4.9	5.2
47-74	-	-	38.15	37.85	24.0	10.38	14.36	4.85	8.41	0.15	4.7	4.9
74-90	31	17	39.64	35.98	24.38	9.80	12.98	6.85	9.90	0.11	4.7	4.9
90-115	28	15	37.68	36.10	26.22	11.21	8.0	10.92	6.60	0.95	4.8	5.0
115-141	27	13	41.97	36.82	21.21	9.55	13.05	9.32	8.55	1.50	5.0	5.1

Depth (cm)	EC (d s/m)		Exch H^+ (cmol /kg)	Exch $A1^{3+}$ (cmol /kg)	Extra-ctable acidity (cmol /kg)	Exch. Bases (c mol /kg)				CEC (c mol /kg)	ECEC (c mol /kg)	Organic Carbon (%)	Base Saturation (%)
	1:2	1:2.5				Na	K	Ca	Mg				
0-13	Trace	Trace	0.9	-	19.9	0.23	0.42	2.3	0.9	6.0	2.85	1.18	48
13-27	"	"	0.8	-	19.9	0.13	0.46	1.0	0.9	4.0	2.49	1.05	62
27-47	"	"	0.3	0.8	19.9	0.14	0.33	0.8	0.55	4.0	2.62	1.05	46
47-74	"	"	0.4	1.5	19.9	0.13	0.35	1.0	0.40	3.2	3.38	1.02	59
74-90	"	"	0.9	1.9	19.9	0.13	0.19	0.7	0.40	3.9	3.32	1.01	36
90-115	"	"	0.4	2.0	19.9	0.11	0.16	0.2	0.20	2.6	2.67	0.88	26
115-141	"	"	0.3	-	19.9	0.08	0.19	0.2	0.15	2.4	0.62	0.35	26

AMRITAMEDU SERIES

Amritamedu series are moderately deep, well drained hill and mountain soils with moderate permeability occurring at very steeply sloping and steeply sloping rocky and stony ridges and mountain tops at an elevations above 900m MSL. These areas are normally covered by shrubs and grasses. It has dark brown to brown silty loam to silty clay loam surface followed by reddish yellow to yellowish red, clay loam to clayey subsoil. Fine gravels are above 10-15 percent in the surface and about 15-40 percent in the subsurface. Stones are embedded throughout the profile. Gneissic parent material at different stages of weathering is observed below a depth of 60-90cm. Principal associated series is Anamudi series which is Typic Kandihumults

Taxonomic classification : fine loamy mixed isohyperthermic Oxic Dystrustepts.

Typifying pedon: Amrithamedu – silty loam – barren

A1	0-9cm	Dark brown (7.5YR 3/2M); silt loam; weak medium granular; friable, non sticky and non plastic; many fine roots; many fine and medium pores; moderate permeability; pH 4.9; clear smooth boundary.
AB	9-23cm	Dark brown to brown (7.5YR 4/4M); gravelly clay loam; weak medium subangular blocky; friable, slightly sticky and slightly plastic; many fine roots; many medium and fine pores; moderate permeability; pH 5.4; clear smooth boundary.
Bw_1	23-36cm	Dark brown to brown (7.5YR 4/4M); gravelly clay loam; weak medium subangular blocky; firm, sticky and plastic; few fine roots; moderately rapid permeability; pH 5.4; clear wavy boundary.
Bw_2	36-64cm	Yellowish red (5YR 5/6M); gravelly clay loam; moderate medium subangular blocky; firm, sticky and plastic; 10% fine gravels and 30% stones; weathering gneissic material about 15%; very few fine roots; moderately rapid permeability; pH 5.4; wavy boundary.
BC	64-86cm	Reddish yellow (5YR 6/8M); clay; moderate medium subangular blocky; firm, sticky and very plastic; weathering gneissic material about 20%; many fine pores; moderate permeability; pH 5.7; abrupt wavy boundary.

Range in Characteristics:

It has dark brown to brown silt loam to silty clay loam surface followed by reddish yellow to yellowish red, clay loam to clayey subsoil. The colour of the surface ranges from dark brown to brown in hue 7.5YR, value 3 and 4 and chroma 2 to4 and its texture ranges from silt loam to silty clay loam. The subsurface colour ranges from yellowish red to reddish yellow in hue 5YR and 7.5YR value 4 to 6 and chroma 6 to 8. The solum thickness ranges from 60-100cm. Stones are embedded throughout the profile.

Type location:

Elappara Tea Estate, 1km from Elappara along Elappara-Vagamon road, Elapparapanchayat,PeerumeduTaluk.

Use and vegetation

Presently these areas are under grass and shrubs. Some areas are planted with tea, coffee and pepper.

Associated soils

Anamudi which is Typic kandihumults

Drainage and permeability

Well drained with moderate permeability.

Interpretative grouping

Land capability class :- VI es ,VII e, VII es

Land capability class :- 6t, 6st

Nutrient status

Nitrogen – low to Medium

Phosphorus – low to Medium

Potassium - low to High

General recommendation

These soils are moderately deep and highly susceptible to erosion. They are not suitable for agricultural use.

ANALYTICAL RESULTS OF AMRITAMEDU SERIES

Depth (cm)	Gravel %	Sand fractions (%)					Total sand	silt	clay	Organic carbon (%)	PH	
	By vol.	v c	c	mc	f	v f					1:1	1:2:5
0-9	15	4.11	3.26	10.91	0.34	2.09	20.71	59.18	20.11	1.99	4.9	4.9
9-23	35	10.01	11.26	5.99	6.27	3.33	36.86	29.23	33.91	1.85	5.2	5.4
23-36	32	5.49	11.21	12.52	10.11	5.49	44.82	22.22	32.96	0.96	5.4	5.4
36-64	33	4.22	12.28	12.09	12.66	2.49	43.74	17.28	38.98	0.77	5.4	5.4
64-86	38	3.47	9.93	4.22	9.93	3.23	30.78	18.21	51.01	0.41	5.5	5.7

Depth (cms)	EC (ds/m)		Acidity			Exchangeable bases (c mol/kg)				CEC	ECEC	Base saturation %
			1.0N KCl		Total Acid							
	1:2	1:2.5	H+	Al 3+		Na+	K+	Ca+	Mg+	(c mol/kg)		
0-9	1.10	1.11	1.9	0.4	2.30	0.36	0.78	0.60	0.10	5.6	2.24	33
9-23	1.52	1.52	1.9	0.4	2.30	0.38	0.36	0.80	0.20	5.6	2.14	31
23-36	1.02	1.04	1.25	-	1.25	0.15	1.53	0.80	0.30	4.4	2.78	63
36-64	0.80	0.89	1.3	-	1.3	0.11	0.26	0.3	0.20	4.1	0.87	21
64-86	1.07	1.09	1.5	-	1.5	0.18	0.33	0.4	0.20	3.5	1.11	32

MATTUPETTY SERIES

Mattupetty series are very deep, well drained mountain soils occurring in very steeply sloping side slopes and steeply sloping hill tops at an elevation 1200m above MSL. They have a reddish brown to dark brown, clay loam surface and red to reddish yellow clay loam to clay subsurface. Occasionally fine gravels occur in the subsoil.

Taxonomic classification:fineclayey mixed isohyperthermicTypic Kanhaplohumults.
Typifying pedon:- Mattupetty - clay loam - grass land.

A1	0-13	Dark brown, (7.5YR 3/2 M); clay loam; weak medium granular to subangular blocky; very friable, non-sticky and slightly plastic; 6% fine gravels; many fine roots, many fine pores, moderately rapid permeability; pH 4.9; clear smooth boundary.
AB	13-33	Reddish brown (5YR 4/4 M); gravelly clay loam ;weak fine granular to subangular blocky; very friable, slightly sticky and non-plastic; fine gravels 38%; many fine roots; many fine pores; moderately rapid permeability; pH 5.0; clear wavy boundary.
Bt1	33-55	Red (2.5YR 5/8 M); sandy clay; weak medium subangular blocky; friable, sticky, and very plastic; 4% fine gravels; many fine roots; many fine and medium pores; moderate permeability; pH 5.2; gradual smooth boundary.
Bt2	55-77	Light-red (2.5YR 6/8M); clay; weak, medium subangular blocky; friable, very sticky and plastic; fine and medium roots; many fine pores; moderate permeability; pH 5.3; diffuse smooth boundary.
Bt3	77-99	Reddish Yellow (5YR 7/5M); clay loam; common medium dark reddish brown (10YR 4/8M) mottles; weak medium subangular blocky; very friable, very sticky and plastic; 7% fine gravel; moderate permeability; pH 5.4; diffuse smooth boundary.

Bt4	99-151	Reddish yellow (5YR 7/6M); sandy clay loam; common medium red(10 YR 4/8M) mottles; weak medium subangular blocky; friable, slightly sticky and slightly plastic; fine gravels 9%; moderate permeability; pH 5.5; diffuse smooth boundary.
BC	151-200	Reddish yellow (5YR 7/6M); sandy clay loam; common medium red (10YR 4/8M) mottles; weak, medium subangular blocky; friable slightly sticky and slightly plastic; moderate permeability; pH5.6.

Range in Characteristics:

The surface texture varies from clay loam to silty clay loam. The surface colour ranges in hue 5YR to 7.5YR and value 3 to 4 and chrome 2 to 4. The subsurface texture ranges from clay loam to clay. The upper portion of the argillic horizon has a clayey texture and the clay content decreases with depth. The colour of the subsoil ranges in hue 2.5YR and 5YR, value 4 to 7 and chroma 6 to 8. Red (10YR 4/8) mottled areas are seen in the subsoil from a depth below 77cm.

Associated series

Principal associated series are Arivikkad series which is Typic Udorthents and Adimali series which is Typic Kandihumults.

Drainage and permeability

Well drained with moderately rapid permeability.

Land Use :- Major crop is Eucalyptus

Type location: Mattupetty

Series proposed by : Soil survey Organization, Kerala

Interpretative grouping

Land capability class :-VIe, VIIe

Land Irrigability class :- 6t

Nutrient status

Nitrogen – Medium to High

Phosphorus – Medium to High

Potassium - Medium

General Recommendation

The soil is not suitable for agricultural use.

ANALYTICAL RESULTS OF MATTUPETTY SERIES

Depth (Cm)	Gravel %		Sand fractions %					Total sand %	Silt %	Clay %	Organic Carbon %	pH (1:2.5)
	By wt	By vol.	Vc	C	mc	f	vf					
0-13	10.0	6.0	8.88	9.47	10.47	5.56	0.79	35.17	32.92	31.91	3.86	4.9
13-33	42.31	38.36	15.06	14.19	4.78	2.75	0.75	37.53	26.75	35.72	1.91	5.0
33-55	7.0	3.90	15.35	14.05	9.84	5.66	3.26	48.16	11.03	40.81	1.8	5.2
55-77	-	-	8.62	5.28	10.82	8.72	3.29	36.73	6.2	57.07	1.9	5.3
77-99	9.0	7.0	7.48	8.53	9.69	12.36	3.75	41.81	27.74	30.45	0.50	5.4
99-151	12.75	9.00	6.85	7.91	12.72	13.51	7.18	48.17	23.15	28.68	0.47	5.5
151-200	-	-	7.26	8.74	17.98	18.49	5.88	58.35	20.08	21.57	0.42	5.6

Depth (cms)	EC(ds/M)		Exchangable bases(c mol/kg)				CEC	Base saturation %
	1:2	1:2.5	Na	K	ca	mg		
0-13	trace	trace	0.06	0.10	0.4	0.2	3.4	22
13-33	"	"	0.12	0.18	0.4	0.3	3.3	30
33-55	"	"	0.06	0.05	0.4	0.3	3.1	26
55-77	"	"	0.08	0.10	0.4.	0.4	3.2	31
77-99	"	"	0.08	0.10	0.7	0.3	2.6	45
99-151	"	"	0.08	0.13	0.7	0.5	3.0	46
151-200	"	"	0.03	0.09	0.6	0.3	2.5	40

SEDIMENT ANALYSIS IN THE DISTRESS AFFECTED AREA

Three sedimented silt samples were collected from the Periyavarum area in Munnar village (SD/MNR/1 to 3). Silt deposition to 198 cm depth was observed in this area. In Panniyarkutty land slide area in Rajakkad Panchayath, the entire soil washed off and debris finally deposited in the river beneath. Silt deposition to a thickness of 2m was found over the top soil. The samples of SD/RJKD/1 &2 were taken from the site. Thadiyambadu area was severely flood affected due to the raising of the dam shutters of Idukki and Mullaperiyar dam. Silt deposited samples were collected from this site. (SD/TDPU/1)

The analytical results of sediment samples are presented below.

Table 5.6.10

Particle size distribution and Soil texture

Sl.no	Sample code	Soil Texture	Particle size distribution %		
			Sand	Silt	clay
1	SD/MNR/1	Sand	88.15	11.37	0.48
2	SD/MNR/2	Sand	89.36	9.95	0.69
3	SD/MNR/3	Sand	86.87	12.31	0.82
4	SD/TDPU/1	Sand	91.36	8.08	0.56
5	SD/RJKD/1	Sand	88.34	11.04	0.62
6	SD/RJKD/2	Sand	87.15	12.36	0.49

All sediment samples are sandy textured indicating the leaching of fine materials in flood or debris flow.

Table 5.6.11

pH, Electrical Conductivity and macronutrients of Sediments

Sl. no	Sample code	Location(GPS)	Panchayat	pH	EC	Macronutrients		
						OC %	P kg/ha	K kg/ha
1	SD/MNR/1	10^o 06' 26.6" 77^o 03' 30.2"	Munnar	5.81	0.12	0.59	24.64	137.76
2	SD/MNR/2	10^o 06' 26.6" 77^o 03' 30.2.23"	-do-	6.04	0.08	0.78	20.16	59.36
3	SD/MNR/3	10^o 06' 26.6.1" 77^o 03' 30.2.23"	-do-	6.11	0.11	1.17	6.72	60.48
4	SD/TDPU/1	9^o 52' 48.9" 76^o 58' 10.9"	-do-	5.85	0.12	0.39	29.12	58.24
5	SD/RJKD/1	9^o 58' 36.2" 77^o 03' 31.9"	Rajakkad	6.04	0.1	0.2	5.6	60.48
6	SD/RJKD/2	Near by area	-do-	6.1	0.11	0.39	8.06	107.52

The soils are medium acid to slightly acidic, low to medium in organic carbon, phosphorus and potassium. Three sediment samples were collected from Munnar panchayat. Difference in nutrient status was observed among these three layers indicating intermixing of horizons and parent materials from different parts of the landslide area. The sediment samples collected from Thadiyambadu area showed that the native fertility is washed off by the flood. The samples are poor in Available nitrogen and potassium. The sediment sample collected from

Panniyarkutty landslide area the soils are poor in Available nitrogen, phosphorus and potassium.

Table 5.6.12

Secondary and micronutrients of Sediments

Sl. no	Sample code	Micronutrients (ppm)					Secondary nutrients (ppm)		
		Fe	Mn	Zn	Cu	B	Ca	Mg	S
1	SD/MNR/1	52.63	22.00	1.54	2.30	2.45	128.00	56.00	1.88
2	SD/MNR/2	67.80	7.20	2.10	1.80	3.21	122.70	51.80	2.25
3	SD/MNR/3	42.63	6.50	2.30	2.30	3.54	116.00	42.00	1.88
4	SD/TDPU/1	17.30	5.90	2.10	1.90	3.52	116.75	103.40	2.25
5	SD/RJKD/1	48.96	12.36	1.70	1.85	2.63	127.00	40.00	2.88
6	SD/RJKD/2	12.20	5.40	1.80	2.00	3.84	94.10	49.32	2.38

On analysis, it is seen that the sediment samples are rich in micronutrients but deficient in secondary nutrients. This may be due to leaching of bases through debris flow and flood.

Table 5.6.13

Exchangeable bases

Sl.no	Sample code	Exchangeable bases $cmolkg^{-1}$				
		K	Ca	Mg	Na	CEC
1	SD/MNR/1	0.22	0.88	0.71	0.01	1
2	SD/MNR/2	0.17	0.75	0.76	0.01	0.3
3	SD/MNR/3	0.12	0.57	0.54	0.01	1
4	SD/TDPU/1	0.10	0.81	0.70	0.01	0.9
5	SD/RJKD/1	0.20	0.76	1.39	0.02	1.2
6	SD/RJKD/2	0.10	1.37	1.96	0.02	0.3

The samples have extremely low CEC and rich base status. The low CEC may be due to the predominance of sand and low organic matter content in the soil.

Results of the study in Idukki district can be summarised as below.

A reduction in the soil pH and nutrient status were observed in these soils.

- Deficiency of sulphur, magnesium, calcium and phosphorus is widespread
- Potassium and organic carbon deficiency is seen localised.

- In the soils of landslide areas intermixing of soil horizons and sand- silt depositions at various depths were observed.
- Cultivation should be avoided in areas having slope more than 33 %.
- If cultivation in such areas is unavoidable, proper soil conservation measures with provision to drain off excess water have to be adopted.
- As the pH of the soil is reduced, the plants become susceptible to fungal diseases and nutrient availability also got decreased. So application of lime is the first step to ameliorate these soils.
- Due to the heavy impact of rain, the soil structure was destroyed in most of the areas . Also removal of top soil has been noticed in many areas. So in order to improve the soil structure and replenish fertility organic matter application is recommended.
- Soil test based fertilizer application is to be done in affected areas

ERNAKULAM

Total Geographic Area : 3,05,826 Ha

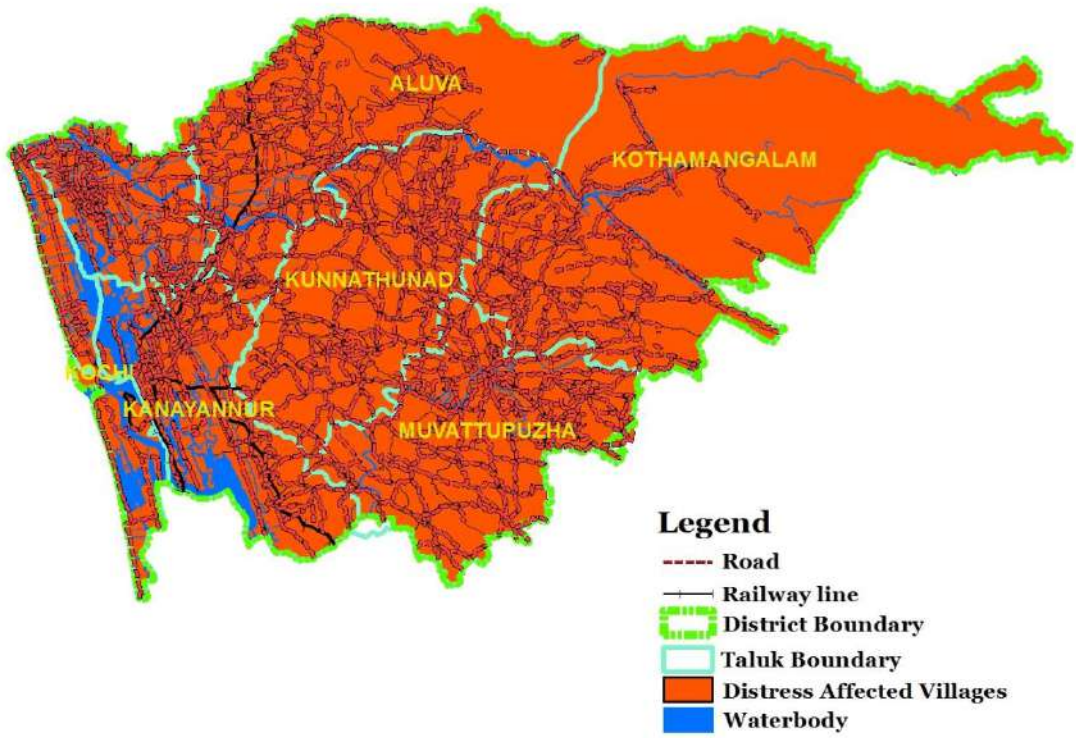
No. of Taluks : 7

No. of Villages : 117

RIVER BASINS

- *Periyar*
- *Muvattupuzha*
- *Chalakkudy river*

DISTRESS AFFECTED VILLAGES



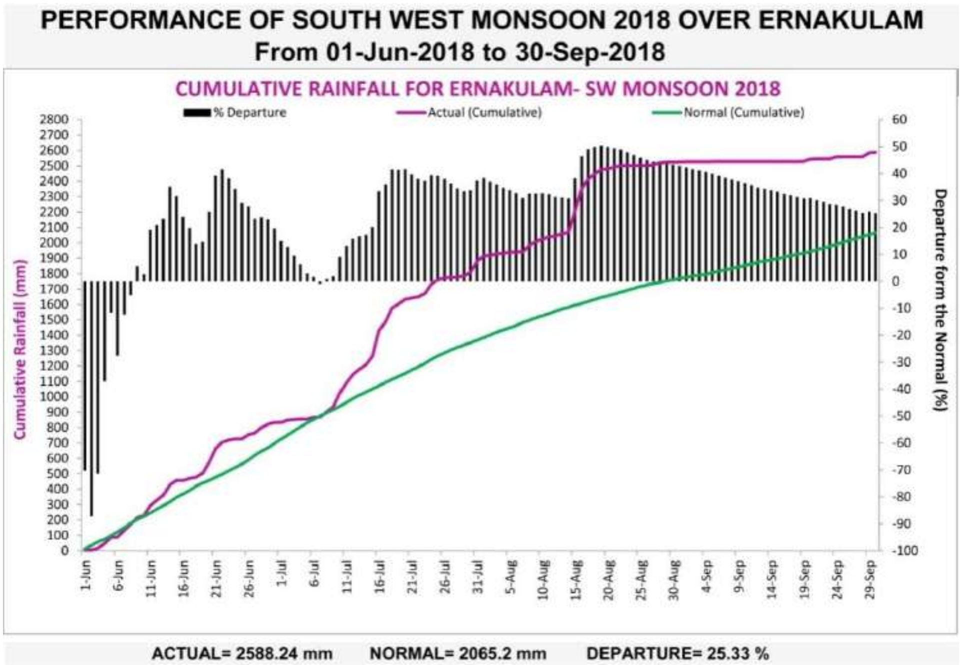
5.7. ERNAKULAM DISTRICT

Ernakulam district lies in the western side of Kerala State adjoining the Arabian sea. The district is bounded by 46 km coastline of the Arabian sea on the west, Kottayam and Alappuzha district on the south, Idukki and the state of Tamilnadu on the east and Thrissur on the north. The total geographical area of the district is 3,05,826 ha.

Ernakulam district possesses a well differentiated diversity physiography, soil types and vegetation. The district can be broadly divided into five physiographic classes viz. lowland, midland, midupland, upland and highland.. The major rivers of the district are Periyar and Muvattupuzha . The drainage pattern is dendritic.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

During the south west monsoon 2018, district receives 500mm more rainfall than the normal rainfall usually received in the district. Very heavy localized rainfall pattern was also seen in many parts of the district. From the rainfall pattern in the graph, it can be inferred that the peak during mid August along with opening of dams in the upper reaches of Periyar have contributed heavy flood in the lower reaches of the district. Opening of Idukki, Mullaperiyar and Idamalayar dams during the peak rainfall in Mid August aggravated the widespread damage to infrastructural facilities and Agriculture to this commercial capital of Kerala.



IMPACT OF DISTRESS IN THE DISTRICT

Eranakulam district is the worst affected district due to floods. The areas adjacent to the lower reaches of Periyar river basin is flooded for 3-4 days. The river course has changed in some places and river overflow through inhabited areas. Out of 82 panchayats in Ernakulam District, only three panchayats viz. Elanji and Palakuzha panchayats in Muvattupuzha Taluk and Vadvucode Puthencruez panchayat in Kunnathunad Taluk were not affected by flood that occurred during August 2018. All the panchayats in ParavurTaluk were fully affected by Flood. Paravur, Aluva, Kothamangalam and Eloor municipalities were fully affected by Flood. Cochin International airport has to shutdown from August 12th to 29th 2018 due to flooding. Cochin Metro had to suspend its activities temporarily. Road and railway network had been damaged disrupted the transport network within and outside district .

Table 5.7.1

Panchayats affected by flood occurred in August 2018 in Eranakulam district

Name of Taluk	Sl no	Name of Panchayat	Whether Flood affected or not
Kochi			
	1	Pallipuram	Yes,Fully
	2	Kuzhupilly	Yes,Fully
	3	Edavanakkad	Yes,Fully
	4	Nayarambalam	Yes,Fully
	5	Narakkal	Yes,Fully, Except one ward
	6	Elamkunnapuzha	Yes, Partly
	7	Kumbalangi	Only 4 wards affected
	8	Chellanum	Only 1 ward affected
Paravur			
	9	Vadakkekara	Yes,Fully
	10	Chennamangalam	Yes,Fully
	11	Puthenvelikkara	Yes,Fully
	12	Kunnukara	Yes,Fully
	13	Chittatukara	Yes,Fully
	14	Ezhikkara	Yes,Fully
	15	Kottuvally	Yes,Fully
	16	Karumalloor	Yes,Fully
	17	Alangad	Yes,Fully
	18	Varappuzha	Yes,Fully
	19	Kadungalloor	Yes,Fully
Kanayannur			
	20	Kadamakudi	Yes,Fully
	21	Cheranallur	Yes,Fully
	22	Mulavukad	Yes, Partly
	23	Udayamperoor	Yes,Fully, Except one ward
	24	Kumbalam	Yes,Fully

	25	Chottanikkara	Yes, Partly
	26	Mulamthuruthy	Yes, Partly
	27	Amballoor	Yes, Partly
	28	Edakkatuvayal	Only two wards affected
Muvattupuzha			
	29	Paipra	Yes, Partly
	30	Valakom	Yes,Fully, Except two wards
	31	Ayavana	Yes,Fully, Except two ward
	32	Ramamangalam	Yes,Fully
	33	Marady	Yes, Partly
	34	Arakkuzha	Yes, Partly
	35	Avoli	Yes, Partly
	36	Manjalloor	Yes, Partly
	37	Kalloorkad	Only one ward affected
	38	Maneed	Yes, Partly
	39	Pampakuda	Yes, Partly
	40	Thirumaradi	Yes, Partly
	41	Elanji	Not affected
	42	Palakuzha	Not affected
Kothamangalam			
	43	Kottappady	Only two wards affected
	44	Pindimana	Only one ward affected
	45	Keerampara	Yes, Partly
	46	Nellikuzhy	Only four wards affected.
	47	Varapetty	Yes, Partly
	48	Pallarimangalam	Yes, Partly
	49	Kavalangad	Yes, Partly
	50	Pothanikad	Yes, Partly
	51	Paingottur	Yes, Partly
	52	Kuttampuzha	Yes,Fully
Kunnathunad			
	53	Poothrika	Yes, Partly
	54	Vengur	Yes, Partly
	55	Mudakuzha	Yes, Partly
	56	Koovappady	Yes,Fully, Except three wards
	57	Vazhakulam	Yes,Fully, Except four wards
	58	Vengola	Yes, Partly
	59	Rayamangalam	Only two wards affected
	60	Assamannur	Yes, Partly
	61	Kizhakkambalam	Yes, Partly
	62	Kunnathunad	Only three wards affected
	63	Mazhuvannur	Yes, Partly
	64	Ikkaranad	Yes, Partly
	65	VadavucodePuthencruez	Not affected
	66	Thiruvaniyoor	Yes, Partly
	67	Okkal	Yes,Fully
Aluva			
	68	Karukutty	Yes, Partly
	69	Mookannur	Yes, Partly
	70	Manjapra	Yes,Fully
	71	Ayyampuzha	Yes, Partly

	72	Parakkadavu	Yes,Fully, Except three wards
	73	Thuravur	Yes,Fully, Except one ward
	74	Malayattur- Nileswaram	Yes,Fully
	75	Chengamanad	Yes,Fully
	76	Nedumbassery	Yes,Fully, Except one ward
	77	Kaladi	Yes,Fully
	78	Kanjoor	Yes,Fully
	79	Sreemolanagaram	Yes,Fully
	80	Keezhmadu	Yes,Fully, Except one ward
	81	Choornikkara	Yes, Partly
	82	Edathala	Yes, Partly
Corporations			
	1	Kochi	Yes, Partly
Municipalities	1	Tripunithura	Yes, partly
	2	Paravur	Yes,Fully
	3	Angamali	Yes, partly
	4	Aluva	Yes,Fully
	5	Kalamasseri	Yes, partly
	6	Perumbavoor	Yes, partly
	7	Kothamangalam	Yes,Fully
	8	Muvattupuzha	Yes, partly
	9	Eloor	Yes,Fully
	10	Maradu	Only 6 wards affected
	11	Thrikkakara	Only 3 wards affected
	12	Piravom	Yes, Partly
	13	Koothattukulam	Not affected

(Source: Deputy director(panchayats),Ernakulam)

The major physiographic divisions affected by flood in the district are lowland and midland areas. Hence the study mainly confined to theses areas. It was undertaken to evaluate the changes in soil health of the distress affected panchayats in the district

FIELD TRAVERSING AND SOIL SAMPLING

Field traversing of the affected areas was carried out and soil samples were collected from 23 panchayats, 1 municipality and Kochi corporation which were fully flood affected. Soil samples were collected at a depth of 0-30 cm. The details of sampling locations is presented below.

Table 5.7.2

Sampling locations

Sl. no	Sample no	Latitude	Longitude	Panchayat	River basin	Slope %	Physiographic position
1	SMN/F/7	NA	NA	Sreemoolanagaram	Periyar	1-3%	Lowland
2	SMN/F/10	NA	NA	Sreemoolanagaram	Periyar	1-3%	Lowland
3	KJR/F/1	$76^0$24’50.4”E	$10^0$08’43.8”N	Kanjoor	Periyar	1-3%	Lowland
4	KJR/F/2	76^0 25’3.1”E	10^0 08’47.1”N	Kanjoor	Periyar	1-3%	Lowland
5	KJR/F/3	76^0 24’ 53”E	10^0 08’36.6”N	Kanjoor	Periyar	1-3%	Lowland

6	KLD/F/1	$76^0$26’46.6”E	10^0 10’21.7”N	Kalady	Periyar	3-5%	Midland
7	KLD/F/2	$76^0$26’55.3”E	10^0 10’ 6.8”N	Kalady	Periyar	1-3%	Midland
8	KKA/F/1	$76^0$18’49.9”E	10^0 09’22.7”N	Kunnukara	Periyar	1-3%	Lowland
9	KKA/F/2	NA	NA	Kunnukara	Periyar	1-3%	Lowland
10	KKA/F/3	NA	NA	Kunnukara	Periyar	3-5%	Lowland
11	PKA/F/1	$76^0$15’48.6”E	10^0 10’ 13”N	Puthenvelikkara	Periyar	1-3%	Lowland
12	PKA/F/2	$76^0$15’49.9”E	10^0 10’12.3”N	Puthenvelikkara	Periyar	1-3%	Lowland
13	CGM/F/1	NA	NA	Chennamangalam	Periyar	3-5%	Lowland
14	CGM/F/2	NA	NA	Chennamangalam	Periyar	1-3%	Lowland
15	CTA/F/1	$76^0$14’47.8”E	10^0 09’37.8”N	Chittattukara	Periyar	1-3%	Lowland
16	CTA/F/2	$76^0$14’51.4”E	10^0 09’17.6”N	Chittattukara	Periyar	1-3%	Lowland
17	KMR/F/1	76^0 18’ 59”E	10^0 08’34.4”N	Karumalloor	Periyar	1-3%	Lowland
18	KMR/F/2	$76^0$18’58.4”E	10^0 08’35.9”N	Karumalloor	Periyar	3-5%	Lowland
19	AGD/F/1	$76^0$18’20.5”E	10^0 07’ 5.3”N	Alangad	Periyar	1-3%	Lowland
20	AGD/F/2	$76^0$18’12.2”E	10^0 06’45.9”N	Alangad	Periyar	3-5%	Lowland
21	KDR/F/1	$76^0$18’7.2” E	$10^0$05’14.14”N	Kadungallur	Periyar	1-3%	Lowland
22	KDR/F/2	$76^0$18’4.9” E	10^0 05’16.2”N	Kadungallur	Periyar	0-1%	Lowland
23	EKP/F/1	$76^0$13’56.1”E	10^0 01’48.5”N	Elamkunnapuzha	Periyar	1-3%	Lowland
24	EKP/F/2	NA	NA	Elamkunnapuzha	Periyar	0-1%	Lowland
25	EKP/F/3	$76^0$13’55.9”E	10^0 01’53.4”N	Elamkunnapuzha	Periyar	1-3%	Lowland
26	EKD/F/1	NA	NA	Edavanakkad	Periyar	1-3%	Lowland
27	EKD/F/2	NA	NA	Edavanakkad	Periyar	0-1%	Lowland
28	KBG/F/1	NA	NA	Kumbalangi	Muvattupuzha	1-3%	Lowland
29	NJK/F/1	NA	NA	Njarakkal	Periyar	0-1%	Lowland
30	KCT/F/1	NA	NA	Kochi Corporation	Periyar	1-3%	Lowland
31	RGM/F/1	$76^0$30’25.6”E	$9^0$58’17.3”N	Ramamangalam	Muvattupuzha	3-5%	Midland
32	RGM/F/2	$76^0$30’20.8”E	$9^0$57’38.9”N	Ramamangalam	Muvattupuzha	1-3%	Lowland
33	VKM/F/1	$76^0$30’29.9”E	09^0 58’ 37”N	Valakam	Muvattupuzha	3-5%	Midland
34	VKM/F/2	$76^0$30’ 30” E	09^0 58’ 44”N	Valakam	Muvattupuzha	1-3%	Lowland
35	AYA/F/1	$76^0$38’12.3”E	09^0 59’16.7”N	Ayavana	Muvattupuzha	3-5%	Midland
36	AYA/F/2	$76^0$38’14.8”E	09^0 59’16.2”N	Ayavana	Muvattupuzha	1-3%	Lowland
37	KDY/F/1	$76^0$30’27.5”E	10^0 10’ 56”N	Koovappady	Periyar	3-5%	Midland
38	KDY/F/2	$76^0$28’20.4”E	10^0 08’14.6”N	Koovappady	Periyar	1-3%	Lowland
39	MYR/F/1	$76^0$30’18.5”E	10^0 11’12.7”N	Malayattoor-Neeliswaram	Periyar	1-3%	Lowland
40	MYR/F/2	76^0 29’38” E	10^0 11’18.4”N	Malayattoor-Neeliswaram	Periyar	1-3%	Lowland
41	OKL/F/1	NA	NA	Okkal	Periyar	3-5%	Midland
42	OKL/F/2	$76^0$28’12.9”E	10^0 08’30.4”N	Okkal	Periyar	1-3%	Lowland
43	VPA/F/1	$76^0$16’20.8”E	10^0 04’17.3”N	Varapuzha	Periyar	3-5%	Lowland
44	VPA/F/2	$76^0$16’32.3”E	10^0 04’43.4”N	Varapuzha	Periyar	1-3%	Lowland
45	KDM/F/1	$76^0$16’43.2”E	10^0 03’ 4.2”N	Kadamakudy	Periyar	1-3%	Lowland
46	KDM/F/2	$76^0$16’39.2”E	10^0 03’ 8.7”N	Kadamakudy	Periyar	1-3%	Lowland
47	CNR/F/1	76^0 16’58” E	10^0 04’11.5”N	Cheranelloor	Periyar	1-3%	Lowland
48	CNR/F/2	76^0 17’5.6”E	10^0 03’31.8”N	Cheranelloor	Periyar	1-3%	Lowland
49	KGM/F/1	76^0 38’8.3”E	10^0 03’35.7”N	Kothamangalam (M)	Muvattupuzha	1-3%	Lowland
50	KGM/F/2	76^0 38’1.5”E	10^0 03’ 37”N	Kothamangalam (M)	Muvattupuzha	1-3%	Lowland

***** GPS points are not available for some locations.**

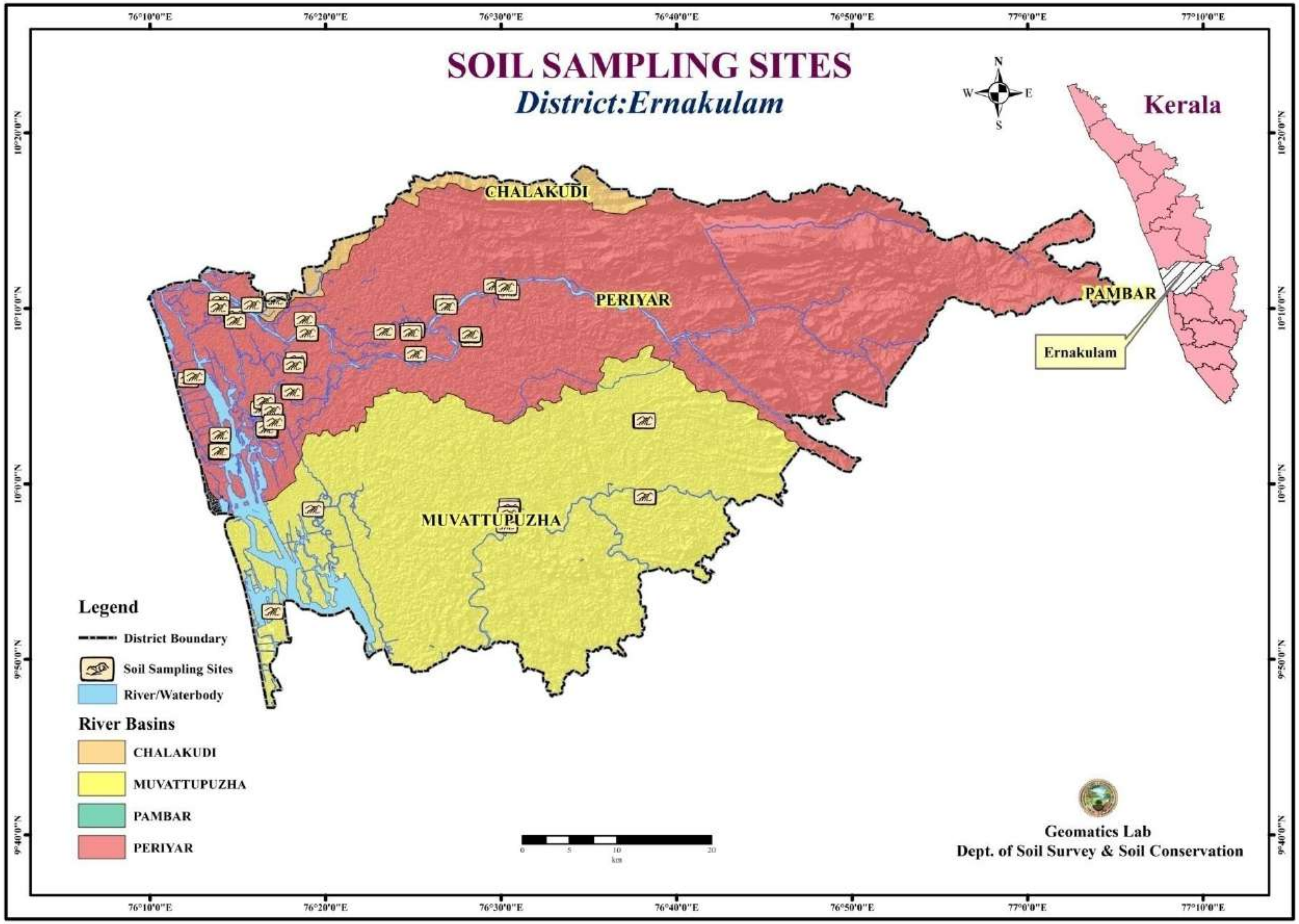

SOIL SAMPLING SITES
District:Ernakulam
Kerala
Ernakulam
CHALAKUDI
PERIYAR
PAMBAR
MUVATTUPUZHA
N
S
E
W
Legend
District Boundary
Soil Sampling Sites
River/Waterbody
River Basins
CHALAKUDI
MUVATTUPUZHA
PAMBAR
PERIYAR
0
5
10
20
km
Geomatics Lab
Dept. of Soil Survey & Soil Conservation
76°10'0"E
76°20'0"E
76°30'0"E
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
10°20'0"N
10°10'0"N
10°0'0"N
9°50'0"N
9°40'0"N

Table 5.7.3

Present land use and site characteristics

Sl. no	Sample code	Landform	Present land use	Site observation
1	SMN/F/7	Valley	Nutmeg	Plants are dried up, Slight surface cracking
2	SMN/F/10	Valley	Nutmeg, Coconut	Plants are dried up.
3	KJR/F/1	Valley	Fallow	Plants are dried up.
4	KJR/F/2	Valley	Paddy	Plants are dried up.
5	KJR/F/3	Valley	Nutmeg	Plants are dried up.
6	KLD/F/1	Riverbank	Nutmeg,Coconut	Plants are dried up.
7	KLD/F/2	Riverbank	Nutmeg, Banana	Fruit dropping in nutmeg. Silt deposition of 1cm thickness
8	KKA/F/1	Valley	Fallow	Plants are dried up.
9	KKA/F/2	Valley	Nutmeg	Silt deposition, Plants are dried up.
10	KKA/F/3	River bank	Nutmeg, Coconut	Silt deposition- >2cm thickness
11	PKA/F/1	Valley	Fallow	Plants are dried up.
12	PKA/F/2	Floodplain	Coconut,Arecanut, Banana, Nutmeg	Plants are dried up.
13	CGM/F/1	River bank	Banana,Coconut	Silt deposition- 1.5cm thickness
14	CGM/F/2	Flood plain	Arecanut,Coconut	Plants are dried up.
15	CTA/F/1	Valley	Coconut, Nutmeg	Plants are dried up.
16	CTA/F/2	Valley	Banana,Coconut	Plants are dried up.
17	KMR/F/1	Valley	Fallow	Plants are dried up.
18	KMR/F/2	Riverbank	Banana, nutmeg	All plants are dried up, Cowpea not germinating
19	AGD/F/1	Valley	Banana	Plants are dried up.
20	AGD/F/2	Flood plain	Banana	Plants are dried up.
21	KDR/F/1	Flood plain	Banana	Plants are dried up.
22	KDR/F/2	Coastal plain	Fallow	Plants are dried up.
23	EKP/F/1	Coastal plain	Coconut, Banana, Bhindi	Plants are dried up.
24	EKP/F/2	Valley	Fallow	Plants are dried up.
25	EKP/F/3	Coastal plain	Coconut,Banana	Plants are dried up.
26	EKD/F/1	Coastal plain	Coconut,Banana	Plants are dried up.
27	EKD/F/2	Coastal plain	Fallow	Plants are dried up.
28	KBG/F/1	Coastal plain	Coconut	Plants are dried up.
29	NJK/F/1	Coastal plain	Coconut, Banana	Plants are dried up.
30	KCT/F/1	Flood plain	Coconut, Arecanut	
31	RGM/F/1	River bank	Nutmeg	Nutmeg seedlings are severely affected.

32	RGM/F/2	Valley	Fallow	Total loss to banana and tapioca, Plants are dried up
33	VKM/F/1	Flood plain	Nutmeg	Nutmeg and banana dried up,
34	VKM/F/2	valley	Nutmeg	Nutmeg seedlings are severely affected.
35	AYA/F/1	River bank	Banana Coconut	All plants dried up
36	AYA/F/2	Valley	Rubber	After flood, rubber shows leaf spot and fungal diseases.
37	KDY/F/1	River bank	Coconut, banana, nutmeg	All plants dried up
38	KDY/F/2	Valley	Fallow	All plants dried up
39	MYR/F/1	Riverbank	Nutmeg, Coconut	All plants dried up
40	MYR/F/2	Valley	Paddy	All plants dried up
41	OKL/F/1	Plain	Coconut, Banana	All plants dried up
42	OKL/F/2	Valley	Fallow	All plants dried up
43	VPA/F/1	Plain	Banana	All plants dried up
44	VPA/F/2	Plain	Coconut, Nutmeg, pepper	Total loss to nutmeg and banana
45	KDM/F/1	Flood plain	banana	Nutmeg dried up
46	KDM/F/2	Flood plain	banana, nutmeg	All plants dried up
47	CNR/F/1	Plain	banana	All plants dried up
48	CNR/F/2	Plain	Coconut, banana	All plants dried up
49	KGM/F/1	Valley	Banana	All plants dried up, silt deposition – 0.5 cm thickness
50	KGM/F/2	Valley	fallow	All plants dried up

CHANGES NOTED IN THE FLOODED AREAS

GENERAL OBSERVATIONS

The general observations of the sites selected are listed below

- Silt deposition was seen in many areas upto a thickness of 1-2 cm. Slight cracking is seen on the soil surface after recession of water and drying of soil. The deposit is easy to break.
- All the plants were seen dried. Soil deposition on leaves has caused drying and scorching of leaves
- Nendran banana plants were completely dried. Roots of these plants were found to be decayed completely.
- Nutmeg trees were seen dried upto the level where water had risen. Some of the plants in the same plots showed green leaves even after flood. Heavy fruit dropping is seen in nutmeg. Nutmeg seedlings are more affected compared to nutmeg trees.

- Pepper was the most severely affected crop. No plant survived the flood.
- All vegetable crops were completely dried up.
- Just after the flood, lots of earthworms were found dead in the soil. But during our visit, we found live earthworms in the soil.
- All tillage machineries are damaged in the flood affected area and hence farmers are facing difficulty in obtaining machineries for raising next crop.

PHYSIOGRAPHY AND LANDSCAPE

- There is no change in landscape, physiography and depth due to floods
- Silt deposition is observed in most of the panchayats

CHANGES IN PHYSICAL AND CHEMICAL PROPERTIES OF SOILS IN DISTRESS AREAS

PHYSICAL PROPERTIES

The physical properties such as texture, structure and permeability of the soil samples collected from the flooded soils are analysed and compared with available data and are as follows.

Table 5.7.4

Physical characteristics

Sl.no	Sample code	Texture	
		Before flood	After flood
Coastal Plain			
1	EKP/F/1	Sandy loam	Sand
2	EKP/F/3	Sandy loam	Sandy Clay Loam
3	EKD/F/1	Loamy sand	Sandy Loam
4	KBG/F/1	Loamy sand	Loamy Sand
5	NJK/F/1	Sandy Loam	Sandy Loam
Lowland Valley			
1	SMN/F/7	Clay loam	Clay
2	SMN/F/10	Clay loam	Sandy Clay
3	KJR/F/1	Silty clay	Sandy Clay
4	KJR/F/2	Clay loam	Clay
5	KJR/F/3	Sandy clay loam	Loam
6	KKA/F/1	Clay loam	Sandy Clay Loam
7	KKA/F/2	Sandy clay loam	Sandy Clay Loam
8	PKA/F/1	Clay loam	Clay
9	CTA/F/1	Sandy clay loam	Sandy Loam
10	CTA/F/2	Sandy clay loam	Sandy Clay Loam
11	KMR/F/1	Clay loam	Sandy Clay Loam
12	AGD/F/1	Clay loam	Sandy Clay

13	KDR/F/2	Silty clay loam	Sandy Clay Loam
14	EKP/F/2	Clay	Sandy Clay Loam
15	RGM/F/2	loam	Sandy Loam
16	VKM/F/2	Silty clay loam	Clay
17	AYA/F/2	Silty clay loam	Clay
18	KDY/F/2	Sandy clay loam	Silty Clay Loam
19	MYR/F/2	Clay	Loam
20	OKL/F/2	clay loam	Clay
21	KGM/F/1	Clay loam	Clay
22	KGM/F/2	Sandy clay loam	Sandy Clay
23	EKD/F/2	Clay	Clay Loam
24	KMR/DP-2/2/F	Clay loam	Sandy Loam
Flood plain			
1	PKA/F/2	Silty clay loam	Sandy Clay Loam
2	CGM/F/2	Sandy loam	Sandy Clay
3	AGD/F/2	Clay loam	Sandy Clay Loam
4	KDR/F/1	Silty clay loam	Sandy Clay
5	KCT/F/1	Loamy sand	Sandy Clay Loam
6	VKM/F/1	Clay loam	Clay Loam
7	KDM/F/1	Sandy loam	Sandy Loam
8	KDM/F/2	Sandy loam	Loamy Sand
River bank			
1	KLD/F/1	Sandy clay loam	Sandy Clay Loam
2	KLD/F/2	Sandy clay loam	Sandy Loam
3	KKA/F/3	Sandy clay loam	Sandy Clay
4	CGM/F/1	Sandy loam	Sandy Clay Loam
5	KMR/F/2	Sandy loam	Sandy Clay Loam
6	RGM/F/1	Silt loam	Clay Loam
7	AYA/F/1	Clay loam	Silty Clay
8	KDY/F/1	Silty clay loam	Sandy Clay Loam
9	MYR/F/1	Sandy clay loam	Sandy Clay Loam
Midland Plain			
1	OKL/F/1	Clay loam	Sandy Clay
2	VPA/F/1	Sandy loam	Sandy Loam
3	VPA/F/2	Sandy loam	Sandy Loam
4	CNR/F/1	Sandy loam	Sandy Loam
5	CNR/F/2	Sandy loam	Sandy Loam

Textural differences are noticed as a result of silt deposition during flooding. It is seen that in some soils sand content increases while in others clay or silt increased. But textural differences noticed are within the textural range of that particular soil series.

SOIL TEXTURE

There is only slight change in surface texture which is within the range of soil series characteristics.

SOIL STRUCTURE

Loss of soil aggregation impacts agriculture by decreasing soil quality and crop production. Flooded soils exhibit decreased aggregate stability.

As soil aggregates breakdown due to flooding, the soil particles plug pores and voids that would help the soil to dry and return to normal after flooding. Soil aeration has to be improved in these type of soils. Application of lime or dolomite and incorporating with soil would improve its structure and reduce compaction.

WATER HOLDING CAPACITY

Due to flooding, silt deposition has occurred in many places. Organic carbon content is high in these areas which might have resulted in increased water holding capacity of these soils.

CHEMICAL PROPERTIES

The chemical properties such as pH, EC, macro, secondary and micronutrients of the soil samples collected from the flooded soils are analysed and compared with available data and are as follows.

Table 5.7.5

pH and Electrical Conductivity

Sl. no	Sample code	Panchayat	Before flood		After flood	
			pH	EC	pH	EC
Coastal alluvium						
1	EKP/F/1	Elamkunnapuzha	6.2	0.06	6.25	0.1
2	EKP/F/3	Elamkunnapuzha	5.7	0.16	5.8	0.08
3	EKD/F/1	Edavanakkad	5.1	0.1	5.37	0.03
4	KBG/F/1	Kumbalangi	5.1	0.1	5.8	0.31
5	NJK/F/1	Njarakkal	5.1	0.1	6.2	0.14
		Mean	*5.44*	*0.104*	*5.88*	*0.132*
Lowland valley						
1	SMN/F/7	Sreemoolanagaram	6.4	0.32	6.29	0.25
2	SMN/F/10	Sreemoolanagaram	6.4	0.48	6.1	0.23
3	KJR/F/1	Kanjoor	6.46	0.7	5.33	0.25
4	KJR/F/2	Kanjoor	5.46	0.13	4.61	0.28
5	KJR/F/3	Kanjoor	5.5	0.09	6.29	0.26
6	KKA/F/1	Kunnukara	6.3	0.12	5.95	0.3
7	KKA/F/2	Kunnukara	6.1	0.04	5.3	0.24
8	PKA/F/1	Puthenvelikkara	4.79	0.19	4.85	0.92

9	CTA/F/1	Chittattukara	5.22	0.1	5.42	0.1
10	CTA/F/2	Chittattukara	5.12	0.27	7.66	0.24
11	KMR/F/1	Karumalloor	6.38	0.26	4.9	4.9
12	AGD/F/1	Alangad	6.5	0.22	5.28	0.03
13	KDR/F/2	Kadungallur	4.4	0.04	7.76	0.24
14	EKP/F/2	Elamkunnapuzha	3	8.5	7.31	4.9
15	RGM/F/2	Ramamangalam	5.5	0.09	5.04	0.28
16	VKM/F/2	Valakam	5.5	0.09	4.92	0.36
17	AYA/F/2	Ayavana	5.8	1.4	4.63	0.16
18	KDY/F/2	Koovappady	5.8	1.4	4.32	0.3
19	MYR/F/2	Malayattoor-Neeliswaram	5.99	0.11	5.36	0.15
20	OKL/F/2	Okkal	5.8	1.4	4.93	0.32
21	KGM/F/1	Kothamangalam Municipality	4.6	0.05	5.58	0.18
22	KGM/F/2	Kothamangalam Municipality	4.8	0.06	5.38	0.23
23	EKD/F/2	Edavanakkad	3	8.5	5.18	2.9
24	KMR/DP-2/2/F	Karumalloor	5.81	0.27	4.56	0.26
		Mean	5.44	1.03	5.53	0.76
Flood plain						
Riverbank						
1	KLD/F/1	Kalady	6.3	0.1	6.52	0.26
2	KLD/F/2	Kalady	6.4	0.11	5.97	0.23
3	KKA/F/3	Kunnukara	4.1	0.12	5.93	0.57
4	CGM/F/1	Chennamangalam	6.22	0.09	5.72	0.21
5	KMR/F/2	Karumalloor	5.15	0.03	6.25	0.24
6	RGM/F/1	Ramamangalam	6.1	0.1	5.83	0.37
7	AYA/F/1	Ayavana	5.15	0.03	5.78	0.34
8	KDY/F/1	Koovappady	6.1	0.1	5.77	0.34
9	MYR/F/1	Malayattoor-Neeliswaram	4.48	0.09	5.78	0.13
		Mean	5.55	0.085	5.95	0.29
Midland plain						
1	OKL/F/1	Okkal	5.15	0.03	6.13	0.18
2	VPA/F/1	Varapuzha	5.68	0.093	5.66	0.22
3	VPA/F/2	Varapuzha	5.84	0.126	5.93	0.18
4	CNR/F/1	Cheranelloor	5.1	0.1	5.91	0.34
5	CNR/F/2	Cheranelloor	5.1	0.05	6.05	0.29
		Mean	5.37	0.079	5.93	0.24

From the table it can be inferred that soil acidity has reduced in the flooded areas. The Pokkali wetland samples collected from Elamkunnapuzha (EKP/F/2)and Edavanakkad (EKD/F/2) panchayats showed increase in acidity. In general, after flood, wetland soils showed increase in acidity and in other samples showed increase or decrease in pH value is seen.

In general the Electrical conductivity values showed a slight increase than pre flood values. Electrical conductivity values are not limiting for crop production except in the pokkali lands where the initial EC was 8.5dS/m which has been reduced to 2.9 and 4.9 dS/m respectively. Since these are saline soils, excess salts may be washed due to flooding.

Table 5.7.6

Macronutrients

Sl. no	Sample code	Before flood			After flood		
		OC %	P (kg/ha)	K (kg/ha)	OC %	P (kg/ha)	K (kg/ha)
Coastal Alluvium							
1	EKP/F/1	1.04	28.21	189.28	0.57	188.5	134.2
2	EKP/F/3	0.57	108.42	75.71	0.585	76.25	66
3	EKD/F/1	0.38	8.1	60.30	0.27	73	105.6
4	KBG/F/1	0.38	9.1	50.3	1.065	94.25	224.4
5	NJK/F/1	0.38	14.50	40.50	0.63	76.16	74.48
	Mean	0.55	33.66	83.21	0.61	101.63	120.9
Lowland valley							
1	SMN/F/7	0.62	13.25	432.54	0.92	106.4	237.66
2	SMN/F/10	2.11	82.88	295.23	1.38	134.4	136.53
3	KJR/F/1	1.48	62.25	270.6	1.68	16.8	82.99
4	KJR/F/2	2.31	10.08	143.36	3.14	11.2	100.69
5	KJR/F/3	1.39	67.2	415.52	0.65	101.92	195.22
6	KKA/F/1	2.48	98.56	478.24	1.68	31.36	85.68
7	KKA/F/2	1.45	75.04	107.52	0.46	82.88	152.43
8	PKA/F/1	2.15	0.01	200.48	0.48	27.25	104.5
9	CTA/F/1	0.99	79.76	212.8	0.48	170.75	64.9
10	CTA/F/2	1.49	135.59	162.4	0.23	175	93.5
11	KMR/F/1	1.93	15.68	159.15	0.19	53	91.3
12	AGD/F/1	1.83	31.36	301.4	0.39	76.75	53.9
13	KDR/F/2	1.41	32	151	0.375	80.75	214.5
14	EKP/F/2	2.42	131.04	49.50	1.935	32.25	389.4
15	RGM/F/2	1.39	10.08	140.21	2.45	13.44	97.44
16	VKM/F/2	1.39	10.8	280.3	2.49	168	361.54
17	AYA/F/2	0.55	12.32	150.34	1.55	56	378
18	KDY/F/2	0.55	12.32	150.34	1.92	42.56	16.24
19	MYR/F/2	0.69	77.28	315.84	2.16	151.2	63.06
20	OKL/F/2	0.55	12.32	150.34	1.88	42.56	27.66
21	KGM/F/1	1.6	106.4	453.94	1.51	70.56	152.88
22	KGM/F/2	1.34	57.12	104.5	1.55	38.08	43.46
23	EKD/F/2	2.42	87.36	80.98	1.68	13.5	609.4
24	KMR/DP-2/2/F	1.81	16.8	127.79	2.17	12.32	66.53
	Mean	1.51	51.56	222.26	1.39	71.21	160.39
Floodplain							
1	PKA/F/2	0.88	7.39	368.48	0.615	98.5	66

2	CGM/F/2	1.29	34.35	670.88	1.11	191.25	79.2
3	AGD/F/2	1.2	11.20	151	0.81	163.25	58.3
4	KDR/F/1	0.81	16.60	179	1.05	39	159.5
5	KCT/F/1	0.38	8.7	75.80	0.86	210.56	62.38
6	VKM/F/1	0.3	114.20	106.50	2.16	26.88	180.43
7	KDM/F/1	1.18	69.44	52.08	0.65	66.08	107.63
8	KDM/F/2	3.6	191.32	139.22	1.14	272.16	87.47
	Mean	1.21	56.65	217.87	1.05	120.96	100.11
Riverbank							
1	KLD/F/1	4.9	114.24	294.56	1.26	17.92	183.34
2	KLD/F/2	1.22	58.24	473.76	0.42	23.52	70.56
3	KKA/F/3	0.66	28	277.76	1.72	82.88	231.17
4	CGM/F/1	1.21	91.95	105.28	0.795	129.75	368.5
5	KMR/F/2	0.28	69	415	0.375	117.75	380.6
6	RGM/F/1	1.66	197.12	96.32	1.76	20.16	93.74
7	AYA/F/1	0.55	110	102.3	1.18	63.84	117.15
8	KDY/F/1	1.66	180.30	93.72	1.27	43.68	73.92
9	MYR/F/1	2.24	250.88	88.48	1.39	103.04	177.52
	Mean	1.59	125.53	216.35	1.13	66.95	188.5
Midland plain							
1	OKL/F/1	0.3	110	102.30	1.96	38.08	219.3
2	VPA/F/1	0.8	94.08	61.6	1.59	217.28	30.02
3	VPA/F/2	1.4	44.8	80.64	0.9	179.2	86.13
4	CNR/F/1	0.38	8.7	75.80	0.98	150.08	57.79
5	CNR/F/2	0.32	7.45	105.28	0.37	22.4	29.46
	Mean	0.64	53.10	85.12	1.16	121.41	84.54

The organic matter content increases in 60% of the soils compared to preflooded soils. Majority of the locations have medium to high status, deficiency also noticed in some area. Phosphorus availability increased after flooding while potassium availability reduced in many locations. More over potassium deficiency is widespread after flooding. Supplementing potassium fertilizer is essential to rejuvenate the soils. In general, soil compaction reduces potassium availbilty which may be the reason for it's reduced availability after flooding.

Table 5.7.7
Secondary nutrients

Sl.no	Sample code	Before flood(ppm)			After flood(ppm)		
		Ca	Mg	S	Ca	Mg	S
Coastal Plain							
1	EKP/F/1	80	48	8.03	50.5	602	134.2
2	EKP/F/3	80	48	17.8	532	28.565	73.5
3	EKD/F/1	80	48	18.7	350.6	25.45	54
4	KBG/F/1	80	48	54	717.5	24.62	86
5	NJK/F/1	80	70.40	21.25	310.05	125.16	26.94

	Mean	80	42.88	23.96	392.13	161.16	74.93
Lowland Valley							
1	SMN/F/7	382	180	3.93	538.35	52.5	167.38
2	SMN/F/10	382	180	196.13	556.6	57	147.25
3	KJR/F/1	81.42	16.06	12.5	901.4	39	189.38
4	KJR/F/2	382	180	1.13	904.3	37.5	151.25
5	KJR/F/3	382	180	4.21	680.85	60	152.5
6	KKA/F/1	80	36	25.60	230.7	88.5	145.88
7	KKA/F/2	832	23	23.80	401.3	37.5	165
8	PKA/F/1	328	7.25	0.35	130.5	447.9	104.5
9	CTA/F/1	1800	252	10.27	389.55	25.12	22.5
10	CTA/F/2	1800	252	7.05	1043.5	28.01	57.35
11	KMR/F/1	80	36	101.25	311.5	25.27	88
12	AGD/F/1	80	36	75.47	333.3	28.165	18
13	KDR/F/2	254	181	29	1278	21.275	21
14	EKP/F/2	508.30	68.70	18.67	1297	31.245	50.5
15	RGM/F/2	81.42	16.06	12.50	148.5	40.5	35.38
16	VKM/F/2	382	180	4.20	207.2	39	47.5
17	AYA/F/2	162.98	122.30	44.89	88.3	28.5	81.88
18	KDY/F/2	162.90	122.30	44.80	121.5	49.5	57.88
19	MYR/F/2	1510.25	60.45	1966.3	395.2	48	116.13
20	OKL/F/2	162.9	122.30	44.8	119.8	27	49
21	KGM/F/1	155.96	145.38	35.76	346.5	46.5	39
22	KGM/F/2	147.22	189.09	46.35	210.3	90	57
23	EKD/F/2	364.28	134.58	15.87	776	31.92	95
24	KMR/DP-2/2/F	215.2	40.1	107.88	388.95	25.79	56
	Mean	446.53	115.02	118.03	491.63	58.57	88.13
Flood plain							
1	PKA/F/2	832	6.98	0.09	436.7	24.55	84
2	CGM/F/2	292	48.1	84.4	148	833.5	79.2
3	AGD/F/2	40	60	12	50	550	58.3
4	KDR/F/1	120	96	6.07	575	22.02	117
5	KCT/F/1	75	56.80	21.25	662.7	67.5	85.88
6	VKM/F/1	20	96	30.50	274.5	51	69.88
7	KDM/F/1	173.6	53.6	9.29	344.2	45	800.13
8	KDM/F/2	321.25	132.54	12.87	392.6	24	702.4
	Mean	234.23	68.75	22.05	360.46	202.19	249.5
Riverbank							
1	KLD/F/1	20	96	30.50	735.8	42	153.5
2	KLD/F/2	120	96	10.70	781.8	78	226
3	KKA/F/3	80	36	10.70	510.4	45	189.38

4	CGM/F/1	292	48.2	63.8	588	27.01	195
5	KMR/F/2	140	98	18.25	54	932	380.6
6	RGM/F/1	994.05	294.50	41.63	878.8	24	69.38
7	AYA/F/1	19	93.54	33.60	312.5	19.5	69.38
8	KDY/F/1	980.30	273.80	39.80	595.5	25.5	45.75
9	MYR/F/1	138.6	26.35	24.5	491.6	42	54
	Mean	309.32	118.04	30.39	549.8	137.22	153.66
MidlandPlain							
1	OKL/F/1	19	93.54	33.60	982.6	21	57.25
2	VPA/F/1	210	75	63.75	559.6	33	106.13
3	VPA/F/2	1422.5	122.5	140	359.5	76.5	48.63
4	CNR/F/1	75	56.80	21.25	436.2	25.5	41.38
5	CNR/F/2	292	48.20	63.80	192.8	25.5	199.25
	Mean	403.7	79.20	64.48	56.14	36.3	90.53

On reviewing the results obtained, it is seen that in general calcium and sulphur availability in soils increased and Magnesium availability reduced after flooding. Moreover widespread Magnesium deficiency is noticed in the district.

Table 5.7.8

Micronutrients

Sl. no	Sample code	Before flood (ppm)					After flood (ppm)				
		Fe	Cu	Zn	Mn	B	Fe	Cu	Zn	Mn	B
Coastal Plain											
1	EKP/F/1	35.57	1.23	3.36	16.23	0.71	23.03	294.4	1.495	6.337	0.162
2	EKP/F/3	83.26	12.62	6.21	1.57	0.22	329.9	2.925	5.28	7.079	0.0163
3	EKD/F/1	70.21	4.30	5.5	3.5	0.31	349.8	0.0481	1.768	1.897	0.01
4	KBG/F/1	81.50	11.71	4.3	4.4	0.21	402.4	0.0769	4.057	16.98	0.4553
5	NJK/F/1	28.96	2.4	1.18	0.98	0.80	62.67	2.5	2.38	6.57	0.71
	Mean	59.9	6.45	4.11	5.34	0.45	233.56	294.4	29.96	7.77	0.27
Lowland valley											
1	SMN/F/7	29.36	2.37	2.2	12.86	0.98	49	1.7	2.32	12.56	0.38
2	SMN/F/10	107.01	2.65	2.04	15.72	1.32	19.46	1.28	1.66	11.24	0.36
3	KJR/F/1	102.5	1.3	1.15	49.84	0.42	52.32	3.26	1.06	18.66	0.44
4	KJR/F/2	243.2	1.04	7.12	0.8	0.32	54.32	1.7	1.12	7.7	0.4
5	KJR/F/3	53.68	1.34	4.68	62.04	0.54	50.3	0.64	0.94	13.98	0.38
6	KKA/F/1	85	1.30	20	11.30	0.42	13.56	3.26	1.3	2.32	0.42
7	KKA/F/2	101	1.10	1.90	5.70	0.62	43.26	0.48	0.82	15.44	0.44
8	PKA/F/1	13.55	40.92	3.25	3.9	0.54	28.815	300.1	0.071	1.271	0.4227
9	CTA/F/1	250.67	11.37	0.58	7.94	0.67	55.95	0.0918	2.599	3.335	0.1382
10	CTA/F/2	63.41	1.71	1.34	73.56	0.58	230.9	0.3086	6.853	25.39	0.0569
11	KMR/F/1	52.62	2.42	1.04	4	0.48	363.3	1.045	3.31	12.37	0.13

12	AGD/F/1	20.09	2.74	10.23	7.6	0.92	173.9	1.489	2.464	2.241	0.046
13	KDR/F/2	87	2.50	1.9	17	0.82	178.7	1.155	68	24.24	0.13
14	EKP/F/2	105.36	1.64	2.57	5.64	0.75	454.1	0.0402	8.074	4.689	0.837
15	RGM/F/2	102.50	1.30	1.15	49.84	0.42	48.12	3.06	1.6	6	0.4
16	VKM/F/2	53.40	1.2	4.50	61.8	0.53	50.36	3.02	1.28	4.34	0.38
17	AYA/F/2	34.20	2.18	4.20	122.30	0.73	50.96	4.3	1.88	19.42	0.34
18	KDY/F/2	34.20	2.1	4.30	122.30	0.7	54.28	4.5	1.34	3.98	0.66
19	MYR/F/2	77.88	2.42	0.7	21.34	0.36	26.86	0.62	2	1	1.04
20	OKL/F/2	34.20	2.10	4.30	122.30	0.7	135.22	2.52	1.9	1.68	0.52
21	KGM/F/1	66.7	3.4	2.18	9.8	0.64	46.98	0.96	0.44	1.52	0.52
22	KGM/F/2	45.58	3.68	2.8	5.4	0.57	40.62	1.7	4.92	8.46	0.54
23	EKD/F/2	120.48	1.59	2.06	1.65	0.53	462.6	0.0613	12.66	3.27	1.341
24	KMR/DP-2/2/F	51.7	2.14	1.3	3.28	0.6	383.3	2.035	3.4	6.842	0.308
	Mean	80.22	4.02	3.65	33.25	0.63	127.80	14.14	5.5	8.83	0.44
Flood plain											
1	PKA/F/2	6.93	29.61	3.93	2.24	0.8	109.7	0.0473	1.839	6.646	0.2276
2	CGM/F/2	90.6	4.5	5.5	4.6	0.9	25.515	210.6	1.802	4.216	0.244
3	AGD/F/2	32	1.70	0.59	79.30	0.12	24.685	283	4.01	6.448	0.146
4	KDR/F/1	37	1.80	1.9	3.90	0.85	115.6	1.032	77.12	15.78	0.13008
5	KCT/F/1	11.24	1.82	2.2	1.20	1.80	48.52	3.34	2.32	3.5	0.38
6	VKM/F/1	30	2.1	1.80	3.4	0.02	49.7	2.88	1.56	8.36	0.48
7	KDM/F/1	24.58	1.65	2.77	1.99	0.21	44.94	1.58	4.16	1.08	0.68
8	KDM/F/2	26.35	1.58	1.35	2.08	0.58	39.5	1.38	5.08	0.98	0.62
	Mean	32.34	5.595	2.50	12.34	0.66	57.27	62.98	12.24	5.88	0.36
Riverbank											
1	KLD/F/1	31.80	2.20	1.97	4.40	0.01	37.92	2.04	1.58	3.24	0.36
2	KLD/F/2	10.10	0.27	0.35	3.07	0.37	41.26	4.04	0.46	16.48	0.6
3	KKA/F/3	93	1.80	2.30	10.40	0.68	15.92	1.96	0.92	24.78	0.28
4	CGM/F/1	107	4.2	2.1	6.8	3.2	192.8	0.08311	2.883	11.37	0.244
5	KMR/F/2	8.65	0.33	0.48	0.49	0.64	25.525	121.6	0.2251	2.92	0.178
6	RGM/F/1	120.56	0.38	2.12	16.94	0.32	48.36	2.98	1.94	4.36	0.36
7	AYA/F/1	29.88	2.41	1.75	2.34	0.03	50.76	2.46	1.62	17.08	0.68
8	KDY/F/1	120.7	0.38	1.31	15.34	0.41	53.68	3.7	1.5	10.98	0.42
9	MYR/F/1	42.68	2.6	0.56	7.48	0.22	37.18	1.5	1.7	4.36	0.3
	Mean	62.70	0.62	1.14	7.47	0.65	55.93	15.6	1.43	10.52	0.38
Midland plain											
1	OKL/F/1	29.88	2.41	1.75	2.34	0.03	64.3	1.18	1.72	2.14	0.54
2	VPA/F/1	40.4	2	3.7	5.6	1.08	59.62	2.08	2.18	1.18	0.64
3	VPA/F/2	128.2	56.1	30.8	2.8	1.34	48.32	2.28	11.56	1.74	0.48
4	CNR/F/1	11.24	1.82	2.20	1.20	1.80	34.38	0.92	6.82	0.58	0.52
5	CNR/F/2	167	4.20	2.10	6.80	3.20	28.26	0.96	8.32	2.5	0.6
	Mean	75.34	13.31	8.11	3.75	1.49	46.98	1.48	6.12	1.63	0.56

In general available iron and zinc increases in all locations compared to preflood value. Reduced availability of boron and copper noticed in post flood samples. Boron deficiency is prevalent in all locations while localized deficiency was observed in the case of copper and zinc.

STATUS OF HEAVY METALS

According to United Nation Environmental Program (UNEP)Percy *et al.* (1997)reported that although the number of heavy metals in earth are about 40, arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and nickel (Ni) are the most common heavy metals pollutants. Cheng *et al.* (2006) stated that among heavy metals, cadmium (Cd), arsenic (As), chromium (Cr), nickel (Ni), and lead (Pb) are commonly considered as toxic to both plants and humans.

Agricultural soils normally contain low levels of heavy metals. Contamination from industrial activities or byproducts can increase the natural levels of heavy metals in soil, creating a health hazard to people, livestock and plants. Fertilizers and other soil amendments also add small amounts of heavy metals to the soil, which can build up over time with repeated applications. The actual toxicity of a heavy metal will be affected by soil texture, organic matter, and pH.

Once metals are introduced and contaminate the environment, they will remain. Metals do not degrade like carbon-based (organic) molecules. Hence Heavy metals belong to the most dangerous contaminants of the environment. Once these elements enter the soil, they persist for thousands years there and it is very difficult to eliminate their effects in the soil-plant system.

Heavy metals are known to accumulate in living organisms (Karatas et al. 2006). There is an inherent tendency of plants to take up toxic substances including heavy metals that are subsequently transferred along the food chain.

Inorder to check whether heavy metal pollution occurred as a result of flooding, samples were collected from selected sites and analysed for Lead and cadmium. The details of sampling sites along with the DTPA extractable lead and cadmium are presented in table 5.7.9

Table 5.7.9

Lead & Cadmium

Sl no.	Sample code	Name of Panchayat	Cd ppm	Pb ppm
1	SMN/F/7	Sreemoolanagaram	0.20	1.44
2	SMN/F/10	Sreemoolanagaram	0.18	1.18
3	KJR/F/1	Kanjoor	0.18	1.74
4	KJR/F/2	Kanjoor	0.16	1.82
5	KJR/F/3	Kanjoor	0.16	1.24
6	KLD/F/1	Kalady	0.18	1.30
7	KLD/F/2	Kalady	0.16	1.56
8	KKA/F/1	Kunnukara	0.22	1.24
9	KKA/F/2	Kunnukara	0.16	1.48
10	KKA/F/3	Kunnukara	0.12	1.24
11	KCT/F/1	Kochi Corporation	0.08	3.20
12	RGM/F/1	Ramamangalam	0.10	2.24
13	RGM/F/2	Ramamangalam	0.14	1.96
14	VKM/F/1	Valakam	0.12	1.96
15	VKM/F/2	Valakam	0.12	2.52
16	AYA/F/1	Ayavana	0.14	2.24
17	AYA/F/2	Ayavana	0.12	2.46
18	KDY/F/1	Koovappady	0.12	2.62
19	KDY/F/2	Koovappady	0.12	3.68
20	MYR/F/1	Malayattoor-Neeliswaram	0.14	3.00
21	MYR/F/2	Malayattoor-Neeliswaram	0.20	2.74
22	OKL/F/1	Okkal	0.18	2.42
23	OKL/F/2	Okkal	0.22	2.40
24	VPA/F/1	Varapuzha	0.34	2.40
25	VPA/F/2	Varapuzha	0.12	2.50
26	KDM/F/1	Kadamakudy	0.16	1.22
27	KDM/F/2	Kadamakudy	0.16	1.02
28	CNR/F/1	Cheranelloor	0.08	0.90
29	CNR/F/2	Cheranelloor	0.10	1.70
30	KGM/F/1	Kothamangalam Municipality	0.10	2.30
31	KGM/F/2	Kothamangalam Municipality	0.33	2.92

The maximum permissible limit for lead and cadmium in soil are 13ppm and 0.31ppm respectively. ((DTPA extractable permissible limit in soil prescribed by Maclean etal,1987).It is seen that none of the sampling locations have lead value above the maximum permissible limit in soil and in two locations cadmium seen above the permissible limit.

The results of the study can be summarized as follows.

- Slight increase in pH and decrease in Electrical conductivity noted in Pokkali soils. In wetland soils acidity reduced after flooding. In garden land soils any specific trend could not be noticed.
- Organic matter content increased after flooding. This may be due to the deposition of leached humus from upper slopes to the flooded area. Moreover flooding increases solubility of organic carbon and the increased decomposition of plant debris might have contributed the higher value. However deficiency is noticed in some locations
- Phosphorus availability enhanced after flooding while potassium availability reduced in flooded soil
- Deficiency of Available potassium, available magnesium and boron are noticed in soils of Eranakulam district
- Surface crusting, soil compaction, loss in aggregate stability etc are noticed after flooding.
- Crop damage is prevalent. Banana, nutmeg and tuber crops are the most affected category
- Textural changes are noticed after silt deposition in many areas

RECOMMENDATIONS FOR IMPROVING CROPSTAND

- Loosen the surface soil by light tillage to break up the crust before it hardens.
- Apply lime to the deposited soil.
- Soil test based nutrient supply .
- Drench the basins of crops like nutmeg with copper oxychloride 2ml/litre and spray with 1% Bordeaux mixture to prevent fungal diseases.
- Mulch the basins of standing crop.
- Spray water to remove soil particles deposited on leaves of survived plants.

Crop damage

Drying of nutmeg

Silt deposition

THRISSUR

Total Geographic Area : 3,02,919 Ha

No. of Taluks : 7

No. of Villages : 166

RIVER BASINS

- *Bharathapuzha*
- *Chalakkudy river*
- *Kanjiramukku*
- *Karuvannur*
- *Keecheri*
- *Periyar*

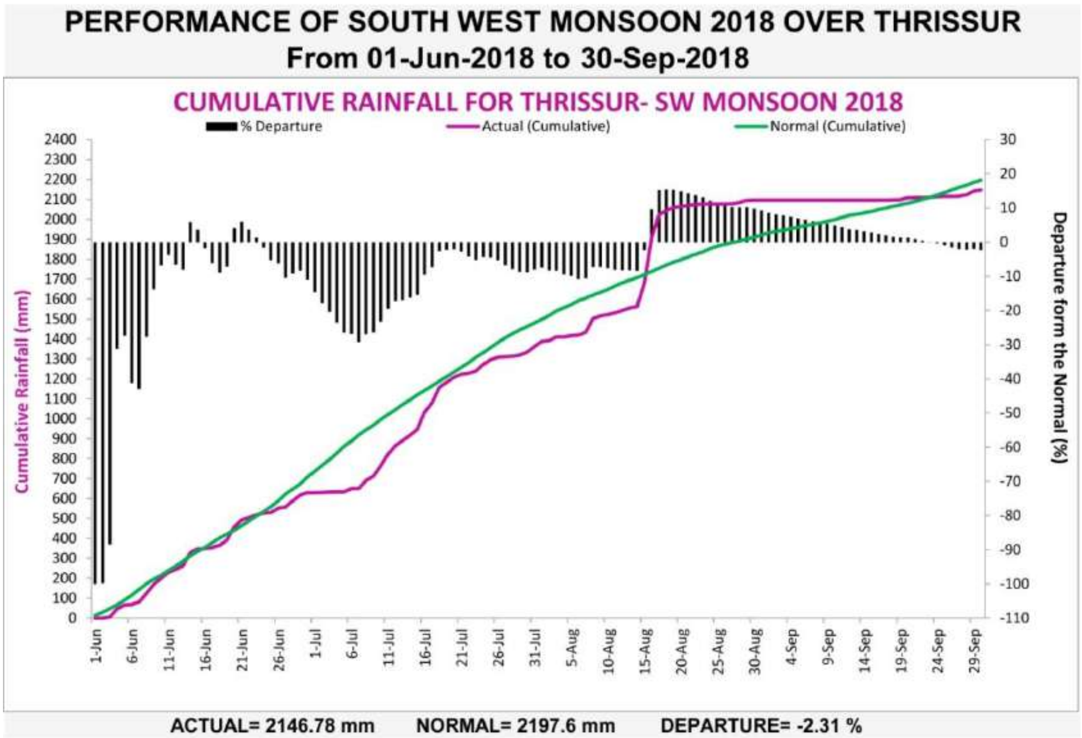
DISTRESS AFFECTED VILLAGES

5.8. THRISSUR DISTRICT

Thrissur district located in the central part of Kerala extends over an area of 3,02,919 ha constituting nearly 8% of the total area of the state. It lies between 10°11' and 10°47' north latitude and 75°54' and 76°57' east longitude. The district is physiographically divided into 5 divisions ie. Lowland, midland, midupland, upland and highland. Major portion of the district is drained by the 6 rivers viz. Kanjiramukku, Kechery, Karuvannur, Bharathapuzha, Chalakkudy puzha, Periyar.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

Heavy rain during the south west monsoon caused flood and landslide in the district. The district receives 10 % excess rainfall than the normal. From the graph below, it is seen that heavy rainfall received during midAugust along with opening of dams in upper reaches of riverbasins have created havoc in the district.



IMPACT OF DISTRESS IN THE DISTRICT

All river basins of Thrissur district were flood / landslide affected. Chalakkudy river basin was the most affected resulting in high crop loss and soil changes. Almost all villages of the district were under distress due to flood,landslide and heavy rains as informed by district administration. The Karuvannur river wreaked havoc in Thrissur district, destroying large tracts of land and washing away a key 2.2km stretch connecting two national highways, NH17 and NH47, near the Arattupuzha temple. Torrential rains and water released from two dams—Peechi and Chimmini—led to the river, which originally flowed westwards, to change its course as it gushed through 40 thickly populated villages in the downstream area to eventually merge with the sea.

Panchayats affected by floods/landslides in the district is presented below.

Sl no	*Panchayat*	*Flood/landslide*
1	Kadukutty	Flood
2	Pariyaram	Flood
3	Kodassery	Flood
4	Athirappilly	Flood
5	Koratty	Flood
6	Melur	Flood
7	Varandarappilly	Flood
8	Mattathur	Flood
9	Alagappa Nagar	Flood
10	Kodakara	Flood
11	Nenmenikkara	Flood
12	Puthukkad	Flood
13	Thrikkur	Flood
14	Chalakkudy (M)	Flood
15	Kadappuram	Flood
16	Orumanaur	Flood
17	Punnayur	Flood
18	Punnayurkulam	Flood
19	Wadakkekad	Flood
20	Venkidangu	Flood
21	Mullassery	Flood
22	Elavally	Flood
23	Pavaratty	Flood
24	Engandiyur	Flood
25	Vadanapally	Flood
26	Thalikulam	Flood
27	Nattika	Flood
28	Valappad	Flood
29	Guruvayur (M)	Flood
30	Chavakkad (M)	Flood
31	Edavilangu	Flood
32	Eriyad	Flood
33	Poyya	Flood
34	Edathiruthy	Flood
35	Kaipamangalam	Flood
36	Mathilakam	Flood
37	Perinjanam	Flood
38	SreeNarayanapuram	Flood
39	Kodungallur (M)	Flood

40	Karalam	Flood
41	Kattur	Flood
42	Muriyad	Flood
43	Parappukkara	Flood
44	Alur	Flood
45	Kuzhur	Flood
46	Annammanada	Flood
47	Mala	Flood
48	Padiyur	Flood
49	Poomangalam	Flood
50	Puthenchira	Flood
51	Velookkara	Flood
52	Vellengallur	Flood
53	Irinjalakuda (M)	Flood
54	Choondal	Flood
55	Chovannur	Flood
56	Kadavallur	Flood
57	Kandanasseri	Flood
58	Kattakambal	Flood
59	Porkulam	Flood
60	Chelakkara	Flood & landslide
61	Pazhayannur	Flood
62	Kondazhi	Flood
63	Thiruvillvamanla	Flood
64	Panjal	Flood
65	Vallatholnagar	Flood & landslide
66	Thekkumkara	Flood & landslide
67	Mullurkara	Flood& landslide
68	Erumappetty	Flood
69	Varavur	Flood
70	Desamangalam	Flood & landslide
71	Kadangode	Flood
72	Velur	Flood
73	Kunnamkulam (M)	Flood
74	Wadakkanchery (M)	Flood &landslide
75	Avinissery	Flood
76	Cherpu	Flood
77	Paralam	Flood
78	Vallachira	Flood
79	Kolazhy	Flood
80	Madakkathara	Flood &landslide
81	Nadathara	Flood &landslide
82	Panancherry	Flood &landslide
83	Puthur	Flood &landslide
84	Adat	Flood
85	Arimpoor	Flood
86	Avanur	Flood
87	Kaipparambu	Flood
88	Mulamkunnathukavu	Flood
89	Tholur	Flood

90	Anthicad	Flood
91	Thanniyam	Flood
92	Chazhoor	Flood
93	Manalur	Flood
94	Thrissur corporation	Flood

Generally flooding was severe in Chalakkdy river basin followed by Karuvannur basin, Kole land areas and Canoli canal areas. Land slide affected upper reaches of the district especially Kuranchery (Thekkumkara panchayat), Kurumala (Chelakkara panchayat), Desamangalam, vavarupallam, Kottamputhur colony (Desamangalam panchayat), Cheruthuruthy - Thazhepra area (Vallathol nagar panchayat), Rubber plantation in Pananchery (Pananchery panchayat), Kolamkunau, Chittakunnu, Urulankunnu (Puthur panchayat), Nadathara panchayat, Madakathara panchayat.

Major crop loss were occurred in Nutmeg plantations adjoining Chalakkudy and Karuvannur rivers especially in Pariyaram, Melur, Chalakkudy, Kadukutty, Annammanada, Padiyur, Kattur panchayats. Crop loss also was severe in Banana and vegetable plots. Livestock population was affected badly.

FIELD TRAVERSING AND SOIL SAMPLING

Field traversing of the affected area was carried out to assess the soil loss due to landslides and heavy rain and changes in the physical and chemical properties due to the subsequent floods in the affected areas. 106 samples were taken from different flood and landslide affected areas for analysis and soils are collected at a depth of 0-30cm. The sampling locations and site characteristics are presented below.

Table 5.8.1

Sampling locations

Sample code	Latitude	Longitude	Panchayat	River basin	Physiography
Kly FD 1	10° 29' 15.4" N	76°19' 13.2"E	Kolazhy	Kechery	Lowland
Kly FD 2	10° 30' 35.3" N	76°20' 17.6"E	Kolazhy	Kechery	Lowland
Kly FD 3	10° 32'12.11"N	76°13' 29.62"E	Kolazhy	Kechery	Lowland
Kly FD 4	10° 29' 15.7" N	76°19' 20.8"E	Kolazhy	Kechery	Lowland
Kly FD 6	10° 29' 21.0" N	76°16' 33.3"E	Kolazhy	Kechery	Lowland
Kly FD 7	10° 29' 26.5" N	76°16' 22.9"E	Kolazhy	Kechery	Lowland
Kly FD 8	10° 33' 45.0" N	76°10' 56.7"E	Kolazhy	Kechery	Lowland

Kly FD 9	10° 30' 46.5" N	76°17' 26.1"E	Kolazhy	Kechery	Lowland
KlyFD10	10°30' 27.9" N	76°20' 15.9"E	Kolazhy	Kechery	Lowland
KlyFD11	10° 29' 16.7" N	76°19' 14.9"E	Kolazhy	Kechery	Lowland
KlyFD12	10° 33' 23.4" N	76°6' 21.9" E	Kolazhy	Kechery	Lowland
KlyFD13	10° 33' 27.7" N	76°6' 0.6" E	Kolazhy	Kechery	Lowland
KlyFD14	10° 13' 13.2"N	76°12' 30.3"E	Kolazhy	Kechery	Lowland
KlyFD15	10° 13' 11.8" N	76°12' 17.5"E	Kolazhy	Kechery	Low land
KlyFD16	10° 34' 29.6" N	76°1' 45.8" E	Kolazhy	Kechery	Low land
FDS 1	10° 13' 26.9" N	76°12' 16.0"E	Kolazhy	Kechery	Low land
FDS 2	10° 24' 34.5" N	76°6' 57.6" E	Kolazhy	Kechery	Low land
FDS 3	10°13' 26.9" N	76°12' 16.0"E	Wadakkanchery (M)	Kechery	Midland
FDS 5	10°12' 38.1" N	76°13' 17.8"E	Erumapetty	Kechery	Midland
FDS 6	10°34' 16.9" N	76°11' 28.5"E	Desamangalam	Bharathapuzh a	Midland
FDS 7	10°33' 18.2" N	76°12' 2.0" E	Erumapetty	Kechery	Midland
FDS 8	10°33' 39.5" N	76°12' 3.6" E	Kadangode	Kechery	Midland
FDS 10	10°34' 23.7" N	76°11' 51.3"E	Chalakkudy	Chalakkudy	Lowland
FDS 11	10°29' 21.0" N	76°16' 33.3"E	Melur	Chalakkduy	Lowland
FDS 12	10°29' 15.4" N	76°19' 13.2"E	Annammanada	Chalakkudy	Lowland
FDS 13	10°30' 35.3" N	76°20' 17.6"E	Chalakkudy	Chalakkudy	Lowland
FDS 14	10°32' 12.11"N	76°13' 29.62"E	Annammanada	Chalakkudy	Lowland
FDS 15	10°29' 15.7" N	76°19' 20.8"E	Pariyaram	Chalakkudy	Midland
FDS 16	10°29' 26.5" N	76°16' 22.9"E	Thiruvilwamala	Bharathapuzha	Midland
FDS 17	10°33' 45.0" N	76°10' 56.7"E	Chalakkudy	Chalakkudy	Lowland
FDS 18	10°30' 46.5" N	76°17' 26.1"E	Thekkumkara	Kechery	Midland
FDS 19	10° 30' 27.9" N	76°20' 15.9"E	Vallatholnagar	Bharathapuzha	Lowland
FDS 20	10° 29' 16.7" N	76° 19'14.9"E	Panjal	Bharathapuzha	Lowland
FDS 21	10° 33' 23.4" N	76° 6' 21.9" E	Thekkumkara	Kechery	Midland
FDS 22	10° 33' 27.7" N	76° 6' 0.6" E	Mullurkara	Kechery	Midland
FDS 23	10° 13' 13.2" N	76°12'30.3"E	Wadakkanchery	Kechery	Midland
FDS 24	10° 13' 11.8" N	76°12' 17.5"E	Mullurkara	Kechery	Midland
FDS 25	10° 34' 29.6" N	76° 1' 45.8" E	Mala	Chalakkudy	Lowland
FDS 26	10° 13' 26.9" N	76° 12' 16.0" E	Kadukutty	Chalakkudy	Lowland
FDS 27	10° 24' 34.5" N	76° 6' 57.6" E	Choondal	Kechery	Lowland

FDS 28	10° 13' 26.9" N	76°12'16.0" E	Choondal	Kechery	Lowland
FDS 29	10° 12' 38.1" N	76°13' 17.8"E	Chelakkara	Bharathapuzha	Midland
FDS 30	10° 34' 16.9" N	76°11' 28.5"E	Thiruvilwamala	Bharathapuzha	Lowland
FDS 31	10° 33' 18.2" N	76° 12' 2.0" E	Kadangode	Kechery	Midland
FDS 32	10° 33' 39.5" N	76°12' 3.6"E	Annammanada	Chalakkudy	Lowland
FDS 33	10° 34' 23.7" N	76°11' 51.3"E	Varavoor	Kechery	Midland
FDS 34	10° 29' 21.0" N	76°16' 33.3" E	Pazhayannur	Bharathapuzha	Lowland
FDS 35	10° 29' 15.4" N	76°19' 13.2"E	Vallatholnagar	Bharathapuzha	Lowland
FDS 36	10° 30' 35.3" N	76°20' 17.6"E	Pazhayannur	Bharathapuzha	Lowland
FDS 37	10° 32'12.11"N	76°13' 29.62" E	Panjal	Bharathapuzha	Lowland
FDS 38	10° 29' 15.7" N	76° 19' 20.8" E	Pazhayannur	Bharathapuzha	Lowland
FDS 39	10° 29' 26.5" N	76° 16' 22.9" E	Chelakkara	Bharathapuzha	Midland
FDS 40	10° 33' 45.0" N	76°10' 56.7"E	Pazhayannur	Bharathapuzha	Lowland
FDS 41	10° 30' 46.5" N	76°17' 26.1"E	Desamangalam	Bharathapuzha	Lowland
FDS 42	10° 30' 27.9" N	76°20' 15.9"E	Panjal	Bharathapuzha	Lowland
FDS 43	10° 29' 16.7" N	76°19' 14.9"E	Wadakkanchery	Kechery	Midland
FDS 44	10° 33' 23.4" N	76° 6' 21.9" E	Thekkumkara	Kechery	Midland
FDS 45	10° 33' 27.7" N	76° 6' 0.6" E	Wadakkanchery	Kechery	Midland
FDS 46	10° 13' 13.2" N	76° 12' 30.3" E	Wadakkanchery	Kechery	Midland
FDS 47	10° 13' 11.8" N	76° 12' 17.5" E	Varavoor	Kechery	Midland
FDS 48	10° 34' 29.6" N	76° 1' 45.8" E	Vallachira	Karuvannur	Lowland
FDS 49	10° 13' 26.9" N	76° 12' 16.0" E	Anthikkad	Karuvannur	Lowland
FDS 50	10° 24' 34.5" N	76° 6' 57.6" E	Choondal	Kechery	Lowland
FDS 51	10° 13' 26.9" N	76°12' 16.0"E	Wadakkanchery	Kechery	Midland
FDS 52	10° 12' 38.1" N	76°13' 17.8"E	Veloor	Kechery	Midland
FDS 53	10° 34' 16.9" N	76°11' 28.5"E	Karalam	Karuvannur	Lowland
FDS 54	10° 33' 18.2" N	76° 12' 2.0" E	Kadangode	Kechery	Midland
FDS 55	10° 33' 39.5" N	76° 12' 3.6" E	Kadangode	Kechery	Midland
FDS 56	10° 34' 23.7" N	76°11' 51.3"E	Erumapetty	Kechery	Midland
FDS 57	10° 29' 21.0" N	76°16' 33.3"E	Annammanada	Chalakkudy	Lowland
FDS 58	10° 29' 15.4" N	76°19' 13.2"E	Thaniam	Karuvannur	Lowland
FDS 59	10° 30' 35.3" N	76°20' 17.6"E	Cherpu	Karuvannur	Lowland
FDS 60	10° 32'12.11"N	76°13' 29.62"E	Chazhur	Karuvannur	Lowland
FDS 61	10° 29' 15.7" N	76°19' 20.8"E	Chazhur	Karuvannur	Lowland
FDS 62	10° 29' 26.5" N	76° 16' 22.9" E	Padiyur	Karuvannur	Lowland

FDS 63	10° 33' 45.0" N	76° 10' 56.7" E	Mullurkkara	Kechery	Lowland
FDS 64	10° 30' 46.5" N	76°17' 26.1"E	Desamangalam	Bharathapuzha	
FDS 65	10° 30' 27.9" N	76°20' 15.9"E	Mullurkkara	Kechery	Lowland
FDS 66	10° 29' 16.7" N	76°19' 14.9"E	Karalam	Karuvannur	Lowland
FDS 67	10° 33' 23.4" N	76°6' 21.9" E	Kattoor	Karuvannur	Low and
FDS 68	10° 33' 27.7" N	76°6' 0.6" E	Thekkumkara	Kechery	Lowland
FDS 69	10° 13' 13.2" N	76°12' 30.3"E	Desamangalam	Bharathapuzha	Lowland
FDS 70	10° 13' 11.8" N	76°12' 17.5"E	Karalam	Karuvannur	Lowland
FDS 71	10° 34' 29.6" N	76° 1' 45.8" E	Chazhur	Karuvannur	Lowland
FDS 72	10° 13' 26.9" N	76°12' 16.0"E	Wadakkanchery(M)	Kechery	Lowland
FDS 73	10° 24' 34.5" N	76° 6' 57.6" E	Varavur	Bharathapuzha	Lowland
FDS 74	10° 13' 26.9" N	76°12' 16.0"E	Vallatholnagar	Bharathapuzha	Lowland
FDS 75	10° 12' 38.1" N	76°13' 17.8"E	Erumapetty	Bharathapuzha	Lowland
FDS 76	10° 34' 16.9" N	76°11' 28.5"E	Choondal	Kechery	Lowland
FDS 77	10° 33' 18.2" N	76° 12' 2.0" E	Veloor	Kechery	Lowland
FDS 78	10° 33' 39.5" N	76°12' 3.6" E	Thekkumkara	Kechery	Lowland
FDS 79	10° 34' 23.7" N	76°11' 51.3"E	Wadakkanchery(M)	Kechery	Lowland
FDS 80	10° 29' 21.0" N	76°16' 33.3"E	Kattoor	Karuvannur	Lowland
FDS 81	10° 29' 15.4" N	76°19' 13.2"E	Paralam	Karuvannur	Lowland
FDS 82	10° 30' 35.3" N	76°20' 17.6"E	Wadakkanchery(M)	Kechery	Lowland
FDS 83	10° 32'12.11"N	76°13' 29.62" E	Chazhur	Karuvannur	Lowland
FDS 84	10° 29' 15.7" N	76°19' 20.8"E	Chazhur	Karuvannur	Lowland
FDS 85	10° 29' 26.5" N	76°16' 22.9"E	Pananchery	Kechery	Lowland
FDS 86	10° 33' 45.0" N	76°10' 56.7"E	Puthur	Karuvannur	Lowland
FDS 87	10° 30' 46.5" N	76°17' 26.1"E	Tholur	Kechery	Lowland
FDS 88	10° 30' 27.9" N	76°20' 15.9"E	Kodungallur	Periyar	Lowland
FDS 89	10° 29' 16.7" N	76°19' 14.9"E	Puthur	Karuvannur	Mid land
FDS 90	10° 33' 23.4" N	76° 6' 21.9" E	Pananchery	Kechery	Midland
FDS 91	10° 33' 27.7" N	76°6' 0.6" E	Thrissur (C)	Kechery	Lowland
FDS 92	10° 13' 13.2" N	76°12' 30.3"E	Puthur	Kechery	Lowland
FDS 93	10° 13' 11.8" N	76°12' 17.5"E	Puthur	Karuvannur	Lowland
FDS 94	10° 34' 29.6" N	76°1' 45.8" E	Puthur	Karuvannur	Mid land
FDS 95	10° 13' 26.9" N	76°12' 16.0"E	Thrissur (C)	Kechery	Lowland
FDS 96	10° 24' 34.5" N	76° 6' 57.6" E	Puthur	Karuvannur	Midland
FDS 97	10° 13' 26.9" N	76°12' 16.0"E	Puthur	Karuvannur	Lowland

FDS 98	10° 12' 38.1" N	76°13' 17.8"E	Adat	Kechery	Lowland
FDS 99	10° 34' 16.9" N	76°11' 28.5"E	Puthur	Karuvannur	Lowland
FDS 100	10° 33' 18.2" N	76°12' 2.0" E	Puthur	Karuvannur	Mid land
FDS 101	10° 33' 39.5" N	76°12' 3.6" E	Puthur	Karuvannur	Lowland
FDS 102	10° 34' 23.7" N	76°11' 51.3"E	Mullassery	Kechery	Lowland
FDS 103	10° 29' 21.0" N	76°16' 33.3"E	Mullassery	Kechery	Lowland
FDS 104	10° 29' 15.4" N	76°19' 13.2"E	Kodungallur	Periyar	Lowland
FDS 105	10° 30' 35.3" N	76°20' 17.6"E	Kodungallur	Periyar	Lowland
FDS 106	10° 32'12.11"N	76°13' 29.62"E	Orumanayur	Kechery	Lowland

Table 5.8.2

Landuse and site characteristics

Sample code	Land form	Slope %	Present land use	Site characteristics
Kly FD 1	Valley	4%	Coconut	Water logging for 2 -3 days
Kly FD 2	Valley	5%	Coconut	Water logging for 2 – 3 days
Kly FD 3	Valley	4%	Coconut	Water logging for 2 days
Kly FD 4	Valley	5%	Coconut, Banana, Arecanut	Water logging 1-2 feet height for 2-3 days
Kly FD 6	Valley	4%	Coconut, Banana	Water logging for 2-3 days
Kly FD 7	Valley	5%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
Kly FD 8	Valley	5%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
Kly FD 9	Valley	5%	Coconut, Arecanut	Water logging 1-2 feet height for 2-3 days
Kly FD10	Valley	5%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
Kly FD11	Valley	5%	Coconut, Banana	Water logging 1-2 feet height for 2-3 days
Kly FD12	Valley	4%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
Kly FD13	Valley	4%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
Kly FD14	Valley	4%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
Kly FD15	Valley	4%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
Kly FD16	Valley	4%	Coconut, Banana, Nutmeg, Pepper	Water logging 1-2 feet height for 2-3 days
FDS 1	Valley	4%	Coconut, Banana, Arecanut	Water logging 1-2 feet height for 2-3 days

FDS 2	Valley	4%	Coconut, Banana, Nutmeg	Water logging 1-2 feet height for 2-3 days
FDS 3	Valley	5%	Coconut, Arecanut, Pepper, Banana	Water logging 1-2 feet height for 2-3 days
FDS 5	Valley	5%	Coconut, Banana, tapioca, Vegetables	Water logging 1 meter height 2-3 days;soil eroded and gravelliness increased
FDS 6	Valley	5%	Coconut, Arecanut	Water logging 1-2 feet 2-3 days. Sand deposited.
FDS 7	Valley	5%	Coconut, Arecanut	Water logging 3 feet 2-3 days. Clay deposited. Compound walls broken.
FDS 8	Side slope	10%	Coconut, Banana, Mixed trees	Water logged for 1 week at 1 feet height. Slight sand deposit.
FDS 10	Riverbank	5%	Coconut	Water logging 1 meter 2-3 days
FDS 11	riverbank	5%	Coconut, Nutmeg	Clay deposit >2.5 inch thick; 4-5 days water stagnation
FDS 12	Valley	5%	Coconut, Arecanut, Nutmeg	Clay deposit >1.5 inch; Water level >1meter for 3-4 days
FDS 13	Valley	3%	Paddy	Clay deposit >2 inch thick ;Water stagnation for 5-6 days
FDS 14	riverbank	5%	Coconut, Arecanut, Nutmeg	Clay deposit >1inch thick. Water level > 1 meter for 3-4 days
FDS 15	riverbank	5%	Coconut, Arecanut, Nutmeg, Banana	Water level for 3-4 m height for 6-7 days. 1 inch thick clay deposit. Heavy flow of water
FDS 16	riverbank	5%	Banana	Sand deposit 1 feet thick for a distance of > 300 meters along river bank
FDS 17	riverbank	5%	Coconut, Arecanut, Nutmeg, Banana	Sand deposit in river bank >1.5 m thick.
FDS 18	Valley	5%	Coconut, Arecanut, Banana	Water logging 1 meter 2-3 days. Soil eroded gravelliness increased.
FDS 19	riverbank	5%	Coconut, Banana	Clay deposit >1 inch thick over sandy textured soil Water level >2 meter height for 5-6 days
FDS 20	Valley	3%	Paddy	Water logging 1-2 feet 2-3 days
FDS 21	Side slope	5%	Coconut, Banana	Water logging 2-3 feet 2-3

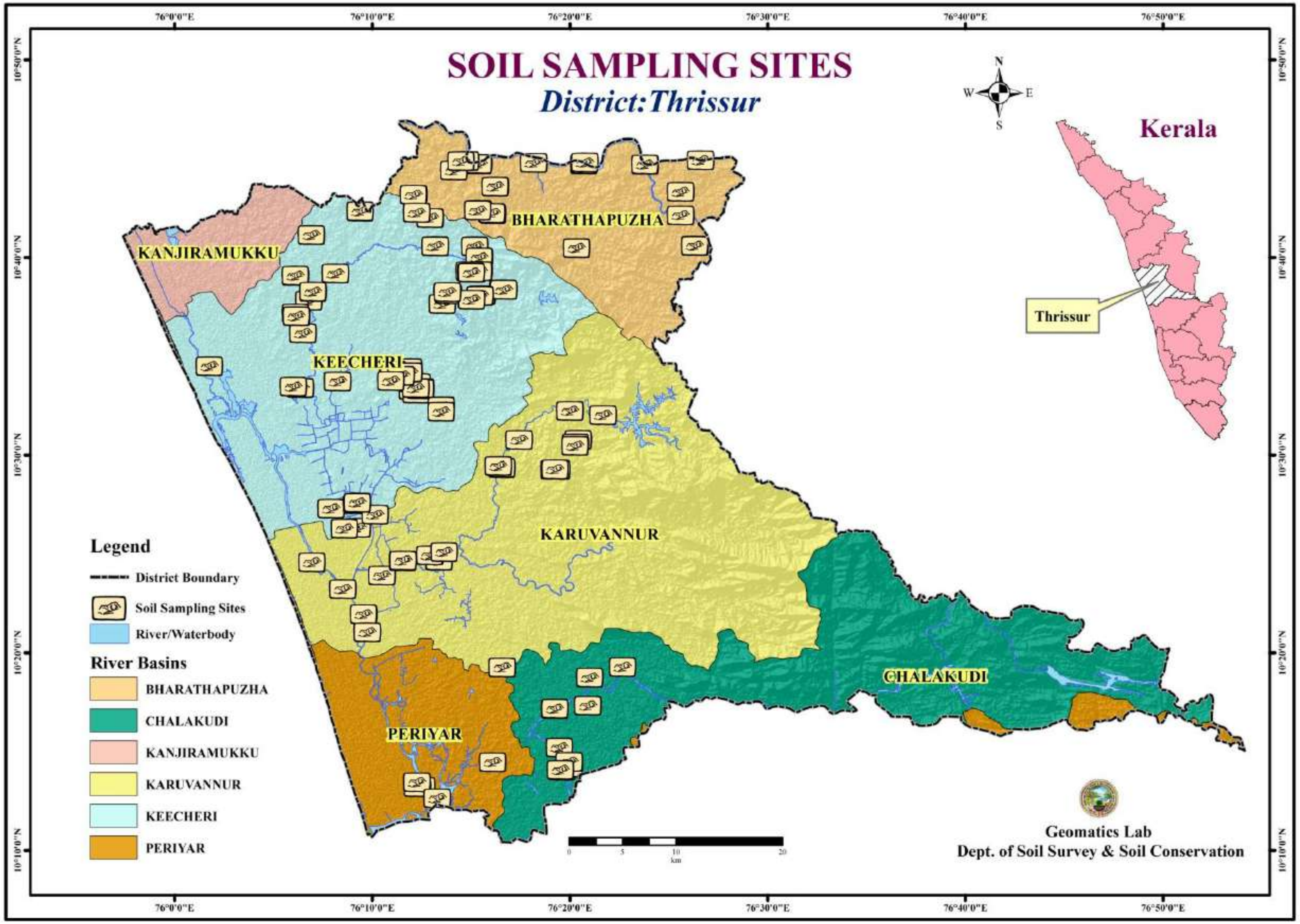
				days. Soil eroded.
FDS 22	Valley	5%	Banana	Water logging 3-4 feet 2-3 days. Sand deposited slightly
FDS 23	Valley	5%	Coconut, Arecanut, Banana, Pepper	Water logging 1-2 feet 2-3 days
FDS 24	Valley	5%	Banana, Coconut	Water logging 2 meters for 2-3 days. sand deposited
FDS 25	Valley	8%	Coconut, Arecanut, Nutmeg, Banana	Clay deposit <1 inch Water stagnation for 4-5 days at >2 meter height
FDS 26	Valley	8%	Coconut, Arecanut, Nutmeg, Banana	Water level for 2 m height for 6 days. Clay deposit of 1 inch thick.
FDS 27	Valley	5%	Coconut, Arecanut	Water level > 2 m height for 6 days. Slight deposit of sand and clay.
FDS 28	Valley	3%	Coconut	Water stagnation half meter high for 4- 5 days
FDS 29	Valley	5%	Paddy, Vegetables	Landslide area. Soil from hillside deposited over paddy land at 1 meter thickness
FDS 30	Riverbank	3%	Paddy	Water logging 1-2 feet 5-6 days
FDS 31	Sideslope	10%	Coconut, Banana, Mixed trees	Water stagnation due to heavy rainfall to 1 feet height for a week.
FDS 32	riverbank	5%	Coconut, Arecanut, Nutmeg, Banana	Surface eroded due to heavy flow of water. Slight sand deposit on surface. water level >1 meter for 4-5 days
FDS 33	Valley	3%	Banana	Water logging for 2-3 days
FDS 34	riverbank	5%	Coconut, Banana	Sand deposit along the river bank. Water logging for 4-5 days.
FDS 35	riverbank	5%	Coconut, Banana	Clay deposit >1 inch thick over sandy textured soil . Water level >2 meter height for 5-6 days
FDS 36	Valley	3%	Paddy	Clay deposit 2 inch thick Water logging for 4-5 days at >1m height
FDS 37	Valley	3%	Paddy	Clay deposit >2 inch thick Water logging for 4-5 days at >1 meter height
FDS 38	Valley	3%	Paddy	Clay deposit 2 inch thick Water logging for 4-5 days

				at >1m height
FDS 39	Valley	5%	Paddy, Vegetables	Landslide area. Soil from hillside deposited over paddy land at 1 meter thickness
FDS 40	riverbank	5%	Coconut, Banana	Sand deposit for >1 feet thick at 200 meter length Water logging >1 meter height
FDS 41	Side slope	35%	Acacia, Rubber	Landslide area, soil piping, high erosion and movement of soil material
FDS 42	riverbank	5%	Banana, Coconut	Clay deposit 1 inch thick Water logging for 4-5 days at >2 meter height
FDS 43	Valley	5%	Coconut, Banana, Arecanut	Water logging 2 meter height for 2-3 days.
FDS 44	Valley	5%	Coconut, Arecanut, Mixed trees	Water logging 3 meter height for 2-3 days. Clay deposit
FDS 45	Side slope	10%	Vegetables, Rambutan	Landslide area. Near Kuranchery land slide area.
FDS 46	Valley	5%	Coconut, Arecanut, Mixed trees	Gravelliness increased. Clay deposition.
FDS 47	Side slope	10%	Rubber	Water logging > 50 cm height for 4-5 days
FDS 48	Valley	5%	Coconut, Banana	Water level for 3-4 m height for 6-7 days. Bund road broken. Heavy flow of water. Heavy erosion.
FDS 49	Flood plain	3%	Paddy (Kole land)	Water logging for more than 3 weeks in kole land and adjoining areas. At height of 3-4 meters
FDS 50	Valley	3%	Paddy	Water logging > 2 m height for 4-5 days. Clay deposit for 1 inch thick.
FDS 51	Valley	3%	Paddy	Water logging > 2 m height for 4-5 days. Clay deposit for 1 inch thick.
FDS 52	Valley	3%	Paddy	Water logging > 1.5 m height for 4-5 days. Clay deposit <1 inch thick.
FDS 53	Valley	4%	Coconut, Nutmeg, Banana	Water logging > 2 m height for 4-5 days. Clay deposit for 1 inch thick.
FDS 54	Valley	3%	Paddy	Water logging 1-2 feet height for 4-5 days. Clay

				deposit for 1 inch thick.
FDS 55	Valley	3%	Paddy	Water logging 1 meter height for 5-6 days. Clay deposit for 1 inch thick.
FDS 56	Valley	3%	Paddy	Sand deposition.
FDS 57	Valley	5%	Arecanut, Nutmeg	Clay deposit > 1 feet thick. Water level > 2 meters for 5- 6 days
FDS 58	Riverbank	5%	Coconut, Nutmeg	Water logging > 1.5 m height for 8-9 days. Slight Clay and sand deposit. Heavy water flow.
FDS 59	Valley	3%	Coconut, Banana	Fine sand deposited for 1 inch thick. Water logged for 5-6 days at 2 m height. Compound walls broken
FDS 60	Floodplain island	3%	Coconut	Water logged for 2 weeks. Height of 2 meters
FDS 61	Valley	3%	Coconut	Water logging at 2 m height for 2-3 days.
FDS 62	Valley	3%	Coconut	Water logging at 2 m height for 7 days.
FDS 63	Valley	1-3%	Paddy	Waterlogged at 1.5 m height for 3 days
FDS 64	Riverbank	3%	Coconut	Clay and Sand deposition for 1 inch height
FDS 65	Valley	1-3%	Paddy	waterlogged at 75 cm height for 2-3 days. Clay deposition of half inch thickness.
FDS 66	Riverbank	1-2%	Paddy	Slight soil erosion.
FDS 67	Valley	1-3%	Coconut, Banana	Waterlogged for >6 ft height. Slight clay deposition.
FDS 68	Valley	1-3%	Paddy	Waterlogged for 2 days.Silt deposited upto half inch.
FDS 69	Valley	1-3&	paddy	Waterlogged at 1.5 m height for 2 m for 3-4 days.Clay deposited.
FDS 70	Valley	3%	Coconut, Arecanut, Banana	Waterlogged for >2.5 cm for 5- days
FDS 71	Valley	3%	Banana	Converted land waterlogged for 3-4 days to a height of 75 cm.
FDS 72	Valley	1-3%	Paddy	Slight Sand deposition.
FDS 73	Valley	1-3%	Paddy	Waterlogged at 3 m height for 2 days.
FDS 74	Valley	1-3%	Paddy	Waterlogged at 1 m height for 3-4 days. Clay

				deposition for 1 inch thickness.
FDS 75	Valley	1-3%	Paddy	Sand and gravel % increased.
FDS 76	Valley	1-3%	Paddy	Waterlogged for>1.5m height for 3-4 days.
FDS 77	Valley	1-3%	Paddy	Waterlogged for>1.5m height for 3-4 days.
FDS 78	Valley	1-3%	Paddy	Waterlogged for 2 days to a height of 1 m. Deposition of sand.
FDS 79	Valley	1-3%	Paddy	Waterlogged at 1 m height for 2- 3 days. Clay and sand deposition of 1 inch thickness.
FDS 80	Valley	1-3%	Paddy	Waterlogged for >1.5m height for 2-3 days
FDS 81	Flood plain	0-1%	Paddy(Kole land)	Water logging for more than 3 weeks in kole land and adjoining areas to a height of 3-4 meters
FDS 82	Valley	1-3%	Paddy	Water logged at 3 m height for 2 days.
FDS 83	Flood plain	0-1%	Paddy(Kole land)	Water logging for more than 3 weeks in kole land and adjoining areas to a height of 3-4 m.
FDS 84	Valley	1-3%	Coconut, Banana	5-8 cm deposition of clay.
FDS 85	Riverbank	1-3 %	Coconut, Nutmeg,Arecanut, Banana	Water logged for 3 m height for 3-4 days. Clay deposition of 1-3 cm height.
FDS 86	Side slope	15-20%	Teak	Land slide area with soil crackings upto 5m depth. 2.5 Km residential area affected. Two houses got damaged.
FDS 87	Flood plain	0-1%	paddy(Kole land)	Water logging for more than 3 weeks in kole land and adjoining areas to a height of 3-4 meters
FDS 88	Coastal area	3%	Coconut	Water logged at height of 1 m for 2-3 days.
FDS 89	Side slope	15-20%	Forest trees	Land slide area. Silt deposition to 2 m height.
FDS 90	Side slope	10-15%	Rubber	Soil Crackings in 1 acre area. A house fully damaged by cracks. Land slided and eroded to

				Manalipuzha
FDS 91	valley	1-3%	Paddy fallow	Slight clay deposition
FDS 92	River bank	3%	Coconut, Arecanut, Banana	Slight clay and sand deposition
FDS 93	Valley	1-3%	Canal /Thodu	Deposition of sand from land slided area to1.5 m height. Presence of typical Soil piping .Canal of 3 m height was fully covered with sand and silt.
FDS 94	Side slope	10-15%	Coconut, Nutmeg, Arecanut, Pepper, Ban	Land slide area. A house fully damaged. Crop loss in 1.5 acres of land. Soil Crackings seen.
FDS 95	valley	1-3%	Banana	Converted land. Water logged for >1.5 m height for 3-4 days.
FDS 96	Side slope	15-20%	Teak	Landslide area. Peechi Left Irrigation canal broken and soil cracks noticed.
FDS 97	Riverbank	3%	Coconut, Arecanut, Banana	Thin layer of sand deposition
FDS 98	Flood plain	0-1%	paddy	Water logging for more than 3 weeks in kole land and adjoining areas to a height of 3-4 meters
FDS 99	Valley	1-3%	Coconut, Banana	Water logged for 1.5 m height for 2 days. Deposition of clay for 2 feet height.
FDS 100	Side slope	10-15%	Rubber	Land slide area.3 houses partially damaged.
FDS 101	Valley	1-3%	Canal/Thodu	Clay deposited to 2 m height and canal got blocked.
FDS 102	Coastal belt	1-3%	Coconut	Soil eroded from the area.
FDS 103	Flood plain	0-1%	Paddy(Kole land)	Waterlogging to a height of 3-4 meters for more than 3 weeks; also in adjoining areas
FDS 104	Coastal belt	1-3%	Coconut	Clay deposition of half inch thickness
FDS 105	Coastal belt	1-3%	Cococnut	Clay deposition of half inch thickness
FDS 106	Coastal belt	1-3%	Coconut	Sand deposition of 1 inch thickness


SOIL SAMPLING SITES
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KANJIRAMUKKU
KEECHERI
KARUVANNUR
CHALAKUDI
PERIYAR
Legend
District Boundary
Soil Sampling Sites
River/Waterbody
River Basins
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Geomatics Lab
Dept. of Soil Survey & Soil Conservation

In all sampling locations preflood data is not available. Hence comparison of chemical properties could be done only with the following soil samples where preflood data is available.

Table 5.8.3

Sampling sites where preflood data available

Sl No	Sample code	Location Decimal degrees	Panchayath	Landform
1	FDS 6	10.31236 N, 76.35014 E	Chalakkudy	River bank
2	FDS 81	10.53739 N, 76.33353 E	Pananchery	-do-
3	FDS 88	10.48917 N, 76.27592 E	Puthur	-do-
4	FDS 93	10.49069 N, 76.27303 E	Puthur	-do-
5	FDS 2	10.67603 N, 76.25314 E	Erumapetty	Midland valley
6	FDS 20	10.70339 N, 76.26831 E	Mullurkkara	-do-
7	KLY FD1	10. 55506 N, 76.20056 E	Kolazhy	lowland valley
8	KLY FD2	10.56097 N, 76.201 E	Kolazhy	-do-
9	KLY FD3	10.57325 N,76.19758 E	Kolazhy	-do-
10	KLY FD4	10.57108 N,76.18406 E	Kolazhy	-do-
11	KLY FD6	10.57136 N,76.19125 E	Kolazhy	-do-
12	KLY FD7	10.57136 N,76.18433	Kolazhy	-do-
13	KLY FD8	10.56303 N,76.18978 E	Kolazhy	-do-
14	KLY FD9	10.56075 N,76.20469 E	Kolazhy	-do-
15	FDS 56	10.63939 N,76.27767 E	Chazhur	flood plain
16	FDS 94	10.5625 N,76.18242 E	Adat	-do-
17	FDS 98	10.5565 N,76.10608 E	Mullassery	Coastal area
18	FDS 104	10.40958 N,76.116 E	Kechery	-do-
19	FDS 82	10.48781 N,76.32169 E	Puthur	valley
20	FDS 90	10.50981 N,76.33822 E	Puthur	Sideslope
21	FDS 92	10.48769 N,76.32244 E	Puthur	Riverbank
22	FDS 96	10.50775 N,76.33775 E	Puthur	Sideslope

CHANGES IN SOILS OF DISTRESS AFFECTED AREAS

LANDSCAPE AND PHYSIOGRAPHY

- Change in slope of the hill side occurred in landslide affected areas of Kuranchery (Thekkumkara panchayat), Kurumala (Chelakkara panchayat), Desamangalam vavarupallam Kottamputhur colony (Desamangalam panchayat) ,Cheruthuruthy-Thazhepra area (Vallathol nagar panchayat), Kuthiran (Pananchery panchayat), Kolamkunnu (Puthur panchayat), Nadathara panchayat, Madakathara panchayat. Severe soil erosion occurred in the above landslide affected areas.

- Changes in soil depth : Clay sand and slit deposition occurred in flood affected areas. Increase in soil height to a few centimeters in clay and silt deposited areas and to more than 2 meters in some sand deposited areas were observed. Sand deposition occurred at various locations in Chalakkudy river bank especially in Pariyaram, Chalakkudy areas.
- Clay deposition occurred in paddy fields as well as garden lands due to water stagnation.
- Eroded surface caused decrease in soil depth by few centimeters (which need further detailed study). The details are as follows

Sl no	River basin	location	Deposits found
1	Chalakkudy	Chalakkudy Kottat area, Pariyaram, Melur, Kadukutty, Annammanada, Mala	Sand deposited on river banks to a height of more than 2 meters to a distance of 200 meters. Clay deposit of 1 inch thickness.
2	Bharathapuzha	Thiruvilwamala, Lakkidi	Sand deposited on river banks – height>1m – 200 meters distance along the riverbank. Clay deposit in flooded area.
3	Bharathapuzha (Gayathripuzha tributary)	Kalleppadam (Pazhayanur) Thozupadam, Vazhalipadam (Panjal)	Clay deposit 2 inches in flooded paddy fields
4	Bharathapuzha	Kuttambully (Thiruvilwamala) Nambiarpallam (Vallatholnagar)	Clay deposit 1 inch thick
5	Bharathapuzha (Gayathripuzha tributary)	Cheerakkuzy (Pazhayannur)	Clay deposit 1 inch thick
6	Karuvannurpuzha	Kattur, Karalam, Cherpu, Vallachira, Aarattupuzha area, Thaniam	Clay deposit <1 inch in wetlands adjoining river

7	Karuvannurpuzha (canoli canal area)	Thriprayar (Nattika)	Not much deposition due to swift flow of water.
8	Kechery river	Chavakkad, Orumanayur	Sand deposited to a thickness of < 1” in flooded areas
9	Kechery river	Mullassery, Adat, Tholur	Clay deposit <1” in flooded garden lands adjoining the Kole lands
10	Periyar river	Kodungallur, Poyya, Pullut area	Clay deposited <1” in flooded areas

CHANGES IN PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL PROPERTIES

The changes in physical properties such as texture, structure and permeability are given in the table below.

Table 5.8.4

Physical characteristics

Sample code	Soil depth	Texture (feel method)	Structure	Permeability
Kly FD 1	>150 cm	Sandy Clay Loam	Sub angular blocky	moderate
Kly FD 2	100-150 cm	Gravelly sandy clay loam	Sub angular blocky	moderate
Kly FD 3	>150 cm	Sandy Clay Loam	Sub angular blocky	moderate
Kly FD 4	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD 6	>150 cm	Sandy Clay Loam	Sub angular blocky	moderate
Kly FD 7	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD 8	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD 9	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD10	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD11	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD12	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD13	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD14	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
Kly FD15	100-150cm	Gravelly clay loam	Sub angular blocky	moderate

Kly FD16	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 1	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 2	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 3	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 5	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 6	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 7	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 8	75-100 cm	Gravelly sandy clay loam	Sub angular blocky	moderate
FDS 10	>150 cm	Sandy loam	granular	High
FDS 11	>150 cm	Sandy loam	granular	High
FDS 12	>150 cm	Sandy clay loam	Sub angular blocky	moderate
FDS 13	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 14	>150 cm	Sandy loam	granular	High
FDS 15	>150 cm	Sandy loam	granular	High
FDS 16	>150 cm	Sandy loam	granular	High
FDS 17	>150 cm	Sandy loam	granular	High
FDS 18	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 19	>150 cm	Sandy loam	granular	High
FDS 20	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 21	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 22	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 23	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 24	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 25	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 26	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 27	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 28	100-150cm	sandy clay loam	Sub angular blocky	moderate
FDS 29	>150 cm	Clay loam	Sub angular blocky	moderate

FDS 30	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 31	100-150cm	Gravelly sandy clay loam	Sub angular blocky	moderate
FDS 32	>150 cm	Sandy loam	granular	High
FDS 33	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 34	>150 cm	Sandy loam	granular	High
FDS 35	>150 cm	Sandy loam	granular	High
FDS 36	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 37	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 38	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 39	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 40	>150 cm	Sandy loam	granular	High
FDS 41	100-150cm	Gravelly sandy clay loam	Sub angular blocky	moderate
FDS 42	>150 cm	Sandy loam	granular	High
FDS 43	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 44	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 45	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 46	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 47	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 48	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 49	>150 cm	Clay	Massive	Low
FDS 50	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 51	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 52	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 53	>150cm	Sandy clay loam	Sub angular blocky	moderate
FDS 54	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 55	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 56	>150 cm	Clay loam	Sub angular blocky	moderate
FDS 57	>150cm	Sandy loam	granular	High

FDS 58	>150 cm	Sandy loam	granular	High
FDS 59	>150cm	Sandy loam	granular	High
FDS 60	100-150cm	Gravelly clay loam	Sub angular blocky	moderate
FDS 61	>150cm	Sandy loam	granular	High
FDS 62	>150cm	Sandy loam	granular	High
FDS 63	100-150 cm	Sandy clay loam	Sub angular blocky	Moderate
FDS 64	>150 cm	Sandy clay loam	Sub angular blocky	Moderate
FDS 65	100-150 cm	Sandy clay loam	Sub angular blocky	Moderate
FDS 66	>15 cm	Clay loam	Sub angular blocky	Moderate
FDS 67	>150 cm	Clay loam	Sub angular blocky	Moderate
FDS 68	100-150 cm	Clay loam	Sub angular blocky	Moderate
FDS 69	100-150 cm	Clay loam	Sub angular blocky	Moderate
FDS 70	>150 cm	Clay	Sub angular blocky	Slight
FDS 71	>150 cm	Sandy loam	Granular	High
FDS 72	>150 cm	clay loam	Sub angular blocky	Moderate
FDS 73	100-150 cm	Clay loam	Sub angular blocky	Moderate
FDS 74	100-150 cm	Sandy clay loam	Sub angular blocky	Moderate
FDS 75	100-150 cm	Sandy clay loam	Sub angular blocky	Moderate
FDS 76	>150 cm	Clay loam	Sub angular blocky	Moderate
FDS 77	>150 cm	Clay loam	Sub angular blocky	Moderate
FDS 78	>150 cm	Clay loam	Sub angular blocky	Moderate
FDS 79	>150 cm	Clay loam	Sub angular blocky	Moderate
FDS 80	>150 cm	Sandy loam	Granular	High
FDS 81	>150 cm	Clay	Sub angular blocky	Slight
FDS 82	>150 cm	Clay	Sub angular blocky	Slight
FDS 83	>150 cm	Clay	Sub angular blocky	Slight
FDS 84	100-150 cm	Clay loam	Sub angular blocky	Moderate
FDS 85	>150 cm	Gravelly clay loam	Sub angular blocky	Moderate

FDS 86	100-150cm	Gravelly clay loam	Sub angular blocky	Moderate
FDS 87	>150 cm	Clay	Sub angular blocky	Slight
FDS 88	>150 cm	Sandy loam	Granular	High
FDS 89	100-150cm	Gravelly clay loam	Sub angular blocky	Slight
FDS 90	100-150cm	Gravelly clay loam	Sub angular blocky	Moderate
FDS 91	>150 cm	Clay loam	Sub angular blocky	Moderate
FDS 92	>150 cm	Sandy clay loam	Sub angular blocky	Moderate
FDS 93	100-150cm	Sandy clay loam	Sub angular blocky	Moderate
FDS 94	100-150cm	Gravelly clay loam	Sub angular blocky	Moderate
FDS 95	>150 cm	Gravelly Sandy clay loam	Sub angular blocky	Moderate
FDS 96	100-150cm	Gravelly clay loam	Sub angular blocky	Moderate
FDS 97	> 150 cm	Gravelly clay loam	Sub angular blocky	Moderate
FDS 98	>150 cm	Gravelly clay loam	Sub angular blocky	Moderate
FDS 99	>150 cm	Gravelly Sandy clay loam	Sub angular blocky	Moderate
FDS 100	100-150cm	Gravelly clay loam	Sub angular blocky	Moderate
FDS 101	>150 cm	Clay loam	Sub angular blocky	Moderate
FDS 102	>150 cm	Sandy loam	Granular	High
FDS 103	>150 cm	Clay	Sub angular blocky	Slight
FDS 104	>150cm	Sandy loam	granular	High
FDS 105	>150cm	Sandy loam	granular	High
FDS 106	>150cm	Sandy loam	granular	High

SOIL TEXTURE

Changes in surface texture (sand, silt, clay) occurred in different soils which are given in appended tabl. Textural changes occurred depending on sand, silt, clay deposited on the surface. Clay deposition on sandy textured soil changed the surface texture to clay loam in many areas.

SOIL STRUCTURE

Loss of soil aggregation impacts agriculture by decreasing soil quality and crop production. As soil aggregates breakdown due to flooding, the soil particles plug pores and voids that would otherwise help soil to dry and return to normal after flooding. Soil cracking is seen in areas where clay was deposited.

WATER HOLDING CAPACITY, POROSITY

There may be changes in water holding capacity of soil depending on the material deposited, which calls for a detailed study. Porosity and permeability of garden land soils might have been affected due to plugging of pores by the clay layer deposited on the surface. Crop failure especially in Nutmeg, Banana etc. due to anaerobic condition of soil is noticed where water stagnation occurred for prolonged period.

CHEMICAL PROPERTIES

The chemical properties such as pH, EC, macro, secondary and micronutrients of the soil samples collected from the identified flooded and landslide sites were analysed. Comparison of data has been done with the values of available pre flood data.

Table 5.8.5

pH & Electrical Conductivity

Sl no	Sample code	pH	EC dS^{m-1}
1	KLY/FD/1	5.89	0.23
2	KLY/FD/2	6.72	0.39
3	KLY/FD/3	6.52	0.28
4	KLY/FD/4	6.4	0.27
5	KLY/FD/6	5.92	0.22
6	KLY/FD/7	6.05	0.24
7	KLY/FD/8	6.68	0.28
8	KLY/FD/9	6.95	0.33
9	KLY/FD/10	6.52	0.27
10	KLY/FD/11	7.02	0.33

11	KLY/FD/12	6.37	0.27
12	KLY/FD/13	6.26	0.24
13	KLY/FD/14	6.81	0.25
14	KLY/FD/15	6.48	0.27
15	KLY/FD/16	6.2	0.22
16	FDS/1	6.06	0.28
17	FDS/2	6.3	0.27
18	FDS/3	6.2	0.29
19	FDS/5	5.88	0.25
20	FDS/6	6	0.27
21	FDS/7	6.26	0.32
22	FDS/8	6.19	0.27
23	FDS/10	5.55	0.36
24	FDS/11	5.79	0.27
25	FDS/12	6.85	0.35
26	FDS/13	5.78	0.33
27	FDS 14	6.44	0.15
28	FDS 15	6.7	0.15
29	FDS 16	6.77	0.16
30	FDS 17	7.23	0.09
31	FDS 18	6.11	0.19
32	FDS 19	5.92	0.2
33	FDS 20	6.03	0.1
34	FDS 21	6.63	0.17
35	FDS 22	6.03	0.19
36	FDS 23	6.3	0.2
37	FDS 24	6	0.11
38	FDS 25	5.68	0.2
39	FDS 26	5.95	0.15

40	FDS 27	7.32	0.17
41	FDS 28	5.57	0.11
42	FDS 29	5.5	0.19
43	FDS 30	5.9	0.2
44	FDS 31	5.75	0.18
45	FDS 32	5.32	0.06
46	FDS 33	5.42	0.08
47	FDS 34	4.19	0.06
48	FDS 35	4.9	0.06
49	FDS 36	6.04	0.06
50	FDS 37	5.33	0.11
51	FDS 38	6.06	0.06
52	FDS 39	6.11	0.18
53	FDS 40	5.12	0.11
54	FDS 41	5.5	0.17
55	FDS 42	6.08	0.06
56	FDS 43	4.86	0.06
57	FDS 44	5.72	0.23
58	FDS 45	5.5	0.08
59	FDS 46	5.18	0.22
60	FDS 47	5.13	1.09
61	FDS 48	5.03	0.19
62	FDS 49	6.22	0.24
63	FDS 50	6.36	0.06
64	FDS 51	5.17	0.09
65	FDS 52	4.98	0.13
66	FDS 53	5.4	0.18
67	FDS 54	5.18	0.41
68	FDS 55	4.47	0.24

69	FDS 56	5.73	0.2
70	FDS 57	6.02	0.18
71	FDS 58	5.72	0.2
72	FDS 59	5.67	0.14
73	FDS 60	5.28	0.09
74	FDS 61	5.93	0.34
75	FDS 62	5.83	0.22
76	FDS 63	6.01	0.34
77	FDS 64	5.7	0.85
78	FDS 65	5.54	0.38
79	FDS 66	5.99	0.34
80	FDS 67	6.96	0.25
81	FDS 68	5.8	0.28
82	FDS 69	5.78	0.29
83	FDS 70	6.03	0.33
84	FDS 71	6.3	0.27
85	FDS 72	6.26	0.2
86	FDS 73	5.75	0.39
87	FDS 74	5.3	0.16
88	FDS 75	5.61	0.39
89	FDS 76	5.28	0.6
90	FDS 77	5.35	0.42
91	FDS 78	5.83	0.37
92	FDS 79	5.27	0.45
93	FDS 80	4.49	0.41
94	FDS/81	5.86	0.25
95	FDS/82	5.35	0.02
96	FDS/83	4.28	0.2
97	FDS/84	3.96	0.64

98	FDS/85	5.42	0.26
99	FDS/86	4.53	0.18
100	FDS/87	4.68	0.24
101	FDS/88	5.53	0.21
102	FDS/89	5.96	0.16
103	FDS/90	5.04	0.15
104	FDS/91	5.95	0.25
105	FDS/92	5.73	0.26
106	FDS/93	5.71	0.24
107	FDS/94	4.66	0.26
108	FDS/95	4.45	0.27
109	FDS/96	5.35	0.22
110	FDS/97	5.6	0.18
111	FDS/98	6.25	0.2
112	FDS/99	5.68	0.26
113	FDS/100	4.76	0.15
114	FDS/101	6.31	0.23
115	FDS/102	6.4	0.21
116	FDS/103	5.38	0.23
117	FDS/104	6.46	0.39
118	FDS/105	6.3	0.26
119	FDS/106	5.23	0.24

On analysing the results obtained, pH ranges from extremely acidic to neutral. Majority of the samples are in medium acid to neutral range. Electrical conductivity values are suitable for agricultural production. Electrical conductivity values are not limiting for crop production.

In the below samples for which preflood data were available, comparison in pH and EC under pre and post flood situations have been attempted. The rest of the samples in the above table have no preflood data.

Table 5.8.6

Comparison of pH &Electrical Conductivity

Sl No	Sample code	Preflood		Postflood	
		pH	EC	pH	EC
1	FDS 6	5.4	0.2	6	0.27
2	FDS 81	5.9	0.1	5.86	0.25
3	FDS 88	7.25	0.06	5.53	0.21
4	FDS 93	6.81	0.06	5.71	0.24
5	FDS 2	6.2	0.1	6.3	0.27
6	FDS 20	6.9	0.1	6.03	0.1
7	KLY FD1	4.5	0.1	5.89	0.23
8	KLY FD2	4.7	0.1	6.72	0.39
9	KLY FD3	4.8	0.1	6.52	0.28
10	KLY FD4	6.43	0.2	6.4	0.27
11	KLY FD6	6.08	0.32	5.79	0.24
12	KLY FD7	7.2	0.2	5.92	0.22
13	KLY FD8	6.25	0.07	6.05	0.24
14	KLY FD9	6.7	0.1	6.68	0.28
15	FDS 56	NA	0.31	5.73	0.2
16	FDS 94	5.8	0.1	4.66	0.26
17	FDS 98	5.3	0.1	6.25	0.2
18	FDS 104	6.1	0.1	6.46	0.39
19	FDS 82	5.13	0.06	5.35	0.02
20	FDS 90	6.31	0.08	5.04	0.15
21	FDS 92	6.6	0.12	5.73	0.26
22	FDS 96	6.15	0.1	5.35	0.22

Comparing preflood and postflood values, pH increases after flood for majority of the samples.

Table 5.8.7

Macronutrients

Sl no	Sample code	OC %	Rating	Av.P kg/ha	Rating	Av.K kg/ha	rating
1	KLY/FD/1	0.5	Low	178.08	High	124.99	Medium
2	KLY/FD/2	0.46	Low	26.88	High	320.1	High
3	KLY/FD/3	0.57	Medium	91.84	High	151.76	Medium
4	KLY/FD/4	2.03	High	85.12	High	80.08	Low
5	KLY/FD/6	1.22	Medium	21.28	Medium	89.94	Low

6	KLY/FD/7	0.8	Medium	133.28	High	76.27	Low
7	KLY/FD/8	1.45	Medium	97.44	High	289.74	High
8	KLY/FD/9	0.73	Medium	60.48	High	196.11	Medium
9	KLY/FD/10	1.76	High	98.56	High	197.12	Medium
10	KLY/FD/11	1.07	Medium	35.84	High	222.1	Medium
11	KLY/FD/12	1.91	High	51.52	High	169.46	Medium
12	KLY/FD/13	1.87	High	32.48	High	83.33	Low
13	KLY/FD/14	1.22	Medium	119.84	High	250.43	Medium
14	KLY/FD/15	1.72	High	34.72	High	105.95	Low
15	KLY/FD/16	1.22	Medium	26.88	High	113.9	Low
16	FDS/1	1.03	Medium	20.16	Medium	167.89	Medium
17	FDS/2	0.92	Medium	26.88	High	189.84	Medium
18	FDS/3	1.38	Medium	87.36	High	266.22	Medium
19	FDS/5	0.61	Medium	56	High	214.03	Medium
20	FDS/6	0.84	Medium	34.72	High	98.45	Low
21	FDS/7	3.06	High	105.28	High	242.82	Medium
22	FDS/8	1.64	High	22.4	Medium	187.6	Medium
23	FDS/10	0.8	Medium	42.56	High	129.36	Medium
24	FDS/11	1.57	High	31.36	High	26.88	Low
25	FDS/12	0.65	Medium	20.16	Medium	89.49	Low
26	FDS/13	0.31	Low	22.4	Medium	74.26	Low
27	FDS 14	0.8	Medium	62.72	High	194.1	Medium
28	FDS 15	0.76	Medium	16.8	Medium	68.99	Low
29	FDS 16	1.61	High	10.08	Medium	108.19	Low
30	FDS 17	1.17	Medium	19.04	Medium	163.52	Medium
31	FDS 18	0.8	Medium	42.56	High	117.71	Medium
32	FDS 19	1.25	Medium	19.04	Medium	128.8	Medium
33	FDS 20	1.21	Medium	31.36	High	243.04	Medium
34	FDS 21	1.17	Medium	15.68	Medium	83.44	Low

35	FDS 22	2.37	High	188.16	High	300.72	High
36	FDS 23	1.17	Medium	127.68	High	199.47	Medium
37	FDS 24	1.69	High	25.76	High	434.9	High
38	FDS 25	1.85	High	25.76	High	56.34	Low
39	FDS 26	0.8	Medium	103.04	High	533.01	High
40	FDS 27	0.96	Medium	36.96	High	139.89	Medium
41	FDS 28	1.41	Medium	66.08	High	96.88	Low
42	FDS 29	1.25	Medium	25.76	High	263.76	Medium
43	FDS 30	2.37	High	12.32	Medium	39.31	Low
44	FDS 31	0.36	Low	68.32	High	183.57	Medium
45	FDS 32	1.49	Medium	10.08	Medium	134.29	Medium
46	FDS 33	1.77	High	19.04	Medium	138.43	Medium
47	FDS 34	1.69	High	6.72	Low	86.35	Low
48	FDS 35	1.37	Medium	8.96	Low	144.82	Medium
49	FDS 36	2.05	High	21.28	Medium	145.15	Medium
50	FDS 37	0.92	Medium	91.84	High	200.03	Medium
51	FDS 38	1.85	High	31.36	High	74.37	Low
52	FDS 39	1.89	High	43.68	High	582.96	High
53	FDS 40	1.41	Medium	14.56	Medium	147.95	Medium
54	FDS 41	1.13	Medium	11.2	Medium	140.67	Medium
55	FDS 42	0.44	Low	5.6	Low	85.79	Low
56	FDS 43	0.96	Medium	11.2	Medium	141.9	Medium
57	FDS 44	1.21	Medium	43.68	High	300.72	High
58	FDS 45	0.6	Medium	16.8	Medium	106.29	Low
59	FDS 46	1.01	Medium	12.32	Medium	99.79	Low
60	FDS 47	1.21	Medium	7.84	Low	123.76	Medium
61	FDS 48	1.45	Medium	11.2	Medium	69.66	Low
62	FDS 49	2.05	High	24.64	High	306.88	High
63	FDS 50	0.96	Medium	15.68	Medium	45.7	Low

64	FDS 51	0.64	Medium	14.56	Medium	92.85	Low
65	FDS 52	0.12	Low	5.6	Low	52.98	Low
66	FDS 53	0.96	Medium	14.56	Medium	27.55	Low
67	FDS 54	2.33	High	56	High	119.95	Medium
68	FDS 55	1.01	Medium	24.64	High	304.3	High
69	FDS 56	1.57	High	14.56	Medium	60.82	Low
70	FDS 57	1.37	Medium	30.24	High	50.85	Low
71	FDS 58	0.64	Medium	85.12	High	47.82	Low
72	FDS 59	0.98	Medium	8.96	Low	45.14	Low
73	FDS 60	1.96	High	20.16	Medium	537.94	High
74	FDS 61	0.9	Medium	16.8	Medium	60.14	Low
75	F69DS 62	2.37	High	31.36	High	68.99	Low
76	FDS 63	0.86	Medium	45.92	High	77.06	Low
77	FDS 64	1.72	High	13.44	Medium	100.58	Low
78	FDS 65	2.04	High	16.8	Medium	131.38	Medium
79	FDS 66	1.47	Medium	39.2	High	250.54	Medium
80	FDS 67	0.53	Medium	13.44	Medium	19.04	Low
81	FDS 68	0.82	Medium	21.28	Medium	173.94	Medium
82	FDS 69	1.31	Medium	2.24	Low	127.34	Medium
83	FDS 70	2.21	High	17.92	Medium	81.42	Low
84	FDS 71	1.1	Medium	19.04	Medium	97.44	Low
85	FDS 72	1.35	Medium	15.68	Medium	91.95	Low
86	FDS 73	1.31	Medium	20.16	Medium	141.34	Medium
87	FDS 74	1.02	Medium	6.72	Low	67.2	Low
88	FDS 75	1.51	High	12.32	Medium	113.79	Low
89	FDS 76	1.63	High	10.08	Medium	179.31	Medium
90	FDS 77	1.76	High	24.64	High	124.99	Medium
91	FDS 78	1.47	Medium	13.44	Medium	94.86	Low
92	FDS 79	1.43	Medium	24.64	High	74.14	Low

93	FDS 80	0.98	Medium	8.96	Low	45.14	Low
94	FDS/81	0.28	Low	136.64	High	894.43	High
95	FDS/82	1.22	Medium	47.04	High	142.8	Medium
96	FDS/83	4.33	High	13.44	Medium	56.22	Low
97	FDS/84	1.34	Medium	32.48	High	42.45	Low
98	FDS/85	1.5	Medium	15.68	Medium	195.44	Medium
99	FDS/86	1.22	Medium	81.76	High	284.03	High
100	FDS/87	2.25	High	10.08	Medium	27.22	Low
101	FDS/88	1.54	High	90.72	High	153.78	Medium
102	FDS/89	0.35	Low	39.2	High	72.8	Low
103	FDS/90	0.35	Low	3.36	Low	111.66	Low
104	FDS/91	2.25	High	15.68	Medium	430.3	High
105	FDS/92	1.14	Medium	16.8	Medium	1106.56	High
106	FDS/93	0.98	Medium	50.4	High	50.74	Low
107	FDS/94	2.64	High	19.04	Medium	100.8	Low
108	FDS/95	0.63	Medium	24.64	High	116.93	Medium
109	FDS/96	0.2	Low	5.6	Low	139.78	Medium
110	FDS/97	0.43	Low	22.4	Medium	49.62	Low
111	FDS/98	0.67	Medium	14.56	Medium	278.32	High
112	FDS/99	0.55	Medium	21.28	Medium	73.14	Low
113	FDS/100	0.87	Medium	82.88	High	108.19	Low
114	FDS/101	2.17	High	81.76	High	124.1	Medium
115	FDS/102	0.55	Medium	44.8	High	59.58	Low
116	FDS/103	0.95	Medium	141.12	High	66.3	Low
117	FDS/104	0.59	Medium	109.76	High	114.8	Low
118	FDS/105	0.51	Medium	148.96	High	88.03	Low
119	FDS/106	1.06	Medium	17.92	Medium	66.98	Low

In the below samples for which preflood data were available, comparison of macronutrient under pre and post flood situations have been attempted.

Table 5.8.8

Comparison of Pre and post flood Macronutrients status

Sl No	Sample code	Preflood			Post flood		
		OC %	Av.P kg/ha	Av.K kg/ha	OC %	Av.P kg/ha	Av.K kg/ha
1	FDS 6	0.67	36	231	0.84	34.72	98.45
2	FDS 81	0.74	35	253	0.28	136.64	894.43
3	FDS 88	2	45.92	159.04	1.54	90.72	153.78
4	FDS 93	1.5	50.06	174.72	0.98	50.4	50.74
5	FDS 2	0.65	35	319	0.92	26.88	189.84
6	FDS 20	0.36	19	319	1.21	31.36	243.04
7	KLY FD1	0.89	18	110	0.5	178.08	124.99
8	KLY FD2	0.96	3	132	0.46	26.88	320.1
9	KLY FD3	1.2	26	77	0.57	91.84	151.76
10	KLY FD4	2.2	53.46	414	2.03	85.12	80.08
11	KLY FD6	2.11	34.06	627	1.22	21.28	89.94
12	KLY FD7	1.72	76.83	537.76	0.8	133.28	76.27
13	KLY FD8	1.36	36.8	333.76	1.45	97.44	289.74
14	KLY FD9	0.85	67	423	0.73	60.48	196.11
15	FDS 56	3.96	4.48	151.2	1.57	14.56	60.82
16	FDS 94	0.38	35	286	2.64	19.04	100.8
17	FDS 98	1	48.8	66	0.67	14.56	278.32
18	FDS 104	0.7	36	165	0.59	109.76	114.8
19	FDS 82	0.44	43.5	487.2	1.22	47.04	142.8
20	FDS 90	0.88	147.9	165.48	0.35	3.36	111.6
21	FDS 92	2.7	121.3	1062.88	1.14	16.8	1106.56
22	FDS 96	1.19	35.62	125.44	0.63	24.64	116.93

ORGANIC MATTER CONTENT

Overall there is no remarkable change in organic matter content of soils analysed.Organic carbon content ranges from low to high.

AVAILABLE P, K

Available Nitrogen, Phosphorus and potassium ranges from low to high. Available potassium content was low in majority of samples analysed indicating leaching of potassium during flood. Localised deficiency of phosphorus also seen. 9% samples showed Phosphorus deficiency.

Table 5.8.9

Secondary nutrients

Sl no.	Sample code	Ca *ppm*	Rating	Mg ppm	Rating	S ppm	Rating
1	KLY/FD/1	563.8	Sufficient	58.5	Deficient	21.5	Sufficient
2	KLY/FD/2	763.1	Sufficient	55.5	Deficient	28.6	Sufficient
3	KLY/FD/3	576	Sufficient	42	Deficient	24.6	Sufficient
4	KLY/FD/4	1391	Sufficient	69	Deficient	25.8	Sufficient
5	KLY/FD/6	658	Sufficient	3	Deficient	21.6	Sufficient
6	KLY/FD/7	376.6	Sufficient	78	Deficient	18.8	Sufficient
7	KLY/FD/8	511.7	Sufficient	76.5	Deficient	21.9	Sufficient
8	KLY/FD/9	1343	Sufficient	51	Deficient	22.5	Sufficient
9	KLY/FD/10	1901	Sufficient	46.5	Deficient	24.5	Sufficient
10	KLY/FD/11	1065	Sufficient	85.5	Deficient	22.8	Sufficient
11	KLY/FD/12	1178	Sufficient	70.5	Deficient	31.9	Sufficient
12	KLY/FD/13	992.5	Sufficient	63	Deficient	20.3	Sufficient
13	KLY/FD/14	762.1	Sufficient	109.5	Deficient	20.5	Sufficient
14	KLY/FD/15	946.6	Sufficient	81	Deficient	170	Sufficient
15	KLY/FD/16	1003	Sufficient	69	Deficient	164	Sufficient
16	FDS/1	674.5	Sufficient	67.5	Deficient	158	Sufficent
17	FDS/2	764.3	Sufficient	45	Deficient	170	Sufficent
18	FDS/3	616.3	Sufficient	37.5	Deficient	170	Sufficent
19	FDS/5	492.7	Sufficient	37.5	Deficient	160	Sufficent
20	FDS/6	379.1	Sufficient	30	Deficient	102	Sufficent
21	FDS/7	420.3	Sufficient	39	Deficient	151	Sufficent
22	FDS/8	340.2	Sufficient	52.5	Deficient	171	Sufficent

23	FDS/10	1013	Sufficient	94.5	Deficient	632	Sufficent
24	FDS/11	727.4	Sufficient	87	Deficient	149	Sufficent
25	FDS/12	858.6	Sufficient	57	Deficient	156	Sufficent
26	FDS/13	796.7	Sufficient	91.5	Deficient	151	Sufficent
27	FDS 14	346.2	Sufficient	100.5	Deficient	42.5	Sufficent
28	FDS 15	652	Sufficient	163.5	Sufficent	83.88	Sufficent
29	FDS 16	432.4	Sufficient	115.5	Deficient	25.88	Sufficent
30	FDS 17	1156.4	Sufficient	120	Sufficent	49.5	Sufficent
31	FDS 18	417.6	Sufficient	111	Deficient	53.75	Sufficent
32	FDS 19	749.2	Sufficient	103.5	Deficient	72.88	Sufficent
33	FDS 20	533.1	Sufficient	118.5	Deficient	78.25	Sufficent
34	FDS 21	1013.9	Sufficient	91.5	Deficient	45.88	Sufficent
35	FDS 22	88.1	Deficient	147	Sufficent	70.5	Sufficent
36	FDS 23	1077.6	Sufficient	115.5	Deficient	47.63	Sufficent
37	FDS 24	403.1	Sufficient	64.5	Deficient	29.13	Sufficent
38	FDS 25	489.8	Sufficient	69	Deficient	39.88	Sufficent
39	FDS 26	113.1	Deficient	144	Sufficent	36.63	Sufficent
40	FDS 27	418.9	Sufficient	87	Deficient	48.88	Sufficent
41	FDS 28	586	Sufficient	46.5	Deficient	82.88	Sufficent
42	FDS 29	162.4	Deficient	28.5	Deficient	34.5	Sufficent
43	FDS 30	540.7	Sufficient	102	Deficient	26.5	Sufficent
44	FDS 31	241.8	Deficient	168	Sufficent	27.75	Sufficent
45	FDS 32	563.4	Sufficient	93	Deficient	34.5	Sufficent
46	FDS 33	625	Sufficient	85.5	Deficient	47.75	Sufficent
47	FDS 34	470.7	Sufficient	85.5	Deficient	37.88	Sufficent

48	FDS 35	384	Sufficient	58.5	Deficient	20.38	Sufficent
49	FDS 36	992.5	Sufficient	102	Deficient	22.63	Sufficent
50	FDS 37	630.6	Sufficient	94.5	Deficient	21.38	Sufficent
51	FDS 38	800	Sufficient	103.5	Deficient	24.13	Sufficent
52	FDS 39	1127.5	Sufficient	102	Deficient	18	Sufficent
53	FDS 40	364.1	Sufficient	55.5	Deficient	19.38	Sufficent
54	FDS 41	280.3	Deficient	54	Deficient	13.5	Sufficent
55	FDS 42	386.4	Sufficient	49.5	Deficient	13.88	Sufficent
56	FDS 43	107	Deficient	46.5	Deficient	11	Sufficent
57	FDS 44	614.6	Sufficient	78	Deficient	16.63	Sufficent
58	FDS 45	103.7	Deficient	40.5	Deficient	18.13	Sufficent
59	FDS 46	123.8	Deficient	46.5	Deficient	54.75	Sufficent
60	FDS 47	230.3	Deficient	58.5	Deficient	16	Sufficent
61	FDS 48	236	Deficient	57	Deficient	27.5	Sufficent
62	FDS 49	1149.5	Sufficient	88.5	Deficient	15.38	Sufficent
63	FDS 50	124.6	Deficient	40.5	Deficient	360.9	Sufficent
64	FDS 51	142.5	Deficient	42	Deficient	20.38	Sufficent
65	FDS 52	175.7	Deficient	48	Deficient	36.63	Sufficent
66	FDS 53	365.7	Sufficient	30	Deficient	21.63	Sufficent
67	FDS 54	552.8	Sufficient	72	Deficient	160.5	Sufficent
68	FDS 55	443.4	Sufficient	70.5	Deficient	34.5	Sufficent
69	FDS 56	331.5	Sufficient	45	Deficient	33.5	Sufficent
70	FDS 57	231.9	Deficient	55.5	Deficient	23.75	Sufficent
71	FDS 58	116.6	Deficient	42	Deficient	24.63	Sufficent
72	FDS 59	217.6	Deficient	61.5	Deficient	24.63	Sufficent

73	FDS 60	1285	Sufficient	88.5	Deficient	25.5	Sufficent
74	FDS 61	131.9	Deficient	75	Deficient	30.75	Sufficent
75	F69DS 62	362.5	Sufficient	42	Deficient	37.13	Sufficent
76	FDS 63	296	Deficient	40.5	Deficient	24.25	Sufficent
77	FDS 64	183.7	Deficient	70.5	Deficient	33.63	Sufficent
78	FDS 65	485.9	Sufficient	81	Deficient	67.63	Sufficent
79	FDS 66	766.8	Sufficient	28.5	Deficient	35.13	Sufficent
80	FDS 67	66.2	Deficient	36	Deficient	35	Sufficent
81	FDS 68	261.4	Deficient	43.5	Deficient	33.75	Sufficent
82	FDS 69	177.5	Deficient	58.5	Deficient	27.13	Sufficent
83	FDS 70	382.9	Sufficient	42	Deficient	41.88	Sufficent
84	FDS 71	258.4	Deficient	42	Deficient	35.75	Sufficent
85	FDS 72	175.8	Deficient	34.5	Deficient	26	Sufficent
86	FDS 73	155.2	Deficient	76.5	Deficient	32.38	Sufficent
87	FDS 74	368.8	Sufficient	42	Deficient	23.38	Sufficent
88	FDS 75	265.9	Deficient	82.5	Deficient	143.6	Sufficent
89	FDS 76	230	Deficient	60	Deficient	417.8	Sufficent
90	FDS 77	454.3	Sufficient	42	Deficient	76.63	Sufficent
91	FDS 78	278.5	Deficient	33	Deficient	75.25	Sufficent
92	FDS 79	122	Deficient	42	Deficient	146.4	Sufficent
93	FDS 80	231.5	Deficient	73.5	Deficient	76.25	Sufficent
94	FDS/81	1828	Deficient	129	Sufficent	174	Sufficent
95	FDS/82	596.7	Sufficient	78	Deficient	548	Sufficent
96	FDS/83	97.85	Deficient	22.5	Deficient	233	Sufficent
97	FDS/84	121.2	Deficient	192	Sufficent	107	Sufficent

98	FDS/85	935.1	Sufficient	111	Deficient	97.5	Sufficent
99	FDS/86	97	Deficient	25.5	Deficient	108	Sufficent
100	FDS/87	149.7	Deficient	33	Deficient	132	Sufficent
101	FDS/88	384.7	Sufficient	60	Deficient	119	Sufficent
102	FDS/89	496.5	Sufficient	75	Deficient	112	Sufficent
103	FDS/90	267	Deficient	100.5	Deficient	114	Sufficent
104	FDS/91	856.5	Sufficient	93	Deficient	120	Sufficent
105	FDS/92	654.2	Sufficient	108	Deficient	135	Sufficent
106	FDS/93	645.5	Sufficient	87	Deficient	125	Sufficent
107	FDS/94	263.5	Deficient	40.5	Deficient	130	Sufficent
108	FDS/95	392.2	Sufficient	42	Deficient	102	Sufficent
109	FDS/96	515.5	Sufficient	81	Deficient	106	Sufficent
110	FDS/97	192.5	Deficient	37.5	Deficient	128	Sufficent
111	FDS/98	453.6	Sufficient	99	Deficient	135	Sufficent
112	FDS/99	274.8	Deficient	46.5	Deficient	110	Sufficent
113	FDS/100	405.6	Sufficient	72	Deficient	122	Sufficent
114	FDS/101	1039	Sufficient	61.5	Deficient	137	Sufficent
115	FDS/102	215.6	Deficient	100.5	Deficient	146	Sufficent
116	FDS/103	94.65	Deficient	33	Deficient	169	Sufficent
117	FDS/104	391.3	Sufficient	30	Deficient	122	Sufficent
118	FDS/105	101.9	Deficient	27	Deficient	127	Sufficent
119	FDS/106	243.6	Deficient	33	Deficient	138	Sufficent

Magnesium is deficient in almost all samples and Calcium is deficient in 36% of the samples.

Table 5.8.10

Micronutrients

Sample code	Fe ppm	Mn ppm	Cu ppm	Zn ppm	B ppm
KLY/FD/1	45.38	7.12	3.82	7.36	0.54
KLY/FD/2	30.72	5.36	5.08	1.42	0.4
KLY/FD/3	17.38	8.66	6	6.96	0.56
KLY/FD/4	25.36	6.32	3.36	6.98	0.66
KLY/FD/6	29.9	14.12	4.24	2.58	0.52
KLY/FD/7	27.74	10.84	3.34	0.92	0.44
KLY/FD/8	41.26	4.04	10.62	4.36	0.54
KLY/FD/9	36.68	7.38	6.56	0.18	0.6
KLY/FD/10	15.32	2.3	2.54	3.24	0.48
KLY/FD/11	23.34	5.14	3.14	2.62	0.6
KLY/FD/12	44.84	8.82	3.94	3.92	0.64
KLY/FD/13	39.28	5.34	4.16	2.08	0.5
KLY/FD/14	50.96	16.1	3.74	2.08	0.38
KLY/FD/15	32.76	8.52	3.86	4.28	0.54
KLY/FD/16	36.16	15.4	4.88	2	0.44
FDS/1	36.72	11.36	5.18	0.76	0.44
FDS/2	44.2	5.4	2.1	2.8	0.66
FDS/3	40.94	9.58	3.34	1.94	0.64
FDS/5	44.3	5.28	2.58	1.04	0.48
FDS/6	10.16	4.58	2.66	1.22	0.44
FDS/7	36.68	17.14	1.88	2.62	0.58
FDS/8	42.32	4.54	1.3	1.78	0.34
FDS/10	52.82	1.04	2.78	1.66	0.44
FDS/11	31.78	1.78	2.18	2.78	0.46

FDS/12	29.2	19.08	1.26	1.72	0.48
FDS/13	32.68	15.08	1.56	2.04	0.46
FDS 14	40.72	13.08	0.9	1.24	0.4
FDS 15	56.44	9.84	2.26	2.72	0.54
FDS 16	31.82	2.26	1.96	3.3	0.46
FDS 17	42.84	14.52	0.64	1.46	0.5
FDS 18	55.3	8.64	0.5	1.88	0.4
FDS 19	52.7	14.32	1.08	0.56	0.38
FDS 20	43.1	12.56	1.24	1.9	0.48
FDS 21	38.64	10.48	2.64	0.92	0.48
FDS 22	30.56	10.66	0.5	1.84	0.5
FDS 23	20.78	14.64	3.44	1.3	0.42
FDS 24	50.28	6.36	1.38	0.64	0.5
FDS 25	55.26	2.72	0.64	0.5	0.44
FDS 26	47.3	9.24	5.08	0.28	0.52
FDS 27	43.02	10.54	2.64	0.32	0.42
FDS 28	34.64	6.3	3.3	0.7	0.42
FDS 29	33.7	12.68	5.7	0.56	0.68
FDS 30	28.64	14.9	2.64	1.68	0.54
FDS 31	41.48	16.44	2.3	0.64	0.52
FDS 32	43.3	15.3	0.96	0.48	0.54
FDS 33	30.58	10.64	1.38	1.32	0.48
FDS 34	28.66	12.66	1.96	1.68	0.52
FDS 35	33.9	14.28	2.04	1.42	0.44
FDS 36	50.74	11.58	2.04	1.3	0.58
FDS 37	48.64	6.9	2.84	1.26	0.5
FDS 38	43.16	8.32	2.2	1.04	0.38

FDS 39	43.12	11.26	2.56	1.44	0.3
FDS 40	49.2	19.74	2.62	0.78	0.3
FDS 41	33.74	4.94	1.96	1.26	0.28
FDS 42	16.68	18.52	1.28	0.58	0.32
FDS 43	30.86	11.74	1.96	1.7	0.3
FDS 44	44.42	10.7	1.1	0.76	0.32
FDS 45	26.5	6.5	1.56	1.9	0.32
FDS 46	55.56	8.12	2.18	0.96	0.28
FDS 47	29.12	9.78	2.3	1.74	0.68
FDS 48	51.58	3.52	3.46	3.1	0.66
FDS 49	36.5	8.5	1.7	2.46	0.4
FDS 50	47.98	13.36	2.18	1.78	1.84
FDS 51	40.3	10.32	1.92	1.46	0.74
FDS 52	48.9	8.32	1.28	0.62	1.08
FDS 53	31.74	6.94	1.08	1.78	1.02
FDS 54	47.72	3.34	1.38	3.38	0.36
FDS 55	40.3	16.38	0.96	1.3	0.4
FDS 56	34.42	1.94	0.74	0.48	0.3
FDS 57	46.48	3.16	0.74	0.86	0.4
FDS 58	52.88	0.74	0.8	0.5	0.36
FDS 59	42.3	3.48	1.7	0.72	0.36
FDS 60	56.3	27.54	4.54	4.52	0.6
FDS 61	50.72	15.78	3.08	2.84	0.42
FDS 62	58.76	15.54	3.98	1.14	0.46
FDS 63	37.94	7.96	2.18	1.3	0.64
FDS 64	55.86	10.46	3.42	1.54	0.42
FDS 65	48.72	8.46	3.26	0.5	0.94

FDS 66	48.1	11.26	3.14	2	0.46
FDS 67	33.23	1.26	0.32	0.45	0.58
FDS 68	40.3	5.1	2.14	0.74	0.64
FDS 69	47.51	2.94	2.95	0.77	0.62
FDS 70	50.46	8.24	3.76	1.18	0.42
FDS 71	55.37	10.98	8.27	2.09	0.2
FDS 72	52.36	6.3	2.9	1.04	0.32
FDS 73	48.84	2.67	3.57	0.89	0.26
FDS 74	42.36	3.96	2.42	1.06	0.42
FDS 75	31.19	2.27	1.86	1.12	0.3
FDS 76	37.18	3.08	1.84	1.02	0.3
FDS 77	42.5	3.8	2.49	0.96	0.32
FDS 78	35.96	4.26	2.36	1.58	0.24
FDS 79	24.72	6.88	2.45	2.21	0.24
FDS 80	39.78	5.74	2.38	2.18	0.24
FDS/81	16.56	14.84	5.88	8.38	0.56
FDS/82	19.12	1.78	1.18	6.9	0.42
FDS/83	57.76	1.06	5.38	3.12	0.66
FDS/84	30.92	4.9	2.24	9.56	0.52
FDS/85	240.4	25.06	2.08	0.84	0.54
FDS/86	40.06	20.52	1.58	4.92	0.48
FDS/87	27.78	4.96	1.76	1.56	0.54
FDS/88	36.92	10.98	2.04	1.12	0.44
FDS/89	55.04	61	0.96	4.92	0.48
FDS/90	20.46	12.98	1.78	1.78	0.6
FDS/91	15.42	8	0.52	1.14	0.38
FDS/92	36.92	16.92	2.04	1.74	0.66

FDS/93	30.36	10.54	1.4	1.28	0.64
FDS/94	26.46	12.5	0.92	2.4	0.44
FDS/95	35.08	12.14	1.02	0.52	0.62
FDS/96	36.98	16.98	1.56	1.7	0.52
FDS/97	6.98	18.12	1.26	0.82	0.28
FDS/98	24.52	2.92	2.04	1.24	0.62
FDS/99	31.48	0.86	0.94	1.42	0.4
FDS/100	42.06	1.78	1.78	2.12	0.44
FDS/101	52.48	2.18	2.98	2.14	0.66
FDS/102	38.98	0.96	2.12	2.3	0.34
FDS/103	58.14	1.14	2.32	3.9	0.46
FDS/104	28.34	2.92	2.92	3.74	0.38
FDS/105	47.9	0.92	2.86	2.3	0.32
FDS/106	53.36	3.2	1.58	0.72	0.36

Micronutrients like Iron, Manganese, Zinc and Copper are found in adequate levels. Boron is deficient in more than 60% of the samples. Data for Ca and Mg cannot be compared as the preflood data were not available.

In the below samples for which preflood data were available, comparison of micronutrient under pre and post flood situations have been attempted.

Table 5.8.11

Comparison of Pre and post flood Sulphur and micronutrients status

Sample code	Pre flood (ppm)						Post flood (ppm)					
	Av. S.	Zn	Fe	Cu	Mn	B	Av.S	Zn	Fe	Cu	Mn	B
FDS 6	18.7	4.2	184	3	28	0.32	102	1.22	10.16	2.66	4.58	0.44
FDS 81	12.9	4.58	88.8	4.8	201.3	0.06	174	8.38	16.56	5.88	14.84	0.56
FDS 88	29.5	0.58	31.46	1.3	18.26	0.12	119	1.12	36.9	2.04	10.98	0.44
FDS 93	7.81	6.96	120.94	7.48	184.66	1.55	125	1.28	30.36	1.4	10.54	0.64
FDS 2	17.4	2.25	229.4	4	58.2	0.02	170	2.8	44.2	2.1	5.4	0.66

FDS 20	5.5	2.41	106.2	2.1	49.4	0.03	78.25	1.9	43.1	1.24	12.56	0.48
KLY FD1	NA	1.29	26.23	3.5	21.29	0.18	21.5	7.36	45.38	3.82	7.12	0.54
KLY FD2	NA	1.85	58.29	6.2	45.43	0.23	28.6	1.42	30.72	5.08	5.36	0.4
KLY FD3	NA	0.98	44.52	2.28	14.79	0.24	24.6	6.96	17.38	6	8.66	0.56
KLY FD4	2.59	8.02	32	2.12	136	0.34	25.8	6.98	25.36	3.36	6.32	0.66
KLY FD6	24.14	5.22	12.92	1.26	11.04	0.34	21.6	2.58	29.9	4.24	14.12	0.52
KLY FD7	2.16	7.4	324.64	1.76	140.3	0.32	18.8	0.92	27.74	3.34	10.84	0.44
KLY FD8	4.74	4.56	180.18	8.14	131.2	0.44	21.9	4.36	41.26	10.62	4.04	0.54
KLY FD9	9.5	1.2	46	1	53	0.26	22.5	0.18	36.68	6.56	7.38	0.6
FDS 56	115.88	0.88	270.6	0.88	46.2	0.6	33.5	0.48	34.42	0.74	1.94	0.3
FDS 94	13.2	4.69	60.5	1.6	110	0.06	130	2.4	26.46	0.92	12.5	0.44
FDS 98	10.8	6.4	40.5	3.7	25	0.08	135	1.24	24.52	2.04	2.92	0.62
FDS 104	6.1	5.2	125.6	2.01	55.6	0.58	122	3.74	28.3	2.92	2.92	0.38
FDS 82	3.99	1.82	178.2	2.32	32.12	0.6	548	6.9	19.12	1.18	1.78	0.42
FDS 90	5.29	2.86	45.1	1.3	117.9	1.4	114	1.78	20.46	1.78	12.98	0.6
FDS 92	6.46	5.02	85.22	2.42	41.26	0.59	135	1.74	36.92	2.04	16.92	0.66
FDS 96	6.84	4.12	223.08	4.14	172.42	0.62	106	0.72	53.36	1.58	16.98	0.52

On comparison, it is seen that available sulphur increases in most of the samples. In general Available iron, manganese, zinc, copper and boron showed decreased values when compared to pre flood values.

HEAVY METALS

Inorder to check whether heavy metal pollution occurred as a result of flooding, samples were collected from selected sites and analysed for Lead and cadmium. The details of sampling sites along with the results are as follows.

Table 5.8.12

Lead & Cadmium

Sl No	Sample code	Latitude	Longitude	Pb ppm	Cd ppm
1	KLY/FD/1	10° 33'18.2" N	76° 12' 2.0" E	1.36	0.34*
2	KLY/FD/2	10° 33' 39.5" N	76° 12' 3.6" E	1.54	0.32*
3	KLY/FD/3	10° 34' 23.7" N	76° 11' 51.3" E	1.08	0.34*
4	KLY/FD/4	10° 34' 15.9" N	76° 11' 2.6" E	1.5	0.24
5	KLY/FD/5	10° 34' 16.1" N	76° 11' 03.1" N	1.36	0.26
6	KLY/FD/6	10° 34' 16.9" N	76° 11' 28.5" E	1.84	0.3
7	KLY/FD/7	10° 34' 6.6" N	76° 11' 3.6" E	1.7	0.26
8	KLY/FD/8	10° 33' 46.9" N	76° 11' 23.2" E	2.28	1.8
9	KLY/FD/9	10° 33' 38.7" N	76° 12' 16.9" E	2.16	0.2
10	KLY/FD/10	10° 33' 22.8" N	76° 12' 27.9" E	1.42	0.22
11	KLY/FD/11	10° 33' 7.0" N	76° 12' 13.6" E	1.94	0.2
12	KLY/FD/12	10° 33' 20.2" N	76° 12' 27.1" E	1.54	0.18
13	KLY/FD/13	10° 33' 23.1" N	76° 12' 12.4" E	1.7	0.16
14	KLY/FD/14	10° 34' 3.6" N	76° 11' 5.6" E	1.8	0.2
15	KLY/FD/15	10° 34' 11.0" N	76° 11' 52.1" E	1.58	0.14
16	KLY/FD/16	10° 34' 1.2" N	76° 11' 27.9" E	1.12	0.24
17	FDS/1	10° 39' 18.3" N	76° 14' 55.2" E	1.44	0.16
18	FDS/2	10° 40' 33.7" N	76° 15' 11.3" E	1.26	0.16
19	FDS/3	10° 44' 51.0" N	76° 14' 43.7" E	1.38	0.26
21	FDS/5	10° 42' 19.5" N	76° 9' 23.6" E	1.08	0.22
22	FDS/6	10° 18' 44.5" N	76° 21' 0.5" E	0.92	0.24
23	FDS/7	10° 17' 19.4" N	76° 20' 55.1" E	1.88	0.28
24	FDS/8	10° 14' 1.5" N	76° 19' 36.8" E	0.7	0.24
25	FDS/9	10° 17' 6.61" N	76 19 1.87" E	0.86	0.24
26	FDS/10	10° 14' 11.8" N	76° 19' 58.4" E	1.16	0.24
27	FDS/11	10° 19' 17.0" N	76° 22' 40.2" E	1.24	0.18
28	FDS/12	10° 44' 54.5" N	76° 26' 37.4" E	1.54	0.2
29	FDS/13	10° 17' 9.8" N	76° 19' 14.5" E	1.6	0.22
30	FDS/81	10° 32' 14.6" N	76° 20' 0.7" E	1.36	0.14
31	FDS/82	10° 29' 16.1" N	76° 19' 18.1" E	1.12	0.18
32	FDS/83	10° 33' 43.6" N	76° 8' 15.8" E	1.14	0.18
33	FDS/84	10° 13' 26.2" N	76° 12' 16.9" E	0.96	0.2
34	FDS/85	10° 30' 46.8" N	76° 20' 25.9" E	1.68	0.18
35	FDS/86	10° 32' 1.3" N	76° 21' 41.1" E	1	0.18
36	FDS/87	10° 32' 27.84" N	76° 13' 30.02" E	1.52	0.14

37	FDS/88	10° 29' 21.0" N	76° 16' 33.3" E	0.96	0.16
38	FDS/89	10° 29' 15.4" N	76° 19' 13.2" E	1.68	0.14
39	FDS/90	10° 30' 35.3" N	76° 20' 17.6" E	1.18	0.36*
40	FDS/91	10° 32' 12.11" N	76° 13' 29.62" E	1.14	0.16
41	FDS/92	10° 29' 15.7" N	76° 19' 20.8" E	0.98	0.18
42	FDS/93	10° 29' 26.5" N	76° 16' 22.9" E	1.04	0.12
43	FDS/94	10° 33' 45.0" N	76° 10' 56.7" E	1.78	0.28
44	FDS/95	10° 30' 46.5" N	76° 17' 26.1" E	1.04	1.26
45	FDS/96	10° 30' 27.9" N	76° 20' 15.9" E	0.48	0.16
46	FDS/97	10° 29' 16.7" N	76° 19' 14.9" E	0.92	0.12
47	FDS/98	10° 33' 23.4" N	76° 6' 21.9" E	1	0.08
48	FDS/99	10° 33' 27.7" N	76° 6' 0.6" E	0.9	0.1
49	FDS/100	10° 13' 13.2" N	76° 12' 30.3" E	1.16	0.4
50	FDS/101	10° 13' 11.8" N	76° 12' 17.5" E	0.76	0.12
51	FDS/102	10° 34' 29.6" N	76° 1' 45.8" E	1.92	0.3
52	FDS/103	10° 13' 26.9" N	76° 12' 16.0" E	1.3	0.3
53	FDS/104	10° 24' 34.5" N	76° 6' 57.6" E	1.36	0.52*
54	FDS/105	10° 13' 26.9" N	76° 12' 16.0" E	1.2	0.46*
55	FDS/106	10° 12' 38.1" N	76° 13' 17.8" E	0.98	0.38*

(*values exceeded maximum permissible limit in soil)

The maximum permissible limit for lead and cadmium in soil are 13ppm and 0.31ppm respectively. ((DTPA extractable permissible limit in soil prescribed by Maclean etal,1987).The areas exceeded maximum permissible limt for cadmium are lowland valleys of Kolazhy, Veloor and Puthur panchayat and Thrissur corporation, midland valleys of Kadungode and Erumapetty panchayats in Keecheri and Karuvannur riverbasins. No sampling locations exceeded maximum permissible value for lead.

Results of the study in Thrissur district can be summarised as below.

- Soil pH ranges from 4.4 to 7.3 i.e the soils are extremely acid to neutral. Soils with pH<5 has to be applied with liming material to correct soil acidity
- Organic carbon, Available phosphorus etc do not show much variation in post flood samples. However areas low in Organic carbon & Available phosphorus are to be supplemented with organic manures and P fertilizers.
- Potassium, Magnesium and Boron deficiency is prevalent in majority of the sampling locations

- Calcium deficiency is widespread in coastal plains, low land and midland valleys.
- Sulphur is found in excess in most locations
- Regarding physical properties, textural changes are noticed in gardenland and wetlands, aggregarate stability has reduced, inducing surface crusting after flooding.
- Banana, nutmeg, vegetables are the most affected crops
- Cadmium pollution is seen in some places.
- In land slide areas severe erosion has taken place(50-75% of B horizon lost exposing the parent material)
- In kole lands soils are very strongly to strongly acidic and Electrical conductivity values are within safe limit for agricultural production, Deficiency of potassium, calcium, Magnesium and boron are noticed in these soils.
- To improve soil structure and soil aeration, remove deposits from the basins of crops and incorporate lime/dolomite in soil : application of Trichoderma may be resorted to for crops. Increase aeration by applying sand and ploughing the basin in clayey areas.
- Apply organic and green manure in sandy soils to increase aggregation and fertility. To increase microbial activity in rhizosphere, mulch the soil with organic matter and green manure. Soil mulching can be done to increase water holding capacity of soil. Apply Pseudomonas to crops for increasing resistance to pest and diseases. Manage pests and diseases by appropriate crop health measures.
- Application of plant nutrients both macro and micro should be done based on proper soil test based results in all the flood affected cropping areas of the district.

Land slide in Kuranchery area

Sand deposition on banks of Chalakkudyriver

Nutmeg plantation damaged due to flood in Chalakkdy area

Nutmeg crop lost in annnammanada area

Clay removed from flood affected area

Clay deposited in garden lands after flood

Banana crop loss in Kadukutty area

Nutmeg garden devastated in Pariyaram area due to flood

Cracking and clay deposition in paddy lands Pazhayannur

Cracks on buildings due to landslide in Pananchery panchayat

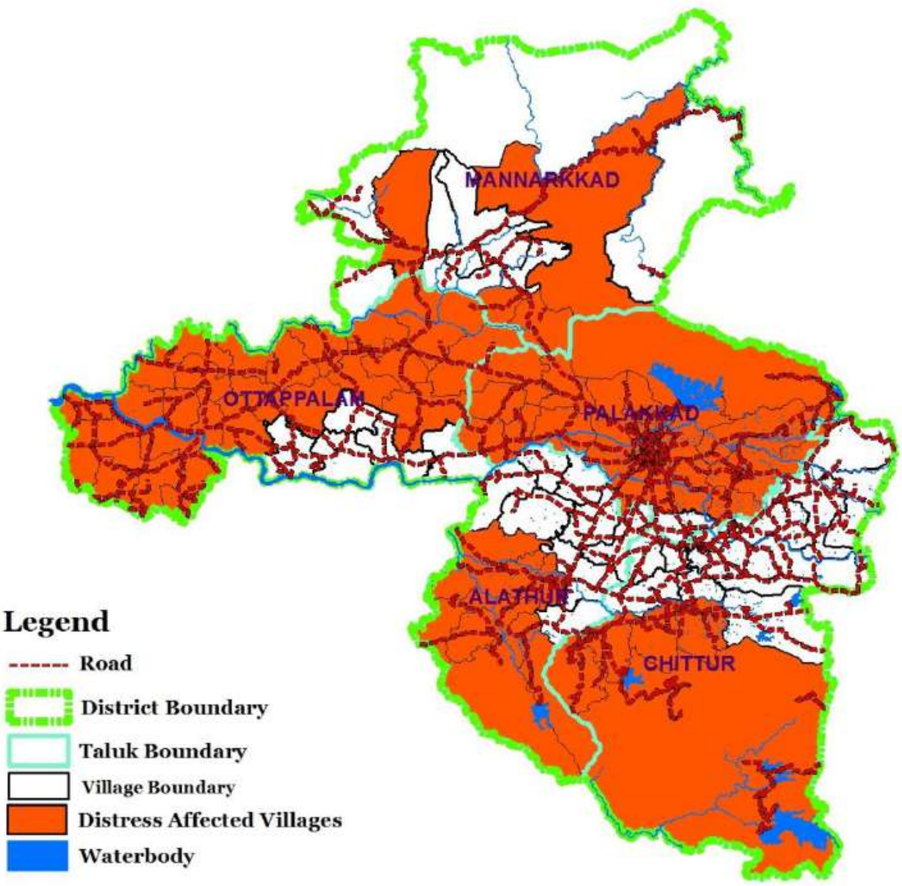
PALAKKAD

Total Geographic Area	: 4,47,584 Ha
No. of Taluks	: 6
No. of Villages	: 174

RIVER BASINS

- *Bharatapuzha*
- *Bhavani*
- *Chalakkudy river*
- *Kadalundi*
- *Kanjiramukku*
- *Keecheri*
- *Uppar*

DISTRESS AFFECTED VILLAGES



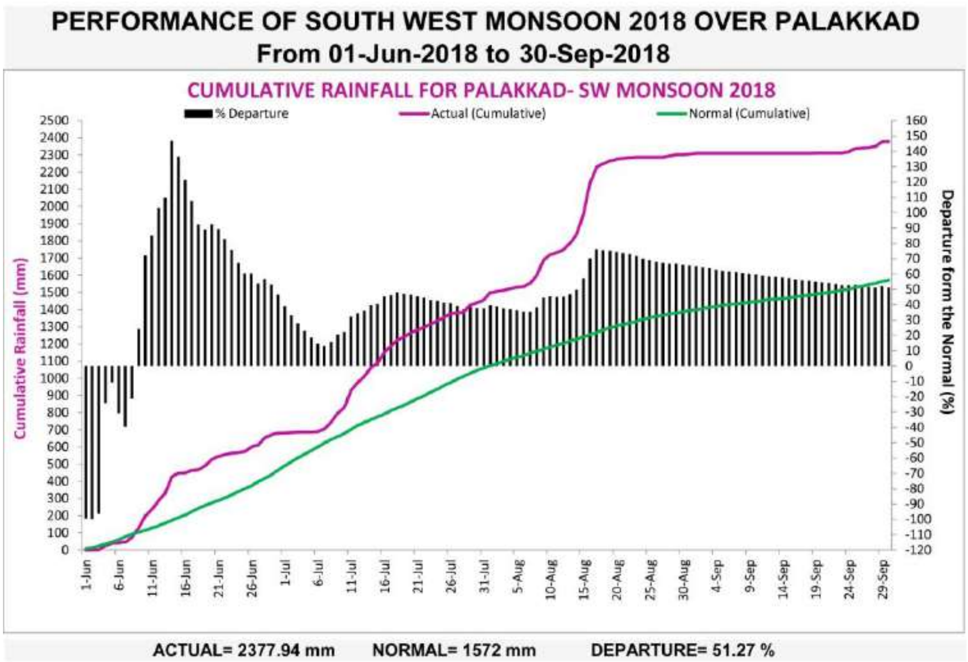
5.9. PALAKKAD DISTRICT

Palakkad District is located between north latitudes 10^{0}19'57" and 11^{0}14' 17"and east longitudes 76^{0}1'35"and 76^{0}54'30"and the total area accounts to 4480 Sq. Kms (4,47,584 ha).

The District is divided into six major physiographic divisions such as Low Land (<20m above MSL), Mid lands (20-100m above MSL), Mid-up lands (100-300m above MSL), Up land (300-600m above MSL), High lands (600-1200m above MSL) and Mountainous region (>1200m above MSL). Palakkad district as a whole can be considered as a mid-land dissected plain being at a higher elevation than the adjoining coastal plains.The remaining portion is hilly and is associated with Nilgiri hills and Southern Sahyadri ranges. The most important river of the district is Bharathapuzha and is the longest of all the rivers in Kerala.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

The great floods that ravaged the entire Kerala during August 2018 had caused distress in the district, heavy rain lashed in the district caused floods, land slides, land slips and earth cracks. From the graph it can be inferred that the district received heavy rainfall ie.50% more than the normal rainfall during the southwest monsoon period. There is no dry period in between June to September. and the soil is in a saturated condition. The peak rainfall received during midAugust caused severe flood and many landslides in the district.



IMPACT OF DISTRESS IN THE DISTRICT

Land slides occured in Nenmara and Attapady blocks of the district, while Palakkad, Mannarkkad, Nenmara, Chittur, Ottapalam, Pattambi, Thrithala and Alathur blocks are flood affected in the district. Nelliyampathy panchayat was cutoff from rest of the district for weeks due to numerous landslides and landslips occurred in the region. Of the 99 panchayats in the district, 63 panchayats were identified by the Government as flood affected. Besides these, Palakkad and Pattambi Municipalities were also flood affected. The panchayats affected by devastating flood and landside of August 2018 are listed below.

- Anakkara
- Thiruvegapura
- Vallappuzha
- Muthuthala
- Pattithara
- Ongallur
- Kulukkallur
- Paruthur
- Thirumittakode
- Kappoor
- Vilayur
- Kizhakkancherry
- Alathur
- Erimayur
- Melarcode
- Mathur
- Kottayi
- Thenkurissi
- Peringottukurissi
- Tharur
- Kavassery
- Puthukkode
- Vadakkanchery
- Vandazhy
- Nelliyambathy
- Nenmara
- Elavanchery
- Ayiloor
- Thiruvazhiyad
- Vadakarapathy
- Pallassana
- Vadavannur
- Muthalamada
- Kollamkode
- Nalleppilly
- Chittor
- Pattenchery
- Eruthenpathy
- Koduvayur
- Perumatty
- Kottoppadam
- Karakurissi
- Agaly
- Alanallur
- Karimba
- Thenkara

- Palakkayam
- Ottappalam
- Karimpuzha
- Cherpulassery
- Ambalappara
- Vaniyamkulam
- Thrikkaderi
- Sreekrishnapuram
- Kadambazhipuram
- Chalavara
- Malambuzha
- Parali
- Kannadi
- Nellaya
- Lekkidiperoor
- Kumaramputhur
- Ananganadi.

Flood, landslide and land slips devastated the district. Incessant rainfall, along with raising of all the shutters of Malampuzha, Chulliyar and Valayar dams has aggravated the situation and inundated areas in and around Palakkad Municipality. Many villages in Attappady were inundated when water released from upper Bhavani dam. Paddy fields near Bharatapuzha and Gayathri puzha were severely affected by Flood. Land slip occured in Nemmara where death toll was 8 Persons. Land cracking was reported from Kizhakkancherry panchayat. In Mannarkkad Taluk there was a divergence in the course of drainage lines which lead to formation of beach like area in the original course and inundated wetlands with flood water. This has led to loss of crop in the nearby areas. Massive landslips have been occurred at Nelliampathy, a hill station on the eastern side. Due to heavy rain, flooding and landslips this region was isolated for weeks. The complete transport system was blocked due to the roads were disrupted.

FIED TRAVERSING AND SOIL SAMPLING

Field traversing was undertaken in the distress affected panchayats to evaluate the changes in soil health. In order to study the impact of flooding and landslides on the soils of district , 45 soil samples were collected from physiographic divisions ranging from lowland to highland at a depth of 15cm from Thenkara panchayat, Karakurissi panchayat, Nelliyampathy panchayat, Nenmara panchayat,Vaniyamkulam Panchayat , Kizhakkanchery panchayat and Alathur panchayat. Random sampling was done to assess the soil changes coming under the agroecologic units in palakkad district ie., Palakkad Central Plain, Northern foot hills, North central Laterites, Southern high hills. Soil samples were analysed and results interpreted.

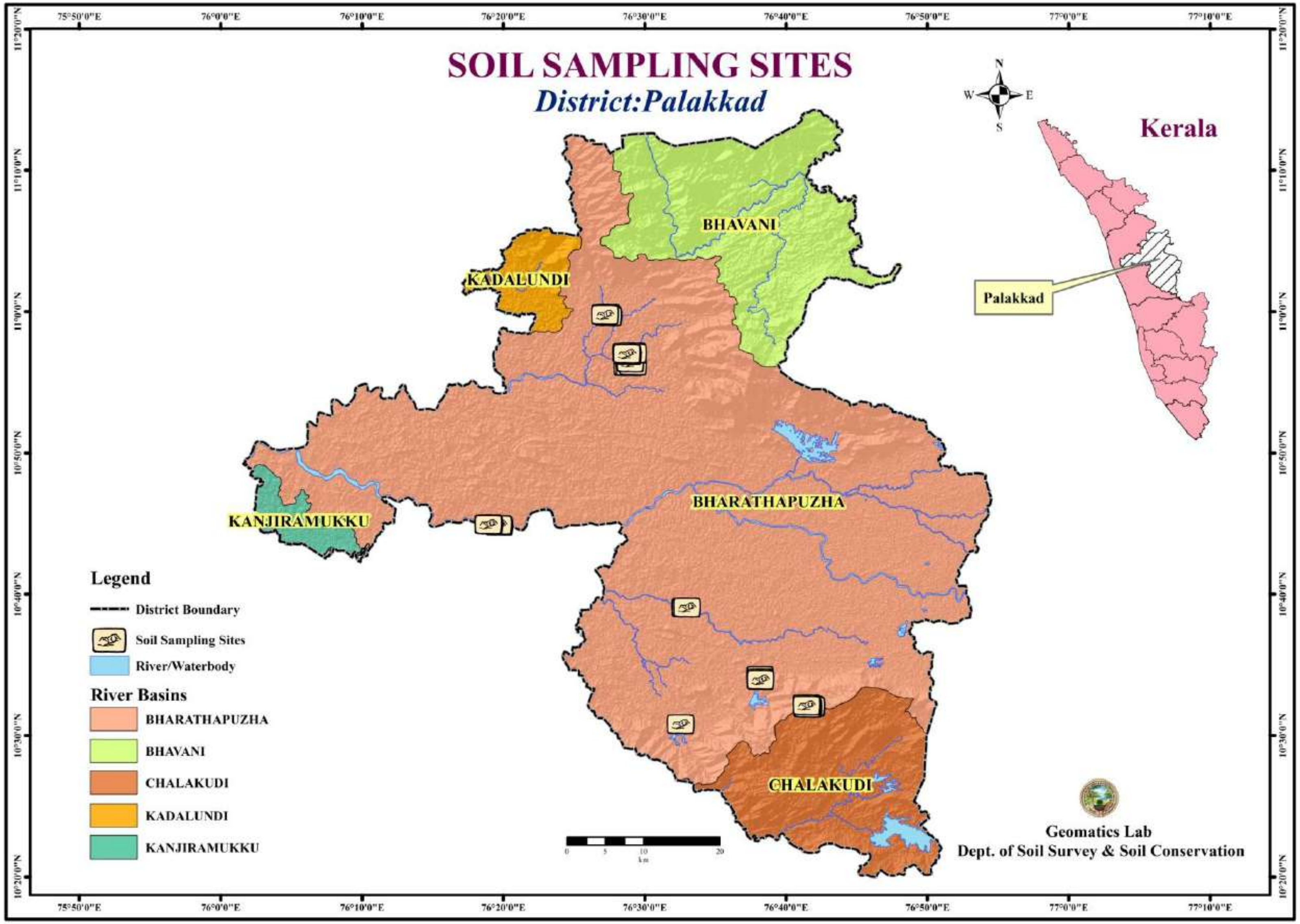
The land characteristics of the sampling locations are presented below.

Table 5.9.1

Site characteristics

Sample code	Geo cordinates	Panchayat	Slope %	Physiography	Landform
PFAS-1	10^{0}59’ 50.76” 76^{0} 27 ’17.75”	Thenkara	1-3	Midupland 107m	riverbank
PFAS-2	10^{0}59’ 51.1” 76^{0} 27 ’18.33”	Thenkara	1-3	Midupland 107 m	riverbank
PFAS-3	10^{0}59’ 50.64” 76^{0} 27 ’18.68”	Thenkara	1-3	Midupland 107m	riverbank
PFAS-4	10^{0}59’ 50.36” 76^{0} 27 ’19.98”	Thenkara	1-3	Midupland 101m	riverbank
PFAS-5	10^{0}59’ 50.36” 76^{0} 27 ’19.98”	Thenkara	1-3	Midupland 101m	riverbank
PFAS-6	10^{0}59’ 40.74” 76^{0} 27 ’28.29”	Thenkara	1-3	Midupland 101m	riverbank
PFAS-7	10^{0}59’ 40.41” 76^{0} 27 ’26.13”	Thenkara	1-3	Midupland 100m	riverbank
PFAS-8	10^{0}59’ 51.16” 76^{0} 27 ’13.42”	Thenkara	1-3	Midupland 112m	riverbank
PFAS-9	10^{0}59’ 46.12” 76^{0} 27 ’12.74”	Thenkara	1-3	Midupland 101m	riverbank
PFAS-10	10^{0}56’ 11.51” 76^{0} 28’59.38”	Karakurissi	0-1	Midland 64m	valley
PFAS-11	10^{0}56’ 10.71” 76^{0} 29’1.68”	Karakurissi	0-1	Midland 71m	valley
PFAS-12	10^{0}56’ 12.60” 76^{0} 29’5.54”	Karakurissi	0-1	Midland 69m	valley
PFAS-13	10^{0}56’ 12.60” 76^{0} 29 ’11.28”	Karakurissi	0-1	Midland 69m	valley
PFAS-14	10^{0}56’ 9.43” 76^{0} 28 ’50.93”	Karakurissi	0-1	Midland 65m	valley
PFAS-15	10^{0}56’ 9.26” 76^{0} 28 ’47.78”	Karakurissi	0-1	Midland 64m	valley
PFAS-16	10^{0}56’ 8.38” 76^{0} 28 ’55.55”	Karakurissi	0-1	Midland 65m	valley
PFAS-17	10^{0}56’ 11.81” 76^{0} 29 ’12.03”	Karakurissi	0-1	Midland 72m	valley
PFAS-18	10^{0}56’ 24.44” 76^{0} 29 ’00.23”	Karakurissi	0-1	Midland 79m	valley
PFAS-19	10^{0}57’ 6.65” 76^{0} 28 ’52.61”	Karakurissi	1-3	Midland 71m	riverbank
PFAS-20	10^{0}57’ 4.11” 76^{0} 28 ’47.84”	Karakurissi	1-3	Midland 70m	riverbank
PFAS-21	10^{0}56’ 58.50” 76^{0} 28 ’50.00”	Karakurissi	1-3	Midland 71m	riverbank

PFAS-22	10 ^{0}57’ 3.38” 76^{0} 28 ’42.81”	Karakurissi	1-3	Midland 61m	riverbank
PFAS-23	10 ^{0}57’ 6.34” 76^{0} 28 ’42.68”	Karakurissi	1-3	Midland 61m	riverbank
PFAS-24	10 ^{0}57’ 8.99” 76^{0} 29 ’3.11”	Karakurissi	1-3	Midland 65m	riverbank
PFAS-25	10 ^{0}57’ 7.77” 76^{0} 29 ’9.43”	Karakurissi	1-3	Midland 68m	riverbank
PFAS-26	10 ^{0}57’ 2.47” 76^{0} 29 ’11.87”	Karakurissi	1-3	Midland 72m	riverbank
PFAS-27	10 ^{0}56’ 55.65” 76^{0} 28 ’50.51”	Karakurissi	1-3	Midland 70m	riverbank
PFAS-28	10 ^{0}57’ 1.03” 76^{0} 28 ’46.00”	Karakurissi	1-3	Midland 63m	riverbank
PFAS-29	10 ^{0}34’ 13.45” 76^{0} 38 ’10.90”	Nenmara	5-10	Upland 302m	summit
PFAS-30	10 ^{0}34’ 2.95” 76^{0} 38 ’12.24”	Nenmara	5-10	Upland 312m	summit
PFAS-31	10 ^{0}33’ 56.46” 76^{0} 38 ’12.15”	Nenmara	5-10	Upland 300m	summit
PFAS-32	10 ^{0}32’ 12.24” 76^{0} 41 ’30.88”	Nelliyampathy	5-10	Higland 995m	summit
PFAS-33	10 ^{0}32’ 14.17” 76^{0} 41 ’27.11”	Nelliyampathy	10-15	Highland 992m	sideslope
PFAS-34	10 ^{0}32’ 7.38” 76^{0} 41 ’44.17”	Nelliyampathy	10-15	Highland 1020m	sideslope
PFAS-35	10 ^{0}32’ 3.76” 76^{0} 41 ’48.64”	Nelliyampathy	10-15	Highland 1024m	sideslope
PFAS-36	10 ^{0}31’ 57.67” 76^{0} 41 ’36.89”	Nelliyampathy	10-15	Highland 999m	sideslope
PFAS-37	10 ^{0}31’ 58.84” 76^{0} 41 ’31.09”	Nelliyampathy	10-15	Highland 1002m	sideslope
PFAS-38	10 ^{0}32’ 7.65” 76^{0} 41 ’28.10”	Nelliyampathy	10-15	Highland 1002m	sideslope
PFAS-39	10 ^{0}44’ 50.70” 76^{0} 19 ’43.24”	Vaniyamkulam	0-1	Lowland 19m	riverbank
PFAS-40	10 ^{0}44’ 54.50” 76^{0} 19 ’39.26”	Vaniyamkulam	0-1	Lowland 18m	riverbank
PFAS-41	10 ^{0}44’ 55.93” 76^{0} 19 ’0.92”	Vaniyamkulam	0-1	Lowland 19m	riverbank
PFAS-42	10 ^{0}44’ 57.17” 76^{0} 18 ’57.18”	Vaniyamkulam	0-1	Lowland 18m	riverbank
PFAS-43	10 ^{0}30’ 48.54” 76^{0} 32 ’33.64”	Kizhakkancherr y	25-33	Midland 82m	sideslope
PFAS-44	10 ^{0}39’ 3.60” 76^{0} 32 ’52.8”	Alathur	1-3	Midland 50m	valley
PFAS-45	10 ^{0}39’ 3.60” 76^{0} 32 ’60.00”	Alathur	1-3	Midland 45m	valley


SOIL SAMPLING SITES
District:Palakkad
Kerala
Palakkad
N
W
E
S
KADALUNDI
BHAVANI
KANJIRAMUKKU
BHARATHAPUZHA
CHALAKUDI
Legend
District Boundary
Soil Sampling Sites
River/Waterbody
River Basins
BHARATHAPUZHA
BHAVANI
CHALAKUDI
KADALUNDI
KANJIRAMUKKU
Geomatics Lab
Dept. of Soil Survey & Soil Conservation
75°50'0"E
76°0'0"E
76°10'0"E
76°20'0"E
76°30'0"E
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
11°20'0"N
11°10'0"N
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N

General observations of each sampling point can be summarized as below

Table 5.9.2
General observations

Sample no	Present land use	General observations
PFAS-1	Beachlike recreation area	Sand deposited by Kunthipuzha. Beach like recreation area formed
PFAS-2	Beachlike recreation area	Sand deposited by Kunthipuzha. Beach like recreation area formed
PFAS-3	Beachlike recreation area	Sand deposited by Kunthipuzha. Beach like recreation area formed
PFAS-4	Banana plantation	Sand deposited by Kunthipuzha. Beach like recreation area formed
PFAS-5	Banana plantation	Sand deposited by Kunthipuzha. Beach like recreation area formed
PFAS-6	Banana plantation	Banana plantations decayed by flood
PFAS-7	Banana plantation	Banana plantations decayed by flood
PFAS-8	Banana plantation	Banana plantations decayed by flood
PFAS-9	Banana plantation	Banana plantations decayed by flood
PFAS-10	Paddy cultivation	Silt deposited in wetlands
PFAS-11	Paddy cultivation	Silt deposited in wetlands
PFAS-12	Paddy cultivation	Silt deposited in wetlands
PFAS-13	Paddy cultivation	Silt deposited in wetlands
PFAS-14	Paddy cultivation	Silt deposited in wetlands
PFAS-15	Paddy cultivation	Silt deposited in wetlands
PFAS-16	Paddy cultivation	Silt deposited in wetlands
PFAS-17	Paddy cultivation	Silt deposited in wetlands
PFAS-18	Paddy cultivation	Silt deposited in wetlands
PFAS-19	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-20	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-21	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-22	coconut	Flooded riverbanks of Kanjirapuzha

	plantation	
PFAS-23	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-24	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-25	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-26	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-27	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-28	coconut plantation	Flooded riverbanks of Kanjirapuzha
PFAS-29	coconut plantation	Landslide pronearea
PFAS-30	coconut plantation	Landslide prone area
PFAS-31	coconut plantation	Landslideprone area
PFAS-32	Passionfruit orchard	Poor fruitsetting observed in passionfruit orchard
PFAS-33	Lemon orchard	Severe erosion with stone capping along the sideslopes of lemon orchard
PFAS-34	Lemon orchard	Severe erosion with stone capping along the sideslopes of lemon orchard
PFAS-35	Lemon orchard	Severe erosion with stone capping along the sideslopes of lemon orchard
PFAS-36	Lemon orchard	Severe erosion with stone capping along the sideslopes of lemon orchard
PFAS-37	Lemon orchard	Severe erosion with stone capping along the sideslopes of lemon orchard
PFAS-38	Lemon orchard	Severe erosion with stone capping along the sideslopes of lemon orchard
PFAS-39	Paddy cultivation	Bharathapuzha overflown lowland area
PFAS-40	Paddy cultivation	Bharathapuzha overflown lowland area
PFAS-41	Paddy cultivation	Bharathapuzha overflown lowland area
PFAS-42	Paddy cultivation	Bharathapuzha overflown lowland area
PFAS-43	Rubber plantation	Cracking of earth observed ,landslide prone area
PFAS-44	Paddy cultivation	Sand deposition observed after flooding
PFAS-45	Paddy cultivation	Sand deposition observed after flooding

CHANGES IN THE DISTRESS AFFECTED AREAS

PHYSIOGRAPHY AND LANDSCAPE CHANGE

At Thathengalam in Mannarkkad block a beach like recreation area formed by the sand deposited by Kunthipuzha. The river deviated from the normal course in this area and the gneissic rocks settled decreasing the depth of the stream. The area was inundated and banana cultivation along the riverbanks were damaged.

Thathengalam,Mannarkkad block- beach like formation due to sand deposition

Flooded area in Malampuzha

Flooded area

PHYSICO- CHEMICAL PROPERTIES

Physical properties

The physical properties such as structure, texture and permeability of soils were determined. The texture of the soils compared with the available data and inference derived.

Table 5.9.3

Physical properties

Sample no	Structure	surface texture		Permeability
		Pre flood	*Post flood*	
PFAS-1	Structureless	Sandy loam	Sand	Rapid
PFAS-2	Structureless	Sandy loam	Loamy sand	Rapid
PFAS-3	Structureless	Sandy loam	Loamy sand	Rapid
PFAS-4	Structureless	Sandy loam	Loamy sand	Rapid
PFAS-5	Structureless	Sandy loam	Loamy sand	Rapid
PFAS-6	Weak	Sandy loam	Loamy sand	Moderately rapid
PFAS-7	Weak	Sandy loam	Loamy sand	Moderately rapid
PFAS-8	Weak	Sandy loam	Loamy sand	Moderately rapid
PFAS-9	Weak	Sandy loam	Loamy sand	Moderately rapid
PFAS-10	Weak	Sandy loam	Sandy loam	Moderate
PFAS-11	Weak	Sandy loam	Sandy loam	Moderate
PFAS-12	Weak	Sandy loam	Loamy sand	Moderate
PFAS-13	Weak	Sandy loam	Sandy loam	Moderate
PFAS-14	Weak	Sandy loam	Sandy loam	Moderate
PFAS-15	Weak	Sandy loam	Sandy loam	Moderate
PFAS-16	Weak	Sandy loam	Sandy loam	Moderate
PFAS-17	Weak	Sandy loam	Sandy clay loam	Moderate

PFAS-18	Weak	Sandy loam	Sandy clay loam	Moderate
PFAS-19	Weak	Sandy loam	Sandy loam	Moderate
PFAS-20	Weak	Sandy loam	Sandy loam	Moderate
PFAS-21	Weak	Sandy loam	loam	Moderate
PFAS-22	Weak	Sandy loam	Sandy loam	Moderate
PFAS-23	Weak	Sandy loam	Sandy loam	Moderate
PFAS-24	Weak	Sandy loam	Sandy clay loam	Moderate
PFAS-25	Weak	Sandy loam	Sandy loam	Moderate
PFAS-26	Weak	Sandy loam	Sandy loam	Moderate
PFAS-27	Weak	Sandy loam	Sandy clay loam	Moderate
PFAS-28	Weak	Sandy loam	Sandy clay loam	Moderate
PFAS-29	Weak	Gravelly sandy clay loam	Gravelly Sandy clay	Moderate
PFAS-30	Weak	Gravelly sandy clay loam	Gravelly Sandy clay	Moderate
PFAS-31	Weak	Gravelly sandy clay loam	Gravelly Clay	Moderate
PFAS-32	Weak	Gravelly sandy clay loam	Gravelly Sandy clay	Moderate
PFAS-33	Weak	Gravelly sandy clay loam	Gravelly Sandy clay loam	Moderate
PFAS-34	Weak	Gravelly sandy clay loam	Gravelly Sandy clay loam	Moderate
PFAS-35	Weak	Gravelly sandy clay loam	Gravelly Sandy clay loam	Moderate
PFAS-36	Weak	Gravelly sandy clay loam	Gravelly Sandy clay loam	Moderate
PFAS-37	Weak	Gravelly sandy clay loam	Gravelly Sandy clay	Moderate
PFAS-38	Weak	Gravelly sandy clay loam	Gravelly Sandy clay loam	Moderate
PFAS-39	Weak	Sandy clay loam	Sandy clay loam	Moderate
PFAS-40	Weak	Sandy clay loam	Sandy clay loam	Moderate
PFAS-41	Weak	Sandy clay loam	Sandy clay loam	Moderate
PFAS-42	Weak	Sandy clay loam	Sandy clay	Moderate
PFAS-43	Moderate	Sandy clay	Clay	Moderate
PFAS-44	Weak	Sandy loam	Sandy loam	moderate
PFAS-45	Weak	Sandy loam	Sandy loam	moderate

Soil texture & structure

Sediments rich in clay, sand and silt deposited in various places. Remarkable change in landscape due to deposition of sand noted in Thathengalam. Here the texture is sand with less than 10% clay and silt is noted. In valley the deposits are more of clayey nature. In Karakurisi panchayat silting upto a depth of 1.5 inch observed after flooding. During field visit it is observed that the soil structure become weak. Inundation and flooding leads to loss in aggregate stability of soil clods and structure become weak. Depending on the nature of the deposits, whether it is clay or sand, the porosity and water holding capacity of native soil might have been changed. Other properties like infiltration, permeability might have been changed due to the deposition.

CHEMICAL PROPERTIES

Chemical properties such as pH, EC, macro, secondary and micronutrients are analysed to analyse the fertility status and to assess measures to improve soil health. The results are presented in the tables below.

Table 5.9.4

pH and electrical conductivity EC

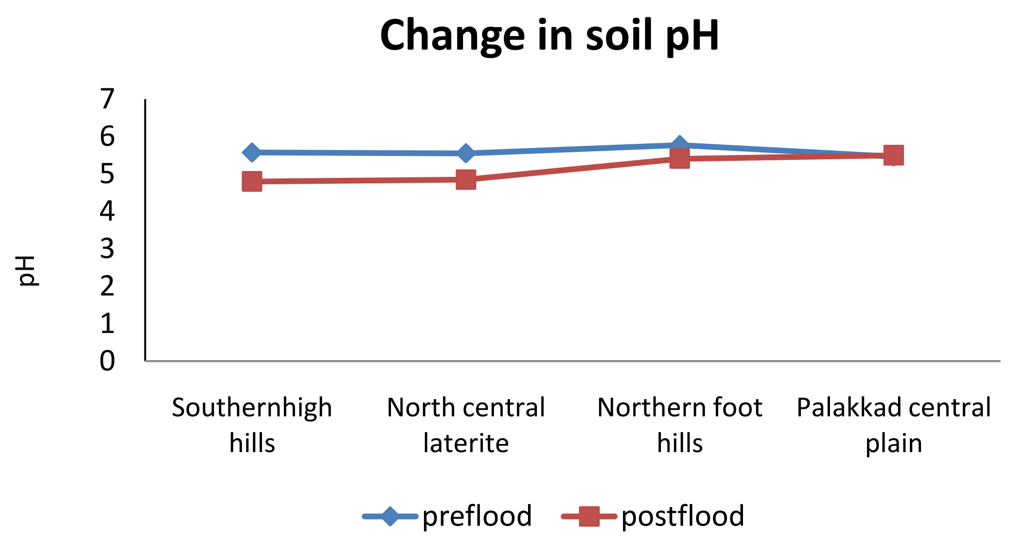
Sample no	Panchayath	pH		EC dSm^{-1}	
		pre flood	Post flood	Pre flood	post flood
PFAS-1	Thenkara	5.30	6.35	0.08	0.17
PFAS-2	Thenkara	5.50	6.27	0.10	0.16
PFAS-3	Thenkara	5.80	6.01	0.12	0.17
PFAS-4	Thenkara	5.60	6.23	0.09	0.17
PFAS-5	Thenkara	5.75	6.21	0.14	0.16
PFAS-6	Thenkara	5.96	5.69	0.20	0.19
PFAS-7	Thenkara	5.98	5.16	0.15	0.22
PFAS-8	Thenkara	5.89	5.53	0.09	0.25
PFAS-9	Thenkara	5.78	5.69	0.20	0.22
PFAS-10	Karakkurissi	5.83	5.00	0.07	0.21
PFAS-11	Karakkurissi	5.94	5.10	0.11	0.18
PFAS-12	Karakkurissi	5.78	5.53	0.10	0.19
PFAS-13	Karakkurissi	5.88	5.65	0.09	0.17
PFAS-14	Karakkurissi	5.97	4.95	0.13	0.18
PFAS-15	Karakkurissi	6.00	4.84	0.08	0.19
PFAS-16	Karakkurissi	6.02	4.43	0.10	0.28
PFAS-17	Karakkurissi	6.11	4.20	0.16	0.21
PFAS-18	Karakkurissi	5.98	5.02	0.13	0.21
PFAS-19	Karakkurissi	5.40	5.81	0.10	0.22
PFAS-20	Karakkurissi	5.55	5.12	0.11	0.17
PFAS-21	Karakkurissi	5.64	5.50	0.13	0.19
PFAS-22	Karakkurissi	5.51	5.63	0.10	0.13
PFAS-23	Karakkurissi	5.48	5.42	0.09	0.14

PFAS-24	Karakkurissi	5.82	4.74	0.08	0.18
PFAS-25	Karakkurissi	5.77	5.65	0.07	0.15
PFAS-26	Karakkurissi	5.66	5.62	0.12	0.16
PFAS-27	Karakkurissi	5.90	5.15	0.15	0.15
PFAS-28	Karakkurissi	5.82	5.20	0.10	0.17
PFAS-29	Nenmara	5.40	5.50	0.07	0.12
PFAS-30	Nenmara	5.33	5.02	0.06	0.12
PFAS-31	Nenmara	5.44	5.50	0.11	0.14
PFAS-32	Nelliampathy	5.66	5.46	0.06	0.12
PFAS-33	Nelliampathy	5.63	4.88	0.09	0.12
PFAS-34	Nelliampathy	5.57	5.15	0.11	0.13
PFAS-35	Nelliampathy	5.70	4.43	0.09	0.15
PFAS-36	Nelliampathy	5.48	4.37	0.08	0.15
PFAS-37	Nelliampathy	5.51	4.73	0.13	0.13
PFAS-38	Nelliampathy	5.47	4.95	0.11	0.2
PFAS-39	Vaniyamkulam	5.69	4.71	0.09	0.18
PFAS-40	Vaniyamkulam	5.70	4.54	0.04	0.15
PFAS-41	Vaniyamkulam	5.34	5.12	0.08	0.17
PFAS-42	Vaniyamkulam	5.49	5.04	0.13	0.12
PFAS-43	Kizhakkencherry	5.33	4.67	0.16	0.17
PFAS-44	Alathur	5.46	5.72	0.20	0.23
PFAS-45	Alathur	5.82	6.63	0.23	0.22

SOIL pH

When compared to preflood samples, in all panchayats except in Karakurissi and Nelliyampathy panchayats, soil pH showed an increasing trend ie acidicity is reduced due to flooding. Clay content of these soils was considerably lowered which caused washing of acidity of these areas while flooded by the river courses. But in cultivated areas, the pH decreased by flooding and hence acidity increased. In areas where soil pH is less than 5.5 and liming is essential. Application of lime or dolomite is necessary in these soil to reduce acidity and for conditioning the soils.

In Karakurissi, the wetlands deposited with silt, showed obvious increase in acidity while the flooded banks of Kanjirapuzha river showed only a slight increase in acidity. The analytical results of soil samples collected from Nenmara landslide prone areas showed slight increase in acidity. In Nelliyampathy panchayat, substantial increase in acidity is observed and this may be due to the intense leaching of basic cations from the steeper slopes. Slight increase in acidity is observed in the lowland fields in Vaniyamkulam panchayat near the riverbanks of Bharathapuzha. The samples collected from Kizhakkenhery ,where soil cracking is noticed, pH decreased at alarming rate. Liming is urgently needed for conditioning these soils. It may be concluded that in higher slopes in general flooding increased acidity while in valleys no significant difference is noticed though variations observed place to place.



ELECTRICAL CONDUCTIVITY

Although electrical conductivity values increased when compared to pre flood condition, the values are within the safe limit for plant growth.

Table 5.9.4

Macro nutrients

Sample no	Panchayath	OC%		P kg/ha		K kg/ha	
		Pre flood	Post flood	Pre flood	Post flood	Pre flood	Post flood
PFAS-1	Thenkara	0.14	0.28	35.00	21.28	74.58	20.61
PFAS-2	Thenkara	0.24	0.56	38.47	25.45	85.03	53.65
PFAS-3	Thenkara	0.16	0.68	42.03	20.16	100.23	51.86
PFAS-4	Thenkara	0.20	0.28	58.71	23.52	96.04	18.59
PFAS-5	Thenkara	0.13	0.16	61.02	20.16	95.14	59.70
PFAS-6	Thenkara	0.89	1.71	33.06	22.4	410.02	324.13
PFAS-7	Thenkara	0.80	1.43	39.45	113.12	155.33	165.65
PFAS-8	Thenkara	0.96	1.31	15.06	15.68	452.36	387.52
PFAS-9	Thenkara	1.02	1.83	29.03	21.28	541.29	461.89

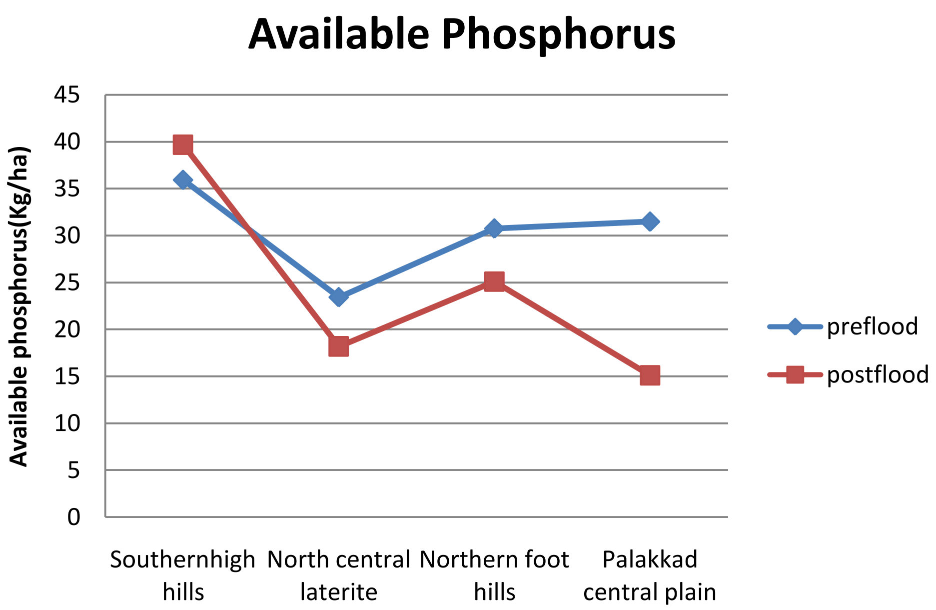
PFAS-10	Karakkurissi	1.06	1.71	18.86	6.72	189.00	84.11
PFAS-11	Karakkurissi	1.97	2.19	20.03	5.6	99.00	26.32
PFAS-12	Karakkurissi	1.02	1.51	14.03	48.16	178.05	76.72
PFAS-13	Karakkurissi	1.41	1.23	36.28	43.68	202.54	24.3
PFAS-14	Karakkurissi	1.23	1.55	17.74	7.84	100.24	27.44
PFAS-15	Karakkurissi	1.35	2.03	11.02	7.84	154.12	90.38
PFAS-16	Karakkurissi	1.04	1.43	9.89	6.72	241.22	151.2
PFAS-17	Karakkurissi	1.75	2.19	18.86	8.96	104.87	86.02
PFAS-18	Karakkurissi	0.85	1.91	14.18	8.96	201.48	92.4
PFAS-19	Karakkurissi	0.68	1.63	34.50	41.44	205.03	324.13
PFAS-20	Karakkurissi	0.54	0.88	37.70	41.44	219.00	65.07
PFAS-21	Karakkurissi	0.69	0.72	35.68	36.96	199.80	88.14
PFAS-22	Karakkurissi	0.99	0.52	41.78	8.96	105.60	25.42
PFAS-23	Karakkurissi	0.87	0.64	49.87	48.16	141.10	64.29
PFAS-24	Karakkurissi	0.95	1.31	31.9	25.76	303.00	85.01
PFAS-25	Karakkurissi	0.49	0.92	37.82	22.4	245.56	59.25
PFAS-26	Karakkurissi	0.56	0.68	40.02	17.92	321.22	52.42
PFAS-27	Karakkurissi	0.75	1.11	18.86	13.44	147.03	88.37
PFAS-28	Karakkurissi	0.82	1.23	20.13	19.04	189.00	87.36
PFAS-29	Nenmara	1.52	2.51	33.80	11.2	178.20	105.39
PFAS-30	Nenmara	1.88	2.35	37.89	8.96	144.42	83.22
PFAS-31	Nenmara	1.94	2.19	45.06	16.8	153.41	125.44
PFAS-32	Nelliampathy	1.74	2.51	36.20	24.64	174.53	120.18
PFAS-33	Nelliampathy	1.45	1.95	33.02	16.8	188.30	154.67
PFAS-34	Nelliampathy	1.89	2.39	45.06	41.44	193.64	149.63
PFAS-35	Nelliampathy	1.44	1.95	20.17	12.32	200.51	117.71
PFAS-36	Nelliampathy	1.52	2.19	32.55	107.52	169.02	134.74
PFAS-37	Nelliampathy	1.66	2.43	39.05	35.84	178.30	128.35
PFAS-38	Nelliampathy	1.46	2.03	45.61	39.2	221.06	196.9
PFAS-39	Vaniyamkulam	0.49	1.27	12.10	8.96	184.23	114.58
PFAS-40	Vaniyamkulam	0.58	1.31	27.63	23.52	100.35	48.83
PFAS-41	Vaniyamkulam	0.34	1.59	39.87	34.72	97.52	60.26
PFAS-42	Vaniyamkulam	0.56	1.43	14.08	5.6	84.02	48.72
PFAS-43	Kizhakkencherry	0.47	1.79	19.80	11.2	195.00	110.99
PFAS-44	Alathur	1.52	1.07	13.44	12.32	244.44	55.22
PFAS-45	Alathur	1.08	0.28	38.88	30.24	239.23	62.16

ORGANIC MATTER CONTENT

In general the organic carbon content of soil increased considerably in the flood plains and uplands. In the uplands, increase may be due to decaying of plant roots and plant debris in the soil.

AVAILABLE N, P, K

Since OC% indicates the Nitrogen level in the soil, the nitrogenous fertilizer application may be planned as per soil analytical data. Generally content of phosphorous is decreased in majority of sampled areas. Drastic reduction in available phosphorous content is noticed in Nenmara panchayat. The P shortage should be replenished with incorporation of phosphatic fertilizers. Leaching loss of potassium observed in all soil samples after flooding. Location specific application of potassium fertilizers is necessary. Along with organic manures/ compost, application of soil nutrients especially phosphorus and potassium through fertilizers based on soil test data is recommended. Except in Southern foot hills , all other agroecologic units recorded lower value for potassium in post flooded season. Irespective of agroecologic units ,soil potassium showed a reducing trend. Majority of the samples are low in potassium. Application of potassium through fertilizers is recommended .



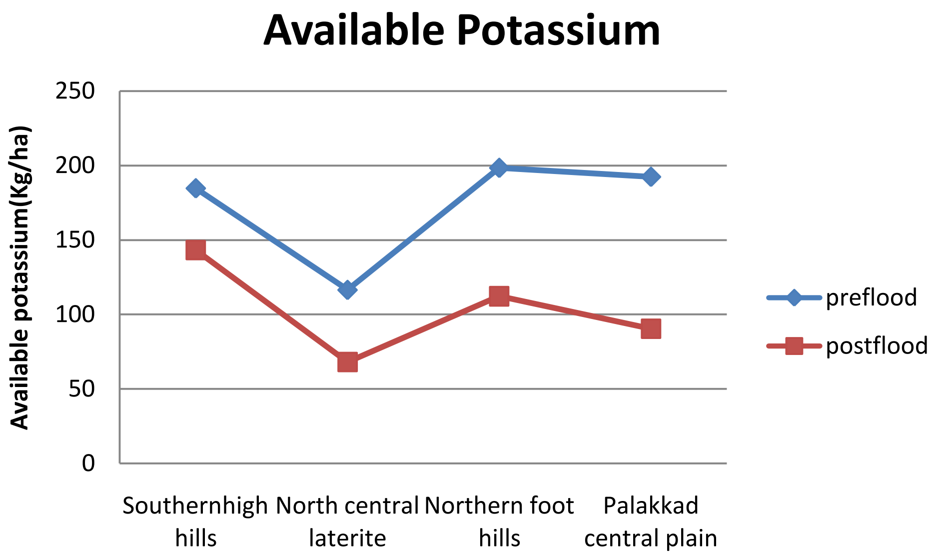


Table 5.9.5

Secondary nutrients

Sl no.	Panchayat	Ca ppm		Mg ppm		S ppm	
		Pre flood	Post flood	Pre flood	Post flood	Pre flood	Post flood
PFAS-1	Thenkara	104	81.3	13.8	22.5	6	49.5
PFAS-2	Thenkara	112	169.95	19.4	49.5	13.75	41
PFAS-3	Thenkara	101	247.7	14.2	48	4.5	149.75
PFAS-4	Thenkara	115	74.1	11.3	22.5	7.2	159.13
PFAS-5	Thenkara	106	114.35	12	25.5	5.8	145.25
PFAS-6	Thenkara	105	658.2	16.2	87	6	132.25
PFAS-7	Thenkara	119	425.6	18.4	54	6.9	136.75
PFAS-8	Thenkara	123	667.05	18	84	16.9	151
PFAS-9	Thenkara	114	830.5	21.5	99	7.6	152.38
PFAS-10	Karakkurissi	109	213.15	12.4	36	12	149.38
PFAS-11	Karakkurissi	101	203.7	15.1	21	14	128.13
PFAS-12	Karakkurissi	150	256.85	14.3	39	14.3	133.63
PFAS-13	Karakkurissi	102	282.2	12.4	25.5	17.5	149.88
PFAS-14	Karakkurissi	108	170.65	15.3	24	17.1	143
PFAS-15	Karakkurissi	101	144.15	14.2	33	21	143.38
PFAS-16	Karakkurissi	109	207.3	17.5	25.5	30.63	132

PFAS-17	Karakkurissi	108	110.65	12.3	33	23.5	142.88
PFAS-18	Karakkurissi	130	184.15	18.6	45	35.13	147.88
PFAS-19	Karakkurissi	187	359.25	16.5	37.5	19.74	169
PFAS-20	Karakkurissi	128	133.4	19.2	30	106.13	123.5
PFAS-21	Karakkurissi	104	120.65	15	34.5	107.5	134.38
PFAS-22	Karakkurissi	101	101.55	14.2	33	109.25	155.25
PFAS-23	Karakkurissi	155	202.5	13.9	43.5	125.38	134.88
PFAS-24	Karakkurissi	124	298.5	12	42	124.25	139
PFAS-25	Karakkurissi	117	193.75	13.7	37.5	125.5	141.88
PFAS-26	Karakkurissi	140	201.35	19	55.5	115.75	126.13
PFAS-27	Karakkurissi	129	338.8	15	33	109.63	155.13
PFAS-28	Karakkurissi	183	347.6	18	40.5	87.63	148
PFAS-29	Nenmara	114	478.45	14.3	31.5	144.88	135.75
PFAS-30	Nenmara	109	177.05	15.8	40.5	69.38	117
PFAS-31	Nenmara	108	543.4	17.4	31.5	77.5	117.88
PFAS-32	Nelliampathy	99	356.4	12	31.5	39.63	131
PFAS-33	Nelliampathy	82	174.9	13.7	30	105	119
PFAS-34	Nelliampathy	100	257.35	13.8	37.5	156.5	138.88
PFAS-35	Nelliampathy	89	80.25	10.8	22.5	102.5	137.25
PFAS-36	Nelliampathy	96	149.45	19.4	34.5	82	119
PFAS-37	Nelliampathy	106	189	18.1	34.5	45.38	123.75
PFAS-38	Nelliampathy	101	247.6	20.4	34.5	105	127.63
PFAS-39	Vaniyamkulam	280	299.85	15.3	51	27.25	143.25
PFAS-40	Vaniyamkulam	205	403.4	24.1	108	27.25	150.25
PFAS-41	Vaniyamkulam	256	839.4	26.9	154.5	31.36	123.5
PFAS-42	Vaniyamkulam	200	353.15	19.7	76.5	34.8	154.13
PFAS-43	Kizhakkencherry	230	460.2	15.9	103.5	7.38	151.13
PFAS-44	Alathur	320	781.75	25.4	123	170.88	165.38
PFAS-45	Alathur	304	958.6	13.8	64.5	170.88	138.13

The Calcium content of soil increased in majority of sampled areas after flood, but it is below the adequate level(300ppm). Liming will improve the Ca level of the soil. Magnesium level showed increase after flooding but majority of the soils are magnesium deficient. Hence application of Mg is to be adopted. Analysis of post flood data showed sufficient amounts of Sulphur in all samples, Use of S containing fertilizers like Factomphos/ ammonium sulphate might have contributed the sulphur status of these soils. Straight fertilizers are recommended in these areas.

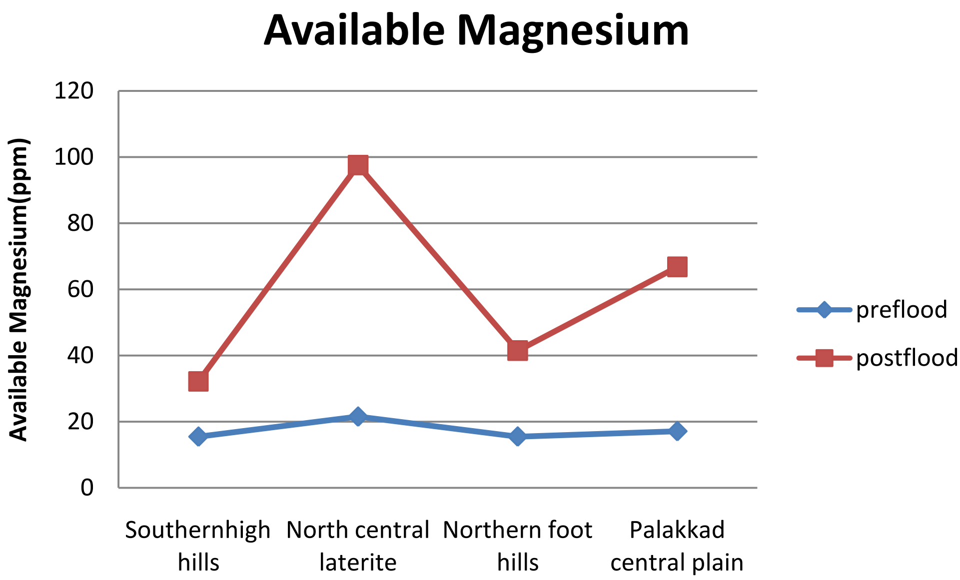


Table 5.9.6

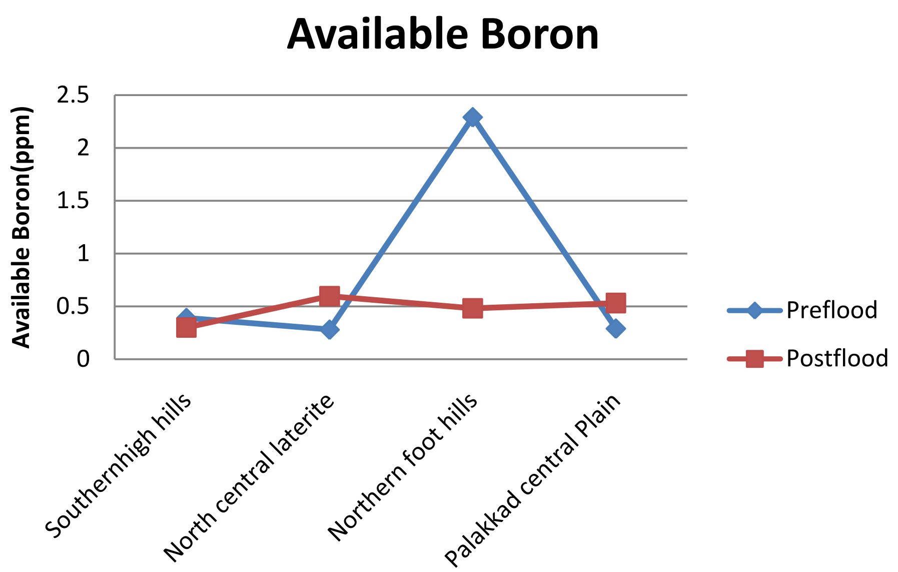
Micronutrients

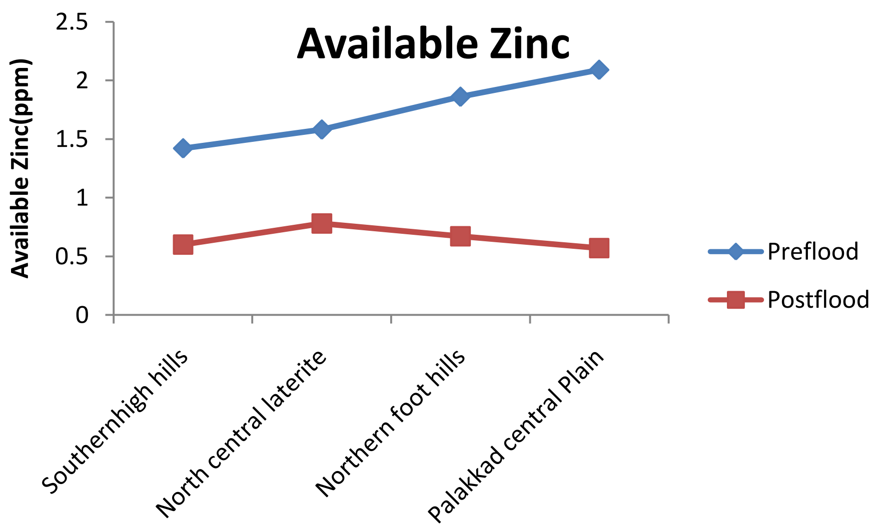
Sample no	B ppm		Cu ppm		Zn ppm		Fe ppm		Mn ppm	
	Pre flood	Post flood	Pre flood	Post flood	Pre flood	Post flood	Pre flood	Post flood	Pre flood	Post flood
PFAS-1	0.3	0.36	2.32	0.28	2.86	0.16	22.16	2.8	40.63	3.2
PFAS-2	0.32	0.44	1.60	0.54	2.86	0.44	20.13	8.4	42.55	9.4
PFAS-3	0.5	0.56	2.13	0.5	2.52	0.36	21.54	8.8	36.51	10.2
PFAS-4	0.38	0.4	2.32	0.3	2.13	0.16	23.66	4.2	52.13	3.4
PFAS-5	0.43	0.46	1.09	0.58	2.21	0.56	22.99	4.2	40.50	2.6
PFAS-6	0.41	0.54	6.09	0.66	2.03	0.54	105.5	18.2	24	9
PFAS-7	0.48	0.52	2.24	0.8	2.16	0.7	110.0	19.8	21	8.6
PFAS-8	0.40	0.46	2.15	2.62	2.32	0.56	111.4	80	32	24.2
PFAS-9	0.38	0.4	3.84	2.36	2.9	0.36	110.3	65.2	28	22.6
PFAS-10	0.41	0.44	1.83	2.54	1.7	1.58	35	206.8	22.9	15.4
PFAS-11	0.35	0.38	1.19	4.22	1.5	0.56	32	107.2	21.3	61.2
PFAS-12	054	0.64	1.68	1.5	1.3	1.28	39	211.4	22.05	6.2

PFAS-13	0.4	0.36	1.71	1.34	1.7	1.22	23	97.8	32.15	4.2
PFAS-14	0.48	0.56	1.96	3.2	1.1	0.6	54	92.8	28.96	7
PFAS-15	0.31	0.8	1.46	2	1.5	0.58	74	185	28.88	10
PFAS-16	0.30	0.72	1.51	2.98	1.3	0.62	87	163.4	31.23	6.8
PFAS-17	0.34	0.72	1.36	1.96	1.9	0.58	59	170.4	23.21	9.8
PFAS-18	0.33	0.56	1.47	1.6	1.1	0.42	89	109.8	33.10	5
PFAS-19	0.25	0.8	1.89	2.5	1.8	1.88	88	126.4	29.20	24.4
PFAS-20	0.39	0.52	1.65	1.24	2.3	0.36	96	37.8	24.25	4.4
PFAS-21	0.32	0.34	1.40	0.98	1.6	0.3	74	36.6	21.32	3.6
PFAS-22	0.4	0.38	0.85	0.84	1.1	0.32	27	25.2	16	7.8
PFAS-23	0.41	0.42	0.96	0.84	1.9	0.54	29	30.6	12.36	5.4
PFAS-24	0.35	0.4	0.78	2.94	1.7	0.58	21	139	15.65	41.4
PFAS-25	0.38	0.46	0.86	1.44	1.8	0.92	16	115.6	16.98	43.6
PFAS-26	0.51	0.54	0.88	1.08	1.9	0.6	22	46.6	23.3	12.4
PFAS-27	0.35	0.24	0.95	3	1.4	1.2	32	85.8	22.31	27.8
PFAS-28	0.29	0.18	0.54	2.96	1.5	0.94	24	82.6	31.55	11.6
PFAS-29	0.35	0.48	3.45	2.48	1.97	0.54	32	39.8	21.25	6.6
PFAS-30	0.18	0.52	3.68	2.1	1.54	0.48	35	24.6	14.31	4.2
PFAS-31	0.28	0.26	3.31	5.02	1.32	0.44	26	39.2	18.72	7
PFAS-32	0.14	0.24	3.54	3.16	1.58	1.2	71	37.8	25	9.8
PFAS-33	0.34	0.22	3.87	9.82	1.36	0.52	65	45.6	45	6.8
PFAS-34	0.94	0.22	5.84	12.92	1.02	0.52	58	46.8	12	5.6
PFAS-35	0.44	0.2	9.32	21	1.05	0.44	63	36.2	32	7.6
PFAS-36	0.08	0.22	6.54	36.9	1.38	0.46	97	65.8	54	6
PFAS-37	0.21	0.22	7.21	11.06	1.89	0.66	56	73.4	21	9.8
PFAS-38	0.81	0.78	5.38	21.68	1.66	0.4	48	77.8	53	16.8
PFAS-39	0.25	0.68	5.34	3.14	1.91	1.08	64.1	60.6	22.4	11.4
PFAS-40	0.29	0.84	5.21	4.24	1.42	0.94	64.1	113.4	31.21	12
PFAS-41	0.31	0.46	5.31	2.44	1.11	0.5	64.1	65	22.4	9.2
PFAS-42	0.28	0.4	5.39	3.12	1.91	0.6	64.1	25.6	22.65	10
PFAS-43	0.44	0.6	3.9	2.06	4.51	0.56	97.1	36	42.3	7.6
PFAS-44	0.28	0.7	3.88	1.12	1.78	1.2	90.6	33.4	36.96	24.4
PFAS-45	0.21	0.6	3.12	0.76	1.44	0.24	90.6	47	32.14	13.8

The deficiency of B and Zinc noticed in preflood and postflood samples. Though it didn’t show a trend throughout the district in various agroecologic regions, in majority of the samples deficiency of these nutrients are seen. Hence this has to be supplemented through microfertilizers.

It is seen that the level of Copper, iron and Manganese are sufficient in the samples collected from Palakkad Central Plain, Southern high hills of Nelliyampathy, Northern foot hill regions and northern central lateritic regions.





SOILS IN LANDSLIDE AREAS IN THE DISTRICT

Soils identified in the landslide areas by the Soil Survey wing of the Department are as follows

Thekkanchira Series

The soils of Thekkanchira series are deep, well drained, fine textured, reddish brown and slightly acid to neutral. These soils are developed from gneissic parent material. These soils occur on moderately sloping to very steep lands mostly around rock out crops with slope of 5 to 50%. Surface texture ranges from sandy clay loam to sandy clay. The thickness of subsurface horizon is 85 to 130cm. The texture varies from sandy clay to clay with slightly acid. These soils are characterized by the presence of argillans in the horizons on the ped surfaces and inner surfaces of the tubular pores. Presence of boulders and stones in the profile can be noticed. These soils are moderately well drained with moderately slow permeability. These are degraded soils and permanaent vegetation is highly essential to prevent soil erosion

Kanjikulam series

The soils of Kanjikulam series are deep, well drained, moderately fine textured to fine textured, dark brown and medium acidic. These soils are formed from gneissic parent material over laterite. They occur on gently sloping to moderately steep side slopes of midlands, with slope of 3 to 20%. They are medium acidic, well to excessively drained and susceptible to soil erosion. Soils are excessively gravelly and prone to moisture stress with poor soil fertility. Surface horizon is 15 to 25cm. thick and the texture ranges from gravelly sandy clay loam to gravelly clay loam. Subsurface horizon is 100 to 125cm thick and the texture ranges from gravelly clay loam to gravelly clay. Plinthite is seen at a depth of 120cm from the surface. Gravel content ranges from 30 to 50 % in these soils.

The results of the study in Palakkad district can be summarized as follows.

- On interpretation of the results, it is seen that soil acidity is to be corrected through liming especially in Southern high hills and north Central laterites. In Nelliampathy regions soils are very acidic or extremely acidic urgent reclamation programme is highly essential in these areas
- Though locational varaiations are there, deficiencies noted in the case of available potassium, available magnesium, available zinc and available boron
- Available phosphorus values showed a declining trend after flood
- Organic carbon values are medium to high in all samples analysed

- Due to flooding soil structure become week and textural changes occurred in soil
- Application of lime/ dolomite , organic manure etc are to be supplemented to soil to improve the structure and soil aeration
- Crop damage was severe in the district and most affected crops were paddy and banana

MALAPPURAM

Total Geographic Area : 3,55,446 Ha

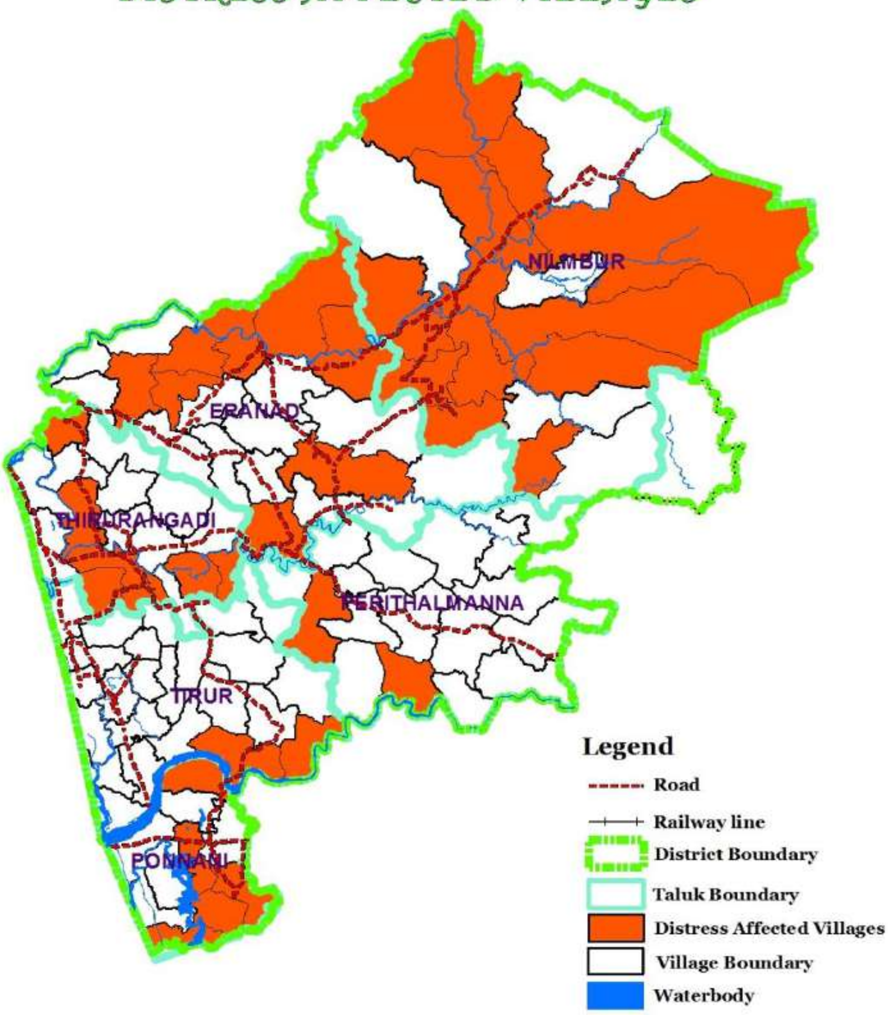
No. of Taluks : 7

No. of Villages : 144

RIVER BASINS

- *Bharathapuzha*
- *Bhavani*
- *Chaliyar*
- *Kadalundi*
- *Kanjiramukku*
- *Thirurpuzha*

DISTRESS AFFECTED VILLAGES



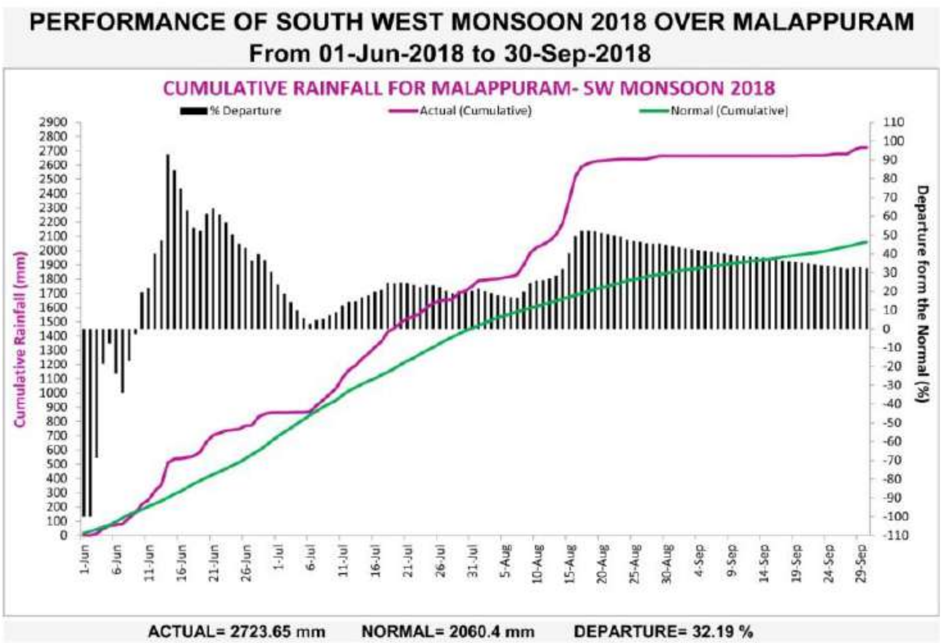
5.10. MALAPPURAM DISTRICT

Malappuram district geographically located between 75°49' 38" and 76°32'52" east longitude and 10°41'31" and 11°31'46" north latitude is bounded on the north by Kozhikode district, east by Nilgris and Coimbatore district of Tamilnadu State, south by Palakkad and Thrissur districts and west by the Arabian sea. The district has a geographical area of 3,55,446 ha which is 9.13% of the total area of the state making it the third largest district in the state.

The major physiographic divisions identified in the district are low land (below 20m MSL) midland (20-100m MSL) mid upland (100-300m MSL), upland (300-600m MSL) high land (600-1200m MSL) and mountainous (>1200m MSL) region. The elevation of the land increases from the sea level as it goes east and the highest elevation is attained at the north eastern boundary lying along the Western ghats ie, 2476m at Nilgiri peaks. The district is drained by six rivers Chaliyar, Kadalundi, Bharathapuzha, Tirurpuzha, Bhavani, and Kanjiramukku puzha and their tributaries.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

The south west monsoon which was pounded over Kerala with 29.5 % excess showers recorded an all time high inflow of water in to the reservoir, lakes and also the highest daily rain fall in the catchment area. From the rainfall graph it can be inferred that the rainfall received during the south west monsoon of 2018 is much higher than normal. The district received 32% more rainfall than normal.



IMPACT OF DISTRESS IN THE DISTRICT

The monsoon rains hit severely in the district created much havoc throughout starting from hill tops, down to coastal areas. Many areas in the district were isolated and transportation system was disrupted. A no: of landslides occurred in high lands of Nilambur, Eranad and Kondotty Taluks and almost all low lands were submerged.

As per the reports of District Administration, 116 villages were affected in the district. Villages in Nilambur Taluk and Eranad Taluk were affected severely.

FIELD TRAVERSING AND SOIL SAMPLING

Field traversing of the affected area was conducted to assess the aftermath of flood in relation to land and soil conditions. The main objective was to evaluate the changes in soil health with special reference to distress affected panchayaths in the district. Soil sampling sites were located randomly while traversing and were taken from the identified spots of flood and land slide affected areas. Accordingly, 23 surface soil samples were taken from a depth of 15 cm from different parts of the panchayaths. The details of sampling sites are given below

Table 5.10.1

Sampling locations

Sample code	Name of site	Panchayath/ Municipality	Geo Co-ordinates
MPM/1	Mylappuram	Malappuram	11^0 02' 17.02" 76^0 04' 09.83"
MPM/2	Mylappuram	Malappuram	11^0 02' 13.90" 76^0 04' 06.36"
MPM/3	Mylappuram	Malappuram	11^0 02' 23.74" 76^0 03' 52.32"
MPM/4	Irumpuzhi	Anakkayam	11^0 04' 41.12" 76^0 06' 15.98"
MPM/5	Irumpuzhi	Anakkayam	11^0 04' 42.07" 76^0 06' 17.19"
MPM/6	Irumpuzhi	Anakkayam	11^0 04' 57.32" 76^0 07' 21.03"
MPM/7	Irumpuzhi	Anakkayam	11^0 05' 17.26" 76^0 08' 18.63"
MPM/8	Irumpuzhi	Anakkayam	11^0 05' 55.19" 76^0 11' 16.55"
MPM/9	Millumpadi-kakkathodu	Manjeri	11^0 06' 14.99" 76^0 11' 14.69"
MPM/10	Valluvangad-oravumbrum	Pandikkad	11^0 05' 56.09" 76^0 11' 35.36"

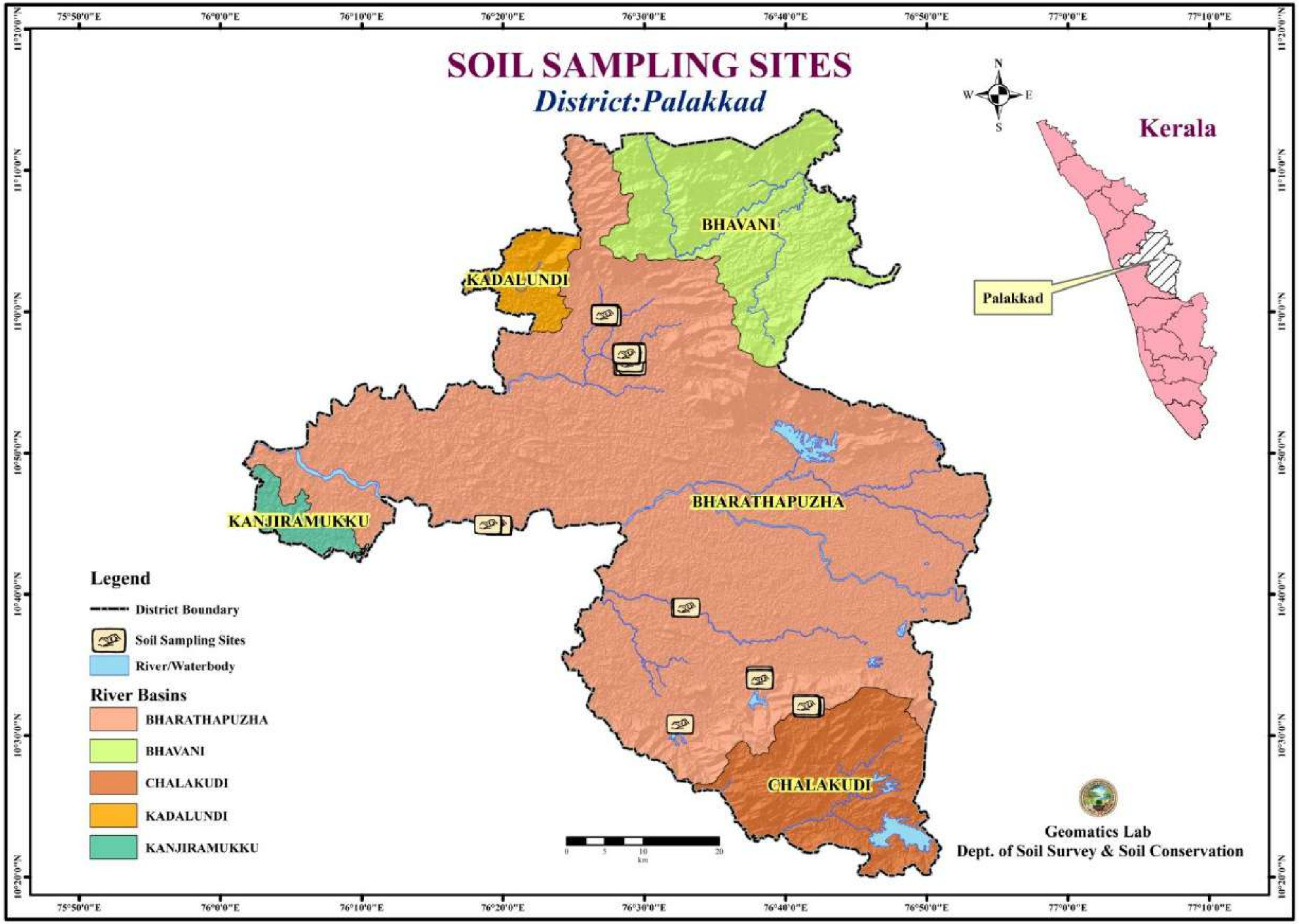
MPM/11	Valluvangad-oravumbrum	Pandikkad	11^0 05' 35.20" 76^0 13' 01.26"
MPM/12	Valluvangad-oravumbrum	Pandikkad	11^0 05' 21.94" 76^0 14' 14.18"
MPM/13	East pandikkad	Pandikkad	11^0 04' 58.94" 76^0 14' 42.01"
MPM/14	Peruvakkad	Pandikkad	11^0 05' 00.43" 76^0 15' 07.08"
MPM/15	Poolamanna	Pandikkad	11^0 05' 12.33" 76^0 15' 31.25"
MPM/16	Valarad	Pandikkad	11^0 04' 58.02" 76^0 13' 58.96"
MPM/17	Thriprangode	Thriprangode	10^0 50' 45.38" 76^0 56' 36.44"
MPM/18	Kuroor colony	Thalakkad	10^0 49' 59.39" 75^0 56' 54.23"
MPM/19	Chamravattom	Thriprangode	10^0 49' 13.57" 75^0 57' 52.76"
MPM/20	Purathur-kappilakakd	Purathur	10^0 49' 26.52" 75^0 55' 20.88"
MPM/21	Mangalampadam	Mangalam	10^0 51' 34.30" 75^0 55' 26.57"
MPM/22	Pookkayithra	Talakkad	10^0 52' 33.33" 75^0 55' 23.19"
MPM/23	Vettilappara Oorngattiri	Oorngattiri	11^0 16' 26.87" 76^0 07' 02.48"

Table 5.10. 2

Site characteristics

Sample code	River basin	Slope %	Physiography	Landform	Present land use
MPM/1	Kadalundi	3%	low land	river bank	coconut, banana, miscellaneous crops
MPM/2	Kadalundi	3%	low land	river bank	coconut, banana, miscellaneous crops
MPM/3	Kadalundi	3%	low land	river bank	coconut, banana, miscellaneous crops
MPM/4	Kadalundi	4%	low land	valley	coconut, banana, vegetables
MPM/5	Kadalundi	4%	low land	valley	coconut, banana, vegetables
MPM/6	Kadalundi	4%	low land	valley	coconut, banana, vegetables
MPM/7	Kadalundi	4%	low land	valley	coconut, banana, vegetables

MPM/8	Kadalundi	4%	low land	valley	coconut, banana, vegetables
MPM/9	Kadalundi	5%	low land	valley	Rubber and miscellaneous crops
MPM/10	Kadalundi	6%	low land	valley	coconut, banana, miscellaneous crops
MPM/11	Kadalundi	6%	low land	valley	coconut, banana, miscellaneous crops
MPM/12	Kadalundi	6%	low land	valley	coconut, banana, miscellaneous crops
MPM/13	Kadalundi	6%	low land	valley	Coconut, miscellaneous crops
MPM/14	Kadalundi	6%	low land	valley	Coconut, miscellaneous crops
MPM/15	Kadalundi	11%	low land	side slope	Coconut, miscellaneous crops
MPM/16	Kadalundi	7%	low land	valley	Coconut, miscellaneous crops
MPM/17	Bharathapuzha	3%	low land	river bank	coconut
MPM/18	Bharathapuzha	4%	low land	river bank	Coconut
MPM/19	Bharathapuzha	3%	low land	river bank	coconut
MPM/20	Bharathapuzha	3%	low land	river bank	coconut
MPM/21	Bharathapuzha	2%	low land	flood plain	paddy, coconut
MPM/22	Bharathapuzha	3%	low land	river bank	coconut
MPM/23	Chaliyar	20%	mid upland	side slope	rubber


SOIL SAMPLING SITES
District:Palakkad
Kerala
Palakkad
N
S
E
W
BHAVANI
KADALUNDI
BHARATHAPUZHA
KANJIRAMUKKU
CHALAKUDI
Legend
District Boundary
Soil Sampling Sites
River/Waterbody
River Basins
BHARATHAPUZHA
BHAVANI
CHALAKUDI
KADALUNDI
KANJIRAMUKKU
Geomatics Lab
Dept. of Soil Survey & Soil Conservation
75°50'0"E
76°0'0"E
76°10'0"E
76°20'0"E
76°30'0"E
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
11°20'0"N
11°10'0"N
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N

CHANGES IN THE DISTRESS AFFECTED AREAS

Physiography and landscape

Due to land slide in highly elevated area of NilamburTaluk, top ridges collapsed, boulders and big stones were rolled down. Wide cracks were formed on steeply sloping areas. In Vettilappara area of Oorngattiri panchayath, land slide occurred at an elevation of 253 m. The origin of the land slide was in forest area at an elevation of 400 m resulting in collapse of 7 houses.

NELLAYI-OORGATTIRI PANCHAYATH

In Mathimoola, Chaliyar panchayath land slide occurred from highly elevated area. Flooded water carried big boulders and stones which destroyed 34 houses and roads. The Kanjirapuzha river flowing through the area diverted its course and damaged roads.

MATHIMOOLA-CHALIYAR PANCHAYATH

In Karuvarakundu panchayath, land slide occurred in Cheriyam area. The landslide originated from Silent Valley buffer zone, which carried enormous amount of rocks and boulders, destroyed large area of rubber plantations.

CHERIAM-KARUVARAKUNDU PANCHAYATH

Manaliyamparathodu which originates from Silent valley hills forming the Keralamkundu water falls (a famous tourist place) also was destroyed due to land slide. The waterfall has ceased and the course of the river changed. Erosion in these areas is very severe ie A horizon and 75% of B horizon lost. No change in soil profile is noticed in these areas. Soils are deep to very deep.

MANALIYAMPARA THODU-KERALAMKUNDU

In lower areas crops have been destroyed and silt is deposited along valley . In many areas top soil has been eroded. Erosion is moderate to severe. No change in soil depth is noticed.

ANAKKAYAM PANCHAYATH

THONNANKADAVU-PANDIKKAD PANCHAYATH

NADUVATH- KARAD ROAD-WANDOOR PANCHAYATH

PHYSICAL AND CHEMICAL CHARACTERISTICS

Physical characteristics

The changes in physical properties such as texture and structure of soils were compared with the available pre flood soil data which is given in the table below.

Table 5.10.3

Soil texture

Sample code	Texture	Sand %	Silt %	Clay %
MPM/1	-			
MPM/2	Clay loam	34	32	34
MPM/3	Clay	20	35	45
MPM/4	Clay loam	37	35	28
MPM/5	Clay loam	28	39	33
MPM/6	--	-**	-	-
MPM/7	Clay loam	26	36	38
MPM/8	Clay loam	32	35	33
MPM/9	Sandy Clay loam	53	21	26
MPM/10	Sandy loam	58	34	8
MPM/11	Sandy loam	60	28	12
MPM/12	Clay loam	31	35	34
MPM/13	-	--**	-	-
MPM/14	Clay loam	29	37	34
MPM/15	Clay	26	22	52
MPM/16	Clay loam	33	38	29

MPM/17	Sandy Clay loam	49	22	29
MPM/18	Clay loam	33	31	36
MPM/19	Loamy sand	81	12	7
MPM/20	Sandy clay loam	35	45	20
MPM/21	-	-**	-	-
MPM/22	Clay loam	34	32	34
MPM/23	Clay	20	35	45

** Texture not available

Clay has been deposited over top soil. After drying cracks are noticed over clay deposits in valleys and paddy lands. After analyses of soil samples from distress area, a change in silt and clay content were noticed.

Samples taken from Mylappuram areas of Malappuram Municipality showed an increase in clay content.

While soils of Millumpadi in Manjeri municipality and some areas of Valluvangad of Pandikkad panchayath showed increase in sand content. Deposition of silt and clay is not noticed in remarkable amount in these soil.

Soils of Poolamanna, Peruvakkad and some areas of Valluvangad of Pandikkad panchayath showed increase in silt content .

Remarkable change in texture is noticed in low land areas of Western Coast. Increase in silt and clay content is noticed in soils of Thriprangode, Kuroor in Thalakkad, Purathoor and Mangalam areas. The texture changed from loamy sand to clay loam.

The change in textural content of these soils are mainly due to deposition of silt and clay during flood.

Soil structure

Soil has become compact in highly eroded areas of Oorgattiri and Karuvarakundu areas. Boulders and stones have been deposited over the surface. Top soil has been eroded. In laterite areas, cappings are exposed. Apart from the above, ground water level decreased approximately 1 m in wells both in lowlands and on mid uplands.

Chemical changes

The chemical properties such as pH, EC, macro, secondary and micronutrients of the soil samples collected from the flooded soils were analysed and compared with available data and are as follows.

Table 5.10.4
pH & Electrical Conductivity and Macro nutrients

Sample code	pH		EC dSm^{-1}		OC %		P kg/ha		K kg/ha	
	Pre-flood	Post-flood	Pre-flood	Post-flood	Pre-flood	Post-flood	Pre-flood	Post-flood	Pre-flood	Post-flood
MPM/1	5.2	6.2	0.11	0.041	0.42	1.37	56.21	27.01	145.23	302.51
MPM/2	5.2	7.1	0.11	0.053	0.42	0.89	56.21	25.35	145.23	283.92
MPM/3	5.2	6.6	0.11	0.02	0.42	1.37	56.21	26.76	145.23	299.71
MPM/4	5.4	5.6	0.018	0.017	2.5	3.06	26.58	24.65	36.2	276.08
MPM/5	5.4	6.4	0.018	0.019	2.5	2.26	26.58	28.13	36.2	315.06
MPM/6	5.4	6.1	0.018	0.024	2.5	4.04	26.58	29.76	36.2	333.31
MPM/7	5.4	6.2	0.018	0.017	2.5	1.37	26.58	28.71	36.2	321.55
MPM/8	5.4	5.7	0.018	0.016	2.5	1.01	26.58	22.85	36.2	255.92
MPM/9	6.5	6.2	0.31	0.031	1.15	0.98	123.2	26.33	5.49	294.9
MPM/10	5.8	6.6	0.026	0.015	0.64	0.86	14.1	22.95	448	257.04
MPM/11	5.8	6.2	0.026	0.021	0.64	0.36	14.1	22.75	448	254.8
MPM/12	5.8	6.1	0.026	0.026	0.64	1.43	14.1	21.56	448	241.47
MPM/13	5.8	6.3	0.022	0.022	0.64	3.15	14.1	95.93	448	1074.42
MPM/14	5.8	6.4	0.02	0.02	0.64	0.45	14.1	23.97	448	268.46
MPM/15	5.8	6.3	0.01	0.012	0.64	0.95	14.1	25.27	448	283.02
MPM/16	5.8	6	0.018	0.018	0.64	2.38	14.1	51.7	448	819.04
MPM/17	5.1	5.7	0.013	0.013	0.31	0.56	28.5	22.25	90	249.2
MPM/18	5.7	5.6	0.027	0.025	0.39	0.62	32	25.36	224	284.03
MPM/19	5.1	6	0.2	0.015	0.31	0.83	28	23.65	90	264.88
MPM/20	6	6.4	0.019	0.019	0.19	1.16	24.69	24.69	276	276.53
MPM/21	5.1	5.6	0.036	0.036	0.31	1.69	28.5	39.87	90	446.54
MPM/22	5.7	6.1	0.027	0.03	0.39	0.74	32	22.04	224	246.85
MPM/23	6.1	5.5	0.25	0.22	2.5	0.75	28.84	15	424.1	240

pH

Increase in P^H values is noticed after flooding in all samples. But the values decreased in eroded areas after land slide in Vettilappara.

In coastal areas values increased from 5.0 to 6.4 and became less acidic. In valley areas of mid land, the value increased from 4.9 to 6.6. But in mid uplands value changed from 6.1 to 5.5 resulting in increase in acidity.

Electrical conductivity

No noticeable variations in EC values.

Organic matter content

Variations are not found in organic matter content in coastal areas. Slight increase is noted in soils of Mangalam and Purathur areas. Increase in organic matter is found in midlands (from 0.6 to 3 %). Soils of midupland especially in

Vettilappara area shows a decrease from 2.5 to 0.75 % in organic carbon content after landslide.

Phosphorous and Potassium

Much variations are not found in values of phosphorous; slight increase is found in Purathur and Mangalam areas. The values found to be decreased in Vettilappara. Soil deficiency of phosphorus is not noticed in any of the sampling locations.

Increase in value of Potassium is noticed except in Poolamanna and Peruvakkad areas of Pandikkad and in Vettilappara areas. Soil deficiency of potassium is not noticed in any of the sampling locations

Table 5.10.5

Micronutrient status of soils

Sample code	**Avail. Fe** *ppm*		**Avail.Mn** *ppm*		**Avail.Zn** *ppm*		**Avail.Cu** *ppm*	
	Pre-flood	Post flood	Pre-flood	Post flood	Pre-flood	Post flood	Pre-flood	Post flood
MPM/1	145.32	50.58	0.75	41.26	2.40	10.88	1.45	4.10
MPM/2	145.32	19.70	0.75	16.90	2.40	4.28	1.45	1.58
MPM/3	145.32	23.40	0.75	23.64	2.40	2.52	1.45	2.66
MPM/4	2.27	28.10	4.50	19.71	0.08	6.08	0.50	2.90
MPM/5	2.27	39.90	4.50	8.64	0.08	4.14	0.50	7.76
MPM/6	2.27	10.96	4.50	13.04	0.08	3.78	0.50	0.96
MPM/7	2.27	3.96	4.50	16.06	0.08	2.04	0.50	1.08
MPM/8	2.27	30.52	4.50	40.28	0.08	1.56	0.50	2.50
MPM/9	28	22.32	27.00	49.24	1.78	1.78	2.88	2.88
MPM/10	39	40.30	4.50	44.96	0.50	1.12	0.50	2.96
MPM/11	39	43.04	4.50	43.48	0.50	1.46	0.50	5.60
MPM/12	39	38.96	4.50	28.96	0.50	2.04	0.50	1.88
MPM/13	39	38.12	4.50	38.46	0.08	1.88	0.50	2.20
MPM/14	39	47.12	4.50	10.96	0.08	1.78	27.01	2.10
MPM/15	39	40.72	4.50	6.46	0.08	1.36	27.01	0.64
MPM/16	39	29.78	4.50	17.58	0.08	2.46	27.01	1.38
MPM/17	78	16.90	0.75	17.62	1.51	1.60	1.59	2.40
MPM/18	21.8	19.30	11.91	12.90	1.92	1.58	1.81	1.56
MPM/19	78	16.70	0.75	14.46	1.51	1.38	1.59	1.20
MPM/20	89	24.10	22.00	10.96	13.00	2.90	7.30	1.68
MPM/21	67	22.58	11.00	5.62	1.15	1.86	1.59	0.36
MPM/22	21.8	40.30	11.91	10.92	1.92	2.26	1.81	2.06
MPM/23	3.5	35.32	52.16	45.22	3.50	2.50	5.10	1.25
Mean	48.15	29.68	8.42	23.36	1.55	2.75	4.94	2.33

Deficiency of available Fe, Mn, Zn, Copper is not noticed except for one location for copper. There is slight increase in Mn, Fe, Zn, Cu content in soils of Mylappuram, Irumpuzhi, Valluvangad and Thriprangode areas. Decrease in all micronutrients are noticed in post flood soils of Purathur and Mangalam areas. Increase in Iron content is noticed in soils of landslided areas of Vettilappara. A slight decrease in Iron content is noticed in soils of Pandallur area in Anakkayam panchayath. In some locations chances of toxicity of iron and manganese noticed.

The results of the study in Malappuram district can be summarized as follows

- Soil cracks are formed along the side slopes on midlands after flood. In Pandikkad, Anakkayam areas clay leached down along slopes and deposited. Cracks are formed on these deposits. These clay deposits may collapse down in the successive rain.
- Laterite cappings are observed on surface in midlands due to removal of topsoil. Boulders & stones from land slides lay deposited in mid uplands.
- Lowering of ground water level up to 1 M was noticed in wells especially in midland areas.
- Bacterial blight is observed in paddy in AnakkayamPanchayath after flooding.
- Due to heavy rain and landslides, top soil has been washed away in sloppy areas in Oorgattiri and Karuvarakundu panchayaths and in other areas of NilamburTaluk. Boulders and stones are seen scattered widely. These areas require a long time for restoration. The cultivation of plantation crops in this area has become impossible. Large quantity of top soil is required for filling up up these areas to take up cultivation, which is not practical.
- Moisture retention practices are to be adopted to preserve existing water level. Mulching and cultivation of green manure crops and cover crops are important for soil moisture conservation.
- In midlands and valleys, large amount of soil is deposited. If the depth of deposition is meager, the deposited sediments can be incorporated with soil and can be used for growing coconut, arecanut, banana and other vegetables. If the depth of deposition is more, the soil must be removed and transferred to other locations and which can be used for growing crops. Water conservation practices are to be adopted to conserve the moisture.

- Deficiency of major or minor nutrients are not noticed in the sampling locations
- Soil acidity has been reduced after flood. The soils are slightly acid to medium acid after flood.

WAYANAD

Total Geographic Area : 2,12,966 Ha

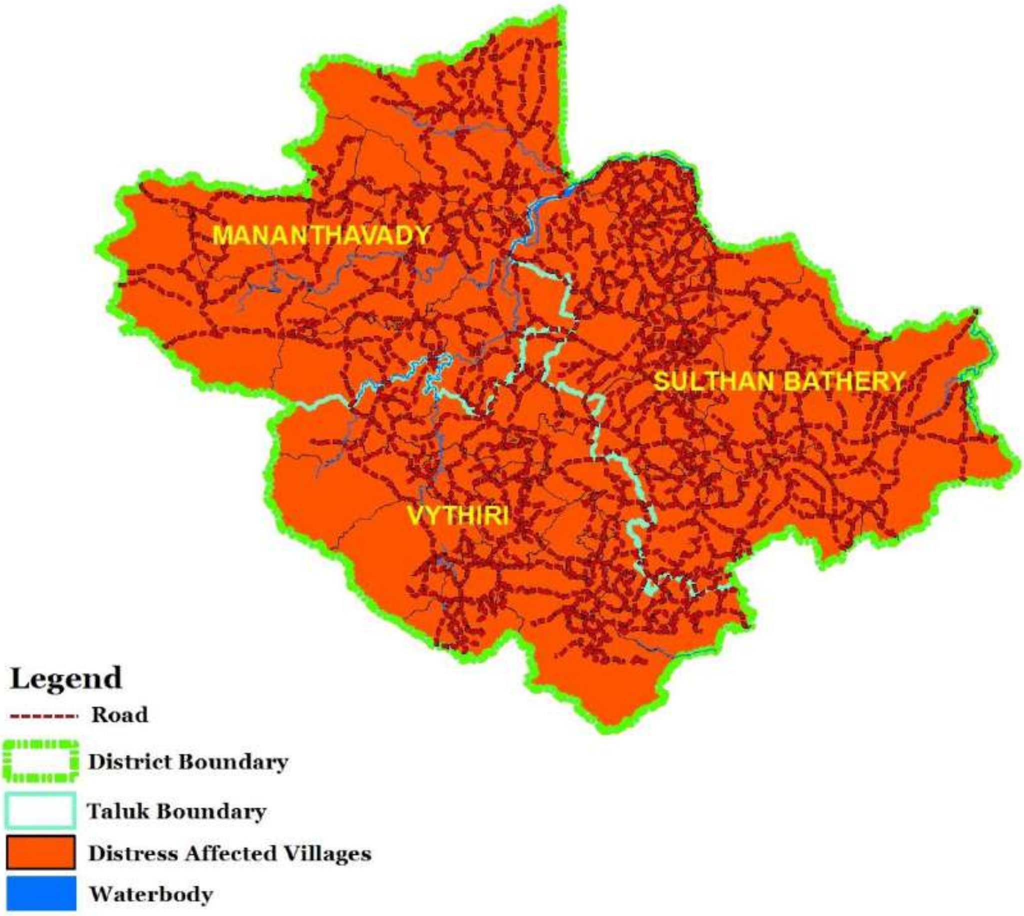
No. of Taluks : 3

No. of Villages : 49

RIVER BASINS

- *Chaliyar*
- *Kabini*
- *Mahe*

DISTRESS AFFECTED VILLAGES



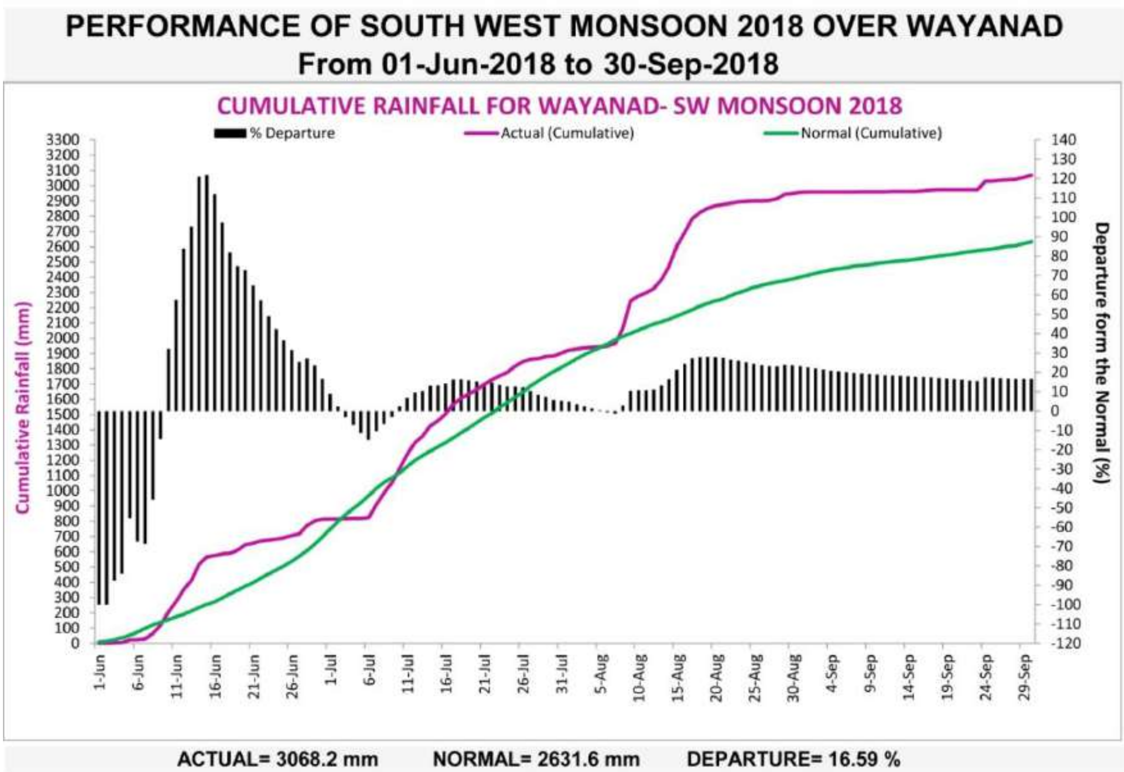
5.11. WAYANAD DISTRICT

Wayanad lies between 11^0 26' and 11^0 0 59' north latitude and 75^0 45' and 76^0 27' East longitude, covering a geographical area of 2,12,966 ha. Physigraphically the area can be divided into three major landforms. Wayanad plateau region, high lands of Central Sahyadiri and mountainous region of Central Sahyadiri. The district is mainly drained by kabani and its tributaries. Panamaram puzha, Baveli puzha, Chali puzha etc are the other rivers in the district.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

On reviewing the rainfall received during the south west monsoon season 2018, it is seen that district received 30% more rainfall than the normal, first peak during June and second peak during August. Since the soil was already saturated with water, this spell during August wreaked havoc in the form of floods and immense number of landslides.

The district experienced heavy rainfall from Aug 15th – 30th. The opening of Karapuzha and Banasura dams following heavy rain has resulted in flooding of panchayaths like Panamaram, Kottathara, Kalpetta municipality etc. Whole of the wet land portion under paddy was affected during this period causing heavy loss of crops.



IMPACT OF DISTRESS IN THE DISTRICT

Vythiri was the worst affected taluk in Wayanad, followed by Mananthavady taluk. In Sulthan Bathery taluk the intensity and duration of rain was less compared to other two taluks. The natural disasters were restricted to road side slips, mud slips behind houses etc. Heavy rains in the beginning of the season resulted in flooding of paddy fields in Noolpuzha, Ambalavayal, Nenmeni and Meenangadi. This was partly due to opening of Karapuzha dam.

FIELD TRAVERSING AND SOIL SAMPLING

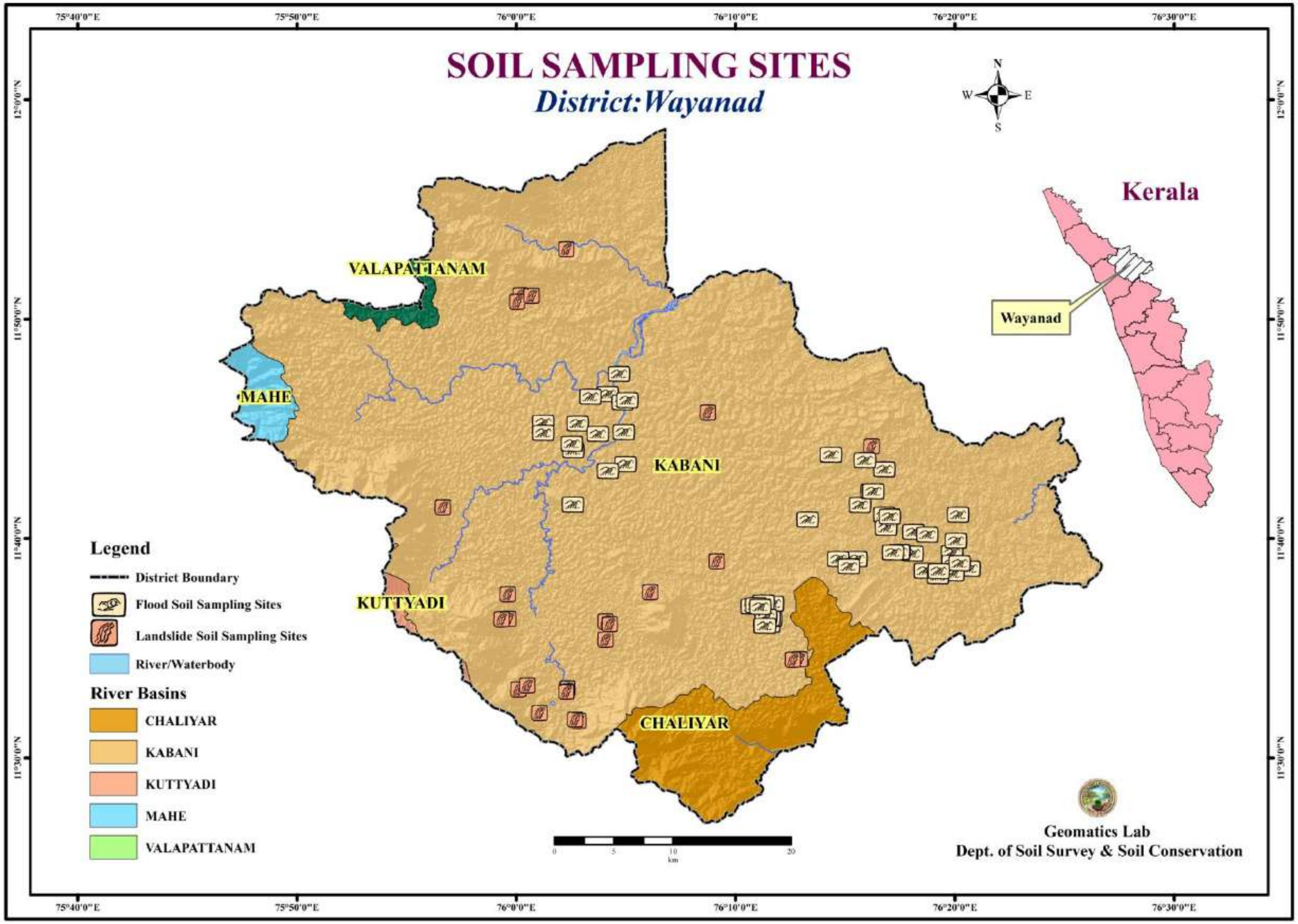
Field traversing was conducted to evaluate the impact of flood in distress affected areas where the intensity of land slide /flood was severe. 60 soil samples were collected from the flood affected panchayats and 28 samples from landslide affected areas. Sampling was done at a depth of 15-30 cm for studying soil properties. Random soil sampling has been done. The results of the soil sample analyses- both physical and chemical parameters- were tabulated and inference derived. The details of sampling locations is presented below.

Table 5.11.1

Sampling locations

1. Ambalavayal panchayat					
Sl No	Sample code	Location (GPS)		Wet/Dry	Series
1	WYD/AMB/1	$76^0$10'55''	$11^0$36'58''	Dry	Pulpally
2.	WYD/AMB/2	$76^0$10'45''	$11^0$36'55''	''	Manjappara
3.	WYD/AMB/3	$76^0$11'27''	$11^0$36'06''	''	Ambalavayal
4	WYD/AMB/4	$76^0$11'27''	$11^0$36'37''	''	Ambalavayal
5	WYD/AMB/5	$76^0$11'33''	$11^0$36'05''	''	Meenangadi
6	WYD/AMB/6	$76^0$11'20''	$11^0$36'02''	''	Ambalavayal
7	WYD/AMB/7	$76^0$11'43''	$11^0$37'03''	''	Meenanagdi
8	WYD/AMB/8	$76^0$11'17''	$11^0$37'06''	''	Meenanagdi
9	WYD/AMB/9	$76^0$10'57''	$11^0$36'58''	''	Meenangadi
10	WYD/AMB/10	$76^0$11'38''	$11^0$36'21''	''	Manjappara
11	WYD/AMB/11	$76^0$11'23''	$11^0$36'21''	''	Pulpally
12	WYD/AMB/12	$76^0$11'33''	$11^0$36'23''	''	Meenangadi
13	WYD/AMB/13	$76^0$11'24''	$11^0$36'27''	''	Meenangadi
14	WYD/AMB/14	$76^0$11'21''	$11^0$36'02''	''	Pulpally
15	WYD/AMB/15	$76^0$11'09''	$11^0$36'54''	''	Ambalavayal
2. Panamaram panchayat					
Sl No	Sample code	Location (GPS)		Wet/Dry	Series
1	WYD/PNM/1	$11^0$46'36''	$76^0$04'11''	Wet	Kambalakkad

2.	WYD/PNM/2	11^{0}46’13’’	76^{0}04’52’’	‘’	Kambalakkad
3.	WYD/PNM/3	11^{0}46’19’’	76^{0}05’05’’	‘’	Kambalakkad
4	WYD/PNM/4	11^{0}47’31’’	76^{0}04’42’’	,,	Kambalakkad
5	WYD/PNM/5	11^{0}46’29’’	76^{0}03’24’’	‘’	Nayikolli
6	WYD/PNM/6	11^{0}45’16’’	76^{0}02’49’’	‘’	Nayikolli
7	WYD/PNM/7	11^{0}44’52’’	76^{0}04’55’’	‘’	Kambalakkad
8	WYD/PNM/8	11^{0}41’34’’	76^{0}02’36’’	‘’	Kambalakkad
9	WYD/PNM/9	11^{0}44’02’’	76^{0}02’37’’	Dry	Mananthavady
10	WYD/PNM/10	11^{0}44’47’’	76^{0}03’44’’	Dry	Purakkadi
11	WYD/PNM/11	11^{0}43’24’’	76^{0}05’00’’	Dry	Ambalavayal
12	WYD/PNM/12	11^{0}44’20’’	76^{0}02’33’’	Dry	Anjukunnu
13	WYD/PNM/13	11^{0}43’06’’	76^{0}04’12’’	Dry	Anjukunnu
14	WYD/PNM/14	11^{0}45’18’’	’76^{0}06’02’’	Dry	Anjukunnu
15	WYD/PNM/15	11^{0}44’50’’	76^{0}01’15’’	Dry	Anjukunnu
3. Noolpuzha panchayat					
Sl No	Sample code	Location (GPS)		Wet/Dry	Series
1	WYD/NLP/1	11^{0}40’19’’	76^{0}18’08’’	Wet	Battuvady
2.	WYD/NLP/2	11^{0}39’14’’	76^{0}19’54’’	‘’	Battuvady
3.	WYD/NLP/3	11^{0}39’22’’	76^{0}19’53’’	Dry	Kallumukku
4	WYD/NLP/4	11^{0}38’39’’	76^{0}20’41’’	Wet	Battuvady
5	WYD/NLP/5	11^{0}38’26’’	76^{0}19’57’’	Dry	Pulpally
6	WYD/NLP/6	11^{0}38’54’’	76^{0}19’54’’	‘’	Sulthan Bathery
7	WYD/NLP/7	11^{0}38’33’’	76^{0}18’39’’	‘’	Sulthan Bathery
8	WYD/NLP/8	11^{0}38’18’’	76^{0}19’15’’	‘’	Sulthan Bathery
9	WYD/NLP/9	11^{0}39’55’’	76^{0}20’04’’	‘’	Kallumukku
10	WYD/NLP/10	11^{0}38’53’’	76^{0}20’14’’	‘’	Kallumukku
11	WYD/NLP/11	11^{0}38’32’’	76^{0}19’17’’	‘’	Sulthan Bathery
12	WYD/NLP/12	11^{0}41’06’’	76^{0}20’10’’	‘’	Kallumukku
13	WYD/NLP/13	11^{0}43’10’’	76^{0}16’48’’	‘’	Sulthan Bathery
14	WYD/NLP/14	11^{0}40’12’’	76^{0}18’46’’	‘’	Kallumukku
15	WYD/NLP/15	11^{0}43’35’’	76^{0}15’55’’	‘’	Sulthan Bathery
4. Sulthan Bathery panchayat					
Sl No	Sample code	Location (GPS)		Wet/Dry	Series
1	WYD/SBY/1	11^{0}41’06’’	76^{0}16’48’’	Dry	Sulthan Bathery
2	WYD/SBY/2	11^{0}40’30’’	76^{0}16’53’’	‘’	Sulthan Bathery
3	WYD/SBY/3	11^{0}41’33’’	76^{0}15’42’’	‘’	Kolagappara
4	WYD/SBY/4	11^{0}39’05’’	76^{0}15’32’’	‘’	Sulthan Bathery
5	WYD/SBY/5	11^{0}39’05’’	76^{0}14’42’’	‘’	Sulthan Bathery
6	WYD/SBY/6	11^{0}41’01’’	76^{0}17’03’’	,,	Kolagappara
7	WYD/SBY/7	11^{0}42’10’’	76^{0}16’13’’	,,	Sulthan Bathery
8	WYD/SBY/8	11^{0}42’10’’	76^{0}16’18’’	,,	Kolagappara
9	WYD/SBY/9	11^{0}39’20’’	76^{0}18’05’’	,,	Ambalavayal
10	WYD/SBY/10	11^{0}39’25’’	76^{0}17’29’’	Wet	Battuvady
11	WYD/SBY/11	11^{0}39’24’’	76^{0}17’28’’	,,	Battuvady
12	WYD/SBY/12	11^{0}39’23’’	76^{0}17’12’’	,,	Battuvady
13	WYD/SBY/13	11^{0}38’45’’	76^{0}15’11’’	Dry	Sulthan Bathery
14	WYD/SBY/14	11^{0}40’53’’	76^{0}13’18’’	,,	Sulthan Bathery
15	WYD/SBY/15	11^{0}43’50’’	76^{0}14’22’’	,,	Pulpally


SOIL SAMPLING SITES
District: Wayanad
Kerala
Wayanad
VALAPATTANAM
MAHE
KABANI
KUTTYADI
CHALIYAR
Legend
District Boundary
Flood Soil Sampling Sites
Landslide Soil Sampling Sites
River/Waterbody
River Basins
CHALIYAR
KABANI
KUTTYADI
MAHE
VALAPATTANAM
Geomatics Lab
Dept. of Soil Survey & Soil Conservation

CHANGES IN SOILS OF DISTRESS AFFECTED AREAS

CHEMICAL PROPERTIES

The chemical properties such as pH, EC, major elements and micronutrients of the soil samples collected from the flooded soils were analysed and compared with available data and are as follows.

Table 5.11.2

pH & Electrical Conductivity

1. Ambalavayal panchayat					
Sl No	Sample code	Before flood		After flood	
		pH	EC	pH	EC
1	WYD/AMB/1	5.3	0.06	5.9	0.21
2	WYD/AMB/2	5.3	0.21	5.2	0.18
3	WYD/AMB/3	5.0	0.06	4.8	0.28
4	WYD/AMB/4	6.4	0.33	4.8	0.29
5	WYD/AMB/5	5.4	0.41	5.4	0.40
6	WYD/AMB/6	5.6	0.06	5.0	0.27
7	WYD/AMB/7	4.9	0.06	4.6	0.18
8	WYD/AMB/8	4.8	0.07	4.4	0.20
9	WYD/AMB/9	5.4	0.15	4.9	4.32
10	WYD/AMB/10	6.1	0.05	5.7	0.32
11	WYD/AMB/11	5.0	0.18	5.8	0.14
12	WYD/AMB/12	6.0	0.17	5.4	0.32
13	WYD/AMB/13	5.5	0.08	4.7	4.21
14	WYD/AMB/14	5.6	0.08	5.1	0.27
15	WYD/AMB/15	4.9	0.61	5.3	0.23

Sl No	Sample code	Before flood			After flood		
		OC %	P kg/ha	K kg/ha	OC %	P kg/ha	K kg/ha
1	WYD/AMB/1	1.35	19.60	192.42	1.62	28.00	254.6
2	WYD/AMB/2	1.43	61.60	380.46	0.01	30.24	421.01
3	WYD/AMB/3	1.35	42	116.6	0.02	5.60	393.72
4	WYD/AMB/4	1.59	123.2	226.8	0.05	14.00	702.24
5	WYD/AMB/5	1.43	36.40	867.22	0.95	28.00	519.01
6	WYD/AMB/6	1.67	58.80	496.16	0.06	22.40	364.112
7	WYD/AMB/7	1.35	33.60	193.31	0.06	19.60	248.64
8	WYD/AMB/8	1.19	42.00	188.83	0.01	28.00	162.29
9	WYD/AMB/9	0.56	19.6	285.15	0.08	30.80	198.58
10	WYD/AMB/10	1.72	8.4	554.85	0.05	30.80	228.7
11	WYD/AMB/11	1.83	28	416.08	0.01	25.20	110.9
12	WYD/AMB/12	1.03	25.20	314.72	0.57	22.40	103.49
13	WYD/AMB/13	2.31	33.60	246.51	0.06	44.80	137.54
14	WYD/AMB/14	1.11	30.80	317.41	0.01	28.00	176.86
15	WYD/AMB/15	1.91	162.4	303.07	0.01	114.80	297.81

2. Panamaram panchayat

Sl No	Sample code	Before flood		After flood	
		pH	EC	pH	EC
1	WYD/PNM/1	4.5	0.29	4.6	0.06
2	WYD/PNM/2	4.9	0.17	6.2	0.18
3	WYD/PNM/3	5.2	0.4	5.1	0.08
4	WYD/PNM/4	4.8	0.07	4.9	0.05
5	WYD/PNM/5	4.4	0.08	5.4	0.05
6	WYD/PNM/6	4.5	0.14	5.3	0.07
7	WYD/PNM/7	4.7	0.04	5.0	0.05
8	WYD/PNM/8	4.3	0.10	5.9	0.12
9	WYD/PNM/9	4.6	0.09	5.0	0.05
10	WYD/PNM/10	4.6	0.1	4.8	0.07
11	WYD/PNM/11	5.3	0.10	4.4	0.08
12	WYD/PNM/12	4.8	0.07	4.1	0.06
13	WYD/PNM/13	4.1	0.09	4.7	0.06
14	WYD/PNM/14	4.9	0.09	4.5	0.06
15	WYD/PNM/15	4.8	0.09	4.5	1.74

Sl No	Sample code	Before flood			After flood		
		OC %	P kg/ha	K kg/ha	OC %	P kg/ha	K kg/ha
1	WYD/PNM/1	0.56	78.40	62.16	1.21	11.20	176.064
2	WYD/PNM/2	1.11	19.60	232.62	1.59	89.60	318.75
3	WYD/PNM/3	0.29	19.60	398.61	2.27	50.40	178.86
4	WYD/PNM/4	1.03	16.80	104.72	0.98	72.80	154.896
5	WYD/PNM/5	1.38	89.6	121.74	0.98	44.80	322.78
6	WYD/PNM/6	2.39	25.20	601.22	1.97	28.00	433.33
7	WYD/PNM/7	2.06	36.4	107.63	2.04	50.40	219.3
8	WYD/PNM/8	1.17	103.60	339.47	3.93	22.40	184.45
9	WYD/PNM/9	1.47	22.4	553.06	2.04	22.40	138.21
10	WYD/PNM/10	2.06	42.00	193.98	2.35	70.00	172.82
11	WYD/PNM/11	1.63	95.20	271.26	2.95	42	301.62
12	WYD/PNM/12	1.99	16.80	546.22	1.89	53.20	160.94
13	WYD/PNM/13	1.21	14.00	299.38	1.89	78.40	155.68
14	WYD/PNM/14	1.47	19.60	510.16	1.74	33.60	123.312
15	WYD/PNM/15	0.26	18.35	205.62	1.36	112.00	156.35

3. Noolpuzha panchayat

Sl No	Sample code	Before flood		After flood	
		pH	EC	pH	EC
1	WYD/NLP/1	4.4	0.02	5.5	0.05
2	WYD/NLP/2	5.4	0.02	4.8	0.06
3	WYD/NLP/3	5.4	0.02	5.7	0.15
4	WYD/NLP/4	5.1	0.01	5.7	0.05
5	WYD/NLP/5	5.3	0.07	5.9	0.08
6	WYD/NLP/6	4.6	0.03	5.8	0.07
7	WYD/NLP/7	5.1	0.03	5.3	0.03

8	WYD/NLP/8	4.4	0.19	4.9	0.03
9	WYD/NLP/9	5.5	0.13	5.2	0.05
10	WYD/NLP/10	5.9	0.15	5.8	0.07
11	WYD/NLP/11	4.9	0.02	5.4	0.06
12	WYD/NLP/12	4.7	0.11	5.3	0.06
13	WYD/NLP/13	5.0	0.07	4.7	0.05
14	WYD/NLP/14	4.6	0.12	5.0	0.06
15	WYD/NLP/15	5.9	0.20	5.5	0.10

Sl No	Sample code	Before flood			After flood		
		OC %	P kg/ha	K kg/ha	OC %	P kg/ha	K kg/ha
1	WYD/NLP/1	0.04	10.91	122.18	0.15	67.20	153.55
2	WYD/NLP/2	0.03	8.48	95.03	0.23	47.60	228.70
3	WYD/NLP/3	0.03	8.89	99.56	3.10	42.00	363.78
4	WYD/NLP/4	0.02	5.13	57.50	0.01	145.60	180.32
5	WYD/NLP/5	2.90	42.00	503.77	0.76	70.00	460.32
6	WYD/NLP/6	6.06	16.13	180.62	0.61	42.00	288.62
7	WYD/NLP/7	0.04	12.41	138.95	0.05	67.20	236.32
8	WYD/NLP/8	0.35	98.68	652.30	0.45	22.40	323.68
9	WYD/NLP/9	0.18	49.59	555.37	0.23	16.80	117.6
10	WYD/NLP/10	0.30	83.36	933.59	1.59	25.20	245.50
11	WYD/NLP/11	0.03	9.35	104.73	0.53	98.00	817.72
12	WYD/NLP/12	0.18	51.06	571.98	2.87	33.60	190.62
13	WYD/NLP/13	0.11	30.55	342.11	0.91	19.60	284.03
14	WYD/NLP/14	0.20	55.97	626.85	1.29	19.60	157.14
15	WYD/NLP/15	0.27	75.44	844.92	0.98	2.80	264.32

4. Sulthan Bathery panchayat

Sl No	Sample code	Before flood		After flood	
		pH	EC	pH	EC
1	WYD/SBY/1	4.9	0.06	4.7	0.19
2	WYD/SBY/2	5.0	0.11	4.7	0.18
3	WYD/SBY/3	4.6	0.08	4.6	0.14
4	WYD/SBY/4	5.1	0.08	4.2	0.16
5	WYD/SBY/5	7.0	0.23	4.8	0.18
6	WYD/SBY/6	4.8	0.07	4.9	0.20
7	WYD/SBY/7	5.1	0.09	5.0	0.26
8	WYD/SBY/8	4.9	0.06	5.1	0.18
9	WYD/SBY/9	5.0	0.05	5.2	0.15
10	WYD/SBY/10	5.1	0.09	5.0	0.12
11	WYD/SBY/11	5.0	0.10	5.3	0.18
12	WYD/SBY/12	4.0	0.16	4.9	0.75
13	WYD/SBY/13	6.0	0.12	5.6	0.28
14	WYD/SBY/14	5.0	0.05	5.5	0.20
15	WYD/SBY/15	4.4	0.11	5.6	0.20

Sl No	Sample code	Before flood			After flood		
		OC %	P kg/ha	K kg/ha	OC %	P kg/ha	K kg/ha
1	WYD/SBY/1	1.02	54.00	195.36	0.03	25.20	103.49
2	WYD/SBY/2	1.59	48.26	219.74	1.62	25.20	134.51
3	WYD/SBY/3	1.66	52.23	243.26	0.04	84.00	350.45
4	WYD/SBY/4	3.46	35.26	414.40	0.57	26.80	507.13
5	WYD/SBY/5	0.59	26.35	256.32	0.01	19.60	170.13
6	WYD/SBY/6	1.04	58	185.40	0.19	11.20	275.63
7	WYD/SBY/7	1.52	24.00	214.52	1.43	11.20	374.08
8	WYD/SBY/8	1.22	123.20	413.39	0.03	50.40	439.15
9	WYD/SBY/9	1.07	40.6	566.16	0.02	11.20	427.84
10	WYD/SBY/10	2.01	10.5	124.56	3.99	8.40	103.2
11	WYD/SBY/11	0.58	18.20	254.20	0.38	22.40	522.26
12	WYD/SBY/12	2.95	45.26	445.76	2.57	14.00	162.06
13	WYD/SBY/13	0.78	35.26	245.32	1.62	210.00	184.13
14	WYD/SBY/14	1.3	162.4	522.62	0.02	22.40	230.38
15	WYD/SBY/15	1.57	11.20	185.58	3.04	72.80	264.09

pH and Electrical Conductivity & Macro Nutrients Status:

Acidity of the soils ranged from extremely acidic to slightly acidic. The value of pH showed increasing/decreasing trend while comparing the results. However in majority of the samples, post flood value of acidity showed a declining trend. In majority of the soil samples analysed after flood, pH value was 4.5 - 5.5. Value of EC showed very slight increase compared to preflood data. Organic carbon in majority of the samples was very low indicating the need for immediate replenishment, especially in Ambalavayal and Sulthan Bathery panchayats. While comparing with preflood samples, the available phosphorus and potassium showed increasing trend. However the rating of these nutrients in majority of the samples is in medium to high range. Wherever organic matter status is low, it should be replenished through organic matter application or Nitrogeneous fertilizer application.

IMPACT OF LANDSLIDE AFFECTED AREA

The area of study was massive land slide areas of Wayanad district.The details of landslides and slips occurred in the district is given below.

Table 5.11.3
Details of landslides and slips

Sl. no	Name of Local Body	landslide			landslip			land subsidence		
		No	Area (Acre)	No of. Families	No	Area (Acre)	No of. Families	No.	Area (Acre)	No of families
1	Thirunelly	1	3	4	-	-	-	11	167	249
2	Kalpetta (M)	1	12	9	8	8.1	65	02	02	17
3	Panamaram	-	-	-	2	0.3	2	5	03	10
4	Pozhuthana	11	243.5	82	5	39.5	19	-	-	-
5	Mananthavady(M)	4	20	40	6	4.6	12	06	10.5	18
6	Pulpally	-	-	-	1	01	2	-	-	-
7	Moopainad	-	-	-	30	2.35	49	1	0	49
8	Noolpuzha	-	-	-	1	0.05	1	-	-	-
9	Padinjarathara	4	10	24	2	2	6	-	-	-
10	Ambalavayal	-	-	-	7	0.7	17	-	-	-
11	Vythiri	16	31.37	35	40	18.9	45	2	0.42	0
12	Kottathara	-	-	-	10	3.74	9	1	-	1
13	Thariode	-	-	-	1	1	30	2	0.5	6
14	Vengapally	-	-	-	5	0.52	6	1	0.3	1
15	Vellamunda	-	-	-	11	1.71	24	3	2.5	4
16	Edavaka	-	-	-	4	0.4	2	1	2	1
17	Thondarnad	1	0.5	15	6	0.47	25	-	-	-
18	Muttil	3	4.5	2	-	-	-	1	0.5	2
19	Thavinjal	2	4	100	8	57	116	8	57	116
20	Meppadi	4	2.55	3	8	4.85	3	1	1	0

(Source: District Soil Conservation Office, Wayanad)

Surface Samples were collected from the landslide affected areas of the affected Panchayats of Wayanad district all of which are in Kabani river basin. Surface samples collected were analysed for fertility. The site characteristics of soil sampling locations are as follows

Table: 5.11.4
Site Characteristics

Sl.no	GPS Point	Panchayath	Slope %	Physiographic position	Topographic division	Present land use
WYD/LS/1	11 ^{0}35’ 24” 76 ^{0}04’ 04”	Vythiri	25	Central sahyadri high lands	Side slope	Coffee
WYD/LS/2	11 ^{0}33’ 11” 76 ^{0}02’ 20”		25		,,	Coffee, mixed
WYD/LS/3	11 ^{0}33’ 00” 76 ^{0}02’ 18”		25		,,	

WYD/LS/4	11 ^{0}33’ 02” 76 ^{0}02’ 17”		30		upper side slope	
WYD/LS/5	11 ^{0}32’ 04” 76 ^{0}01’ 03”		40	Mountainous region of Central Sahyadri	Shoulder slope	Forest
WYD/LS/6	11 ^{0}31’ 42” 76 ^{0}02’ 50”		50		Upper side slope	Coffee
WYD/LS/7	11 ^{0}31’ 46” 76 ^{0}02’ 41”		25	Central sahyadri high lands	Side slope	Coffee
WYD/LS/8	11 ^{0}33’ 08” 76 ^{0}00’ 05”	Pozhuthana	40	Mountainous region of Central Sahyadri	Side slope	Forest trees
WYD/LS/9	11 ^{0}33’ 19” 76 ^{0}00’ 30”		50		Side slope	Coffee mixed
WYD/LS/10	11 ^{0}36’ 14” 76 ^{0}04’ 04”		30		Side slope	Tea
WYD/LS/11	11 ^{0}36’ 21” 75 ^{0}59’ 38”		25		Side slope	Coffee
WYD/LS/12	11 ^{0}36’ 20” 75 ^{0}59’ 19”		>50		Side slope	Forest
WYD/LS/13	11 ^{0}36’ 39” 76 ^{0}59’ 23”		40		Side slope	Coffee
WYD/LS/14	11 ^{0}45’ 45” 76 ^{0}08’ 44”	Mananthavad y	45	Central sahyadri high lands	Side slope	Forest/ coffee
WYD/LS/15	11 ^{0}51’ 06” 76 ^{0}00’ 11”		25		Side slope	Forest
WYD/LS/16	11 ^{0}50’ 48” 76 ^{0}00’ 02”		25		Side slope	Coffee mixed
WYD/LS/17	11 ^{0}35’ 24” 76 ^{0}04’ 04”	Padinjarathar a	35		Side slope	Coffee, mixed
WYD/LS/18	11 ^{0}41’ 26” 75 ^{0}56’ 39”		30		Side slope	Rubber, coffee
WYD/LS/19	11 ^{0}37’ 28” 75 ^{0}59’ 36”	Thariode	25		Side slope	Forest
WYD/LS/20	11 ^{0}50’ 55” 76 ^{0}50’ 53”	Thirunelly	45		Side slope	Coffee
WYD/LS/21	11 ^{0}51’ 05” 76 ^{0}00’ 42”		25		Side slope	Forest
WYD/LS/22	11 ^{0}53’ 12” 76 ^{0}02’ 17”		25		Shoulder slope	Coffee
WYD/LS/23	11 ^{0}38’ 58” 76 ^{0}09’ 08”	Muttil	45		Side slope	Coffee,
WYD/LS/24	11 ^{0}37’ 34” 76 ^{0}06’ 06”		40		Side slope	Coffee estate
WYD/LS/25	11 ^{0}44’ 12” 76 ^{0}16’ 12”	Noolpuzha	20		Side slope	Arecanut, Coconut, pepper
WYD/LS/26	11 ^{0}36’ 06” 76 ^{0}04’ 16”	Kalpetta (M)	40		Side slope	--

WYD/LS/27	11 ^{0}34' 30" 76 ^{0}12' 55"	Ambalavayal	45		Side slope	Arecanut, coffee
WYD/LS/28	11 ^{0}34' 29" 76 ^{0}12' 37"		45		Side slope	Coffee

On reviewing the table, it is observed that the landslides were occurred in areas having more than 20% - 50% slope. Majority of landslides or slips occurred at 25-35% slope. The land use of the area ranges from arecanut, coconut intercropping to plantation crops and forests. Side slopes or shoulder slopes are seen susceptible to the distress.

PHYSICAL PROPERTIES

Physical properties such as texture, depth and general observations noticed are as follows.

Table 5.11.5

Physical characteristics

Sl. no	Sample code	Soil depth	Surface Texture (Feel method)	Elevation (m)	General observations
1	WYD/LS/1	Deep to very deep	Clay loam	784	Vellaramkunnu areas of Vythiri panchayath. The cause of landslide is slope modification for construction of roads
2	WYD/LS/2		Sandy clay	769	,,
3	WYD/LS/3		Sandy clay loam	773	Vythiri area. Heavy debris and mud flow from forest. A two storied building was completely embedded in soil due to soil piping/soil subsidence.
4	WYD/LS/4		Sandy clay loam	780	,,
5	WYD/LS/5	Moderately shallow	Sandy clay loam	830	Pookode area of Vythiripanchayath. Landslide occurred in the upper reach, check dam constructed along the course of flow was ruptured and the increased flow resulted in the soil and vegetation loss, along the course of flow.
6	WYD/LS/6	Very deep	Clay loam	892	Thalipuzha, Vythiri panchayath. Mud slip as a result of destruction of retaining wall supporting the concrete road in the plantation.

					Heavy mud loss and deposition in the lower reaches
7	WYD/LS/7		Sandy clay loam	790	Thalipuzha, Vythiri panchayath. Landslide due to heavy flow from the forest. The profile contains gneissic boulders and stones.
8	WYD/LS/8	Moderately deep	Sandy clay loam	823	Sugandhagiri area of Pozhuthana panchayath. Very steep areas given to tribes as part of rehabilitation. Generally these areas are under forest trees. A small area is cultivated with coffee, cardamom, pepper etc. The soil in these areas has large boulders and stones in the sub surface and exposed granite rocks on the surface
9	WYD/LS/9		Clay loam	938	Same as above. A house was destructed due to land slide
10	WYD/LS/10		Clay loam	903	Kurichyarmala. Pozhuthana panchayath. Massive and largest landslide ever occurred in the district. The origin was in the forest. The debris and mud flow was carried to a distance of 4 km. The paddy fields and the lower slopes were completely silted by the debris. An area of 250 acres was lost.
11	WYD/LS/11		Loam	910	
12	WYD/LS/12		Clay loam	1069	
13	WYD/LS/13		Sandy clay	964	Settukunnu area of Pozhuthana panchayath. Landslide due to debris flow.
14	WYD/LS/14	Deep to very deep	Clay	933	Pancharakkolly, Mananthavady municipality. Land slide occured in the upper slope.
15	WYD/LS/15		Clay	842	Maniyankunnu , Mananthavady municipality, Slide occurred on top of the hill
16	WYD/LS/16		Sandy clay	810	Maniyankunnu , Mananthavady municipality, middle of the hill
17	WYD/LS/17		Clay loam	876	Kuttiyamvayal, Padinjarathara panchayath. Landslide in steep area due to heavy rain.
18	WYD/LS/18		Sandy clay loam	816	Cheriya Narippara, Padinjarathara panchayath
19	WYD/LS/19		Sandy clay loam	778	Road side along Vythiri-Padinjarathara- heavy land slip
20	WYD/LS/20		Clay loam	856	Thacharakolly, Thirunelli panchayath. Land slide due to

					heavy mass flow of soil and water
21	WYD/LS/21		Clay	865	Thrissilerry, Thirunally panchayath. Landslide from forest.
22	WYD/LS/22		Clay loam	801	Plamoola, Thirunelly panchayath. Land subsidence noticed in surrounding areas. Tribal colony houses were subsided to a depth of 3 m to 5 m. Almost all the houses in the areas are unfit for habitation.
23	WYD/LS/23	Deep to very deep	Sandy clay loam	769	Pakkianikunnu, Muttil panchayath. Land subsidence noticed in the surrounding areas.
24	WYD/LS/24		Sandy clay loam	951	Edappattikolppara, Muttil panchayath, Rock side estate;. Heavy land slide occured
25	WYD/LS/25		Sandy loam	762	Pallivayal, Noolpuzha panchayath adjoining forest area, Land slip occured, house destruction due to heavy fall of mud from top.
26	WYD/LS/26		Sandy clay loam	758	Chenamala colony, Kalpetta (M), Land slip causing destruction of houses.
27	WYD/LS/27		Sandy clay loam	833	Thomattuchal, Ambalavayal panchayath, landslip.
28	WYD/LS/28		Sandy clay loam	903	Kattikolly, Ambalavayalpanchayath, land slip, lost 15 cents

Regarding soil texture, sandy clay loam predominates the samples collected from the affected area. In most cases, parent material mixed with weathered rocks are exposed showing a silty nature.

PHYSIOGRAPHY AND LANSCAPE CHANGES

In general due to heavy wash out from top, slope length has increased in landslide/slip areas. In areas like Melmuri, origin of land slide in Kurchyarmalai hills of Pozhuthana panchayath, as a result of heavy wash out, the bed rock has been exposed causing heavy loss of surface and sub surface layers. The erosion status has changed from moderate to severe.

Due to intense deposition of silt, sand and debris,soil depth has considerably changed in lower reaches. Heavy crop loss has occurred due to flooding in the lower reaches of Pozhuthana, Kottathara, Panamaram, and Kalpetta municipality.

Paddy is the major crop affected. Apart from this, banana and arecanut which are cultivated in foot and toe slopes of hills were also seriously affected.

Plantation crops are also facing serious threat due to land slide and landslips, which in turn is affecting the livelihood of the people and economy of the state. Acres of Tea have been lost not only in big plantations of HML, but also under individual holdings. Bearing coffee gardens are damaged in Pozhuthana, Vythiri, Mananthavady, Thirunelly panchayaths and Kalpetta Municipality.

Table 5.11.6
Soil Series identified in the Landslide area

Sl.no	Soil Series identified	Physiographic unit	Panchayaths
1	Meenangadi	**Wayanad Plateau -3**-strongly sloping to steep side slopes of isolated high hills with slope range from 10-33%, at an elevation 600-600 m above MSL	Ambalavayal, Muttil, Meppadi
2	Anchukunnu		Mananthavady, Vengapally, Panamaram
3	Puliyarmala		Kalpetta, Pozhuthana,
4	Manathavady		Manathavady, Thavinjal, thirunally, Thondarnad
5	Palvelicham		
6	Kurichyarmala	**Central Sahyadri-2**- strongly sloping to very steep isolated hillocks with elongated ridges and denudational rocky phase slope ranging from 10-50 %at an elevation of 900-1200 M above MSL	Pozhuthana
7	Vellaramkunnu		Vythiri, Pozhuthana, Mananthavady
8	Periya	**Mountainous region of central Sahyadiri (M R)** elevation above 1200 meters, including summit sites, rocky cliffs, escarpments, having slope percentage more than 40.	Thirunelly, Thavinjal, Thondarnad, mananthavady
9	Lakkidi		Vythiri

SERIES IDENTIFIED IN THE LANDSLIDE AREAS OF WAYANAD DISTRICT

1 . KURICHYARMALA

The massive landslide occurred on August 9^{th} 2018. The area comes in Pozhuthana panchayath, Kalpetta Block, Vythiri taluk. The series identified are Kurichyamala series and Madakkunnu series.

a. Madakkunnu Series

Madakkunnu soils are moderately deep having reddish brown to dark reddish brown strongly acid to slightly acid sandy clay loam to clay loam A horizon and red to dark reddish brown very strongly acid to strongly acid sandy clay loam to clay loam B horizon. Gravelly layer is frequented in the upper part of the B horizon. These soils are well drained with moderate permeability. They are formed on gneissic rocks on moderately sloping to steep hill slopes in the western part in Wayanad district, at an elevation of 600 to 900 m above MSL. The thickness of the solum is 50 to 85 cm resting on granite gneiss.

b. Kurichyarmala Series

Kurichyarmala soils have dark brown very strongly acid gravelly sandy clay loam to clay A horizon and dark reddish brown to strong brown very strongly acid to strongly acid clay loam to clay B horizons. These soils are formed on granite gneiss on the summits and shoulder slopes of steep hills in Wayanad district, at an elevation of 900 to 1500 m above MSL. These soils are well drained with moderate permeability.

2. VELLARAMKUNNU (VYTHIRI PANCHAYATH)

The cause of landslide is due to unscientific slope modification for road construction.

Vellaramkunnu Series

Vellaramkunnu soils are formed on charnockite and biotite gneiss on moderately sloping to steep hills in Wayanad district, at an elevation of 700 to 900 m above MSL. The thickness of the solum is more than 150 cm. The A horizon is 8 to 10 cm thick. The texture is sandy clay loam to clay. The B horizon is more than 140 cm thick. The texture is sandy clay loam to clay. Generally a few gravels are noticed in the profile. Well drained with moderately slow to slow permeability.

3. POOKODE, THALIPUZHA

Areas located in Vythiri panchayath. Landslide occurred in the upper reaches, check dam constructed along the course of flow was ruptured and the increased flow resulted in the soil and vegetation loss along the course of flow. In Thalipuzha, Vythiri panchayath, mud slip as a result of destruction of retaining wall supporting the concrete road in the plantation. Heavy mud flow and deposition in the lower reach-Repitition.. Major soil series are Vellaramkunnu, Puliyarmala and Lakkidi series.

a. Puliyarmala Series

Puliyarmala soils are formed on gneissic material on moderately sloping to steep lands in Wayanad district, at an elevation of 600 to 900 m above MSL. The thickness of the solum is 150 to 180 cm resting on gneiss parent material .The A horizon is 10 to 15 cm thick. Its colour is in hue 7.5 YR and 10 YR, value 3 to 2.5 and chroma 2 to 3. The texture is sandy loam to sandy clay loam. The B horizon is 165 to 170 cm thick. Its colour is in hue 7.5 YR and 10 YR, value 3 to 6 and chroma 3 to 8. The texture is sandy clay to clay. Gravels and cobbles are present in pockets at different depths in some profiles. (Averege less than 35%). These soils are well drained with rapid permeability

b. Lakkidi Series

Lakkidi soils are moderately deep forest soils formed on gneissic material on strongly sloping to steep isolated hillocks with elongated ridges and denudational rocky phase ranging from 10-33 % slopes of Wayanad district, at an elevation of 900 to 1200 m above MSL. Solum rests on gneiss at a depth of 90cm. The A horizon is 10 to 15 cm thick. Its colour is yellowish red in hue 5YR value 5 and chroma 6 to 8. The texture is sandy clay loam and is very strongly acidic. The B horizon is less than 90 cm thick. Its colour ranges from yellowish red to reddish yellow in hue 5YR, value 5 and chroma 6 to 8. The texture is sandy clay to gravelly clay. They are very strongly acidic in reaction. Excessively drained with moderately rapid permeability. The soils are under grass cover. Erosion and run off are likely to trigger when disturbed . In areas where scientific soil and water conservation measures are not practiced, these soils show a tendency to slip off when disturbed. Care should be taken while planning interventions in this area.

4. PANCHARAKOLLI, MANIYAKUNNU AREAS

These areas are included in Mananthavady Municipality, Mananthavady taluk. Series identified are Palvelicham, Anchukunnu and Periya series.

a. Palvelicham Series

Palvelicham soils are formed on charnockite and biotite gneiss on moderately sloping to very steep hills in Wayanad district, at an elevation of 700 m to 900 m above MSL. The thickness of the solum is more than 150 cm. The A horizon is 50 to 55 cm thick. Its colour is in hue 7.5 YR and 10 YR, value 3 to 5 and chroma 2 to 6. The texture is sandy clay loam to gravelly clay. The B horizon is more than 100 cm thick. Its colour is in hue 2.5 YR to 7.5 YR, value 3 and chroma 3 to 4. The texture is gravelly clay loam to clay. Gravels, stones and boulders are noticed in the B horizon. The content of coarse material decreases towards the lower part of the profile. Well drained with moderate permeability.

b. Anjukunnu Series

Anjukunnu soils are formed on charnockite and biotite gneiss on moderately sloping to steep hills in Wayanad district, at an elevation of 700 to 900 m above MSL. The thickness of the solum is more than 200 cm. The A horizon is 40 to 50 cm thick. The texture is gravelly loam to gravelly clay. The B horizon is more than 150 cm thick. The texture is gravelly clay loam to gravelly clay. Fine gravels are generally noticed in the profile. Well drained with moderate permeability

c. Periya Series

Periya soils are developed from gneissic parent material occurring on steeply sloping to very steep hills in Wayanad district, at an elevation of 900-1200 m above MSL. The thickness of the solum is 175 cm. A layer of O horizon with thickness 3 cm is present. The A horizon is less than 20 cm thick. Its colour is in hue 10YR, value 3 and chroma 4. The texture is sandy clay loam and is very strongly acidic in reaction. The B horizon is more than 150 cm thick. Its colour is in hue 7.5 YR, value 3 to 4 and chroma 6. The texture is gravelly clay and strongly acidic in reaction. The soils are moderately well drained with moderately rapid to moderate permeability.

CHEMICAL PROPERTIES

Chemical properties such as pH, EC, macronutrients and physical properties like Water Holding Capacity of the soil samples collected from the landslide affected soils are as follows.

Table 5.11.7

pH, EC,WHC and Macronutrients

Sl no	Sample code	pH	EC	OC (%)	Av.P Kg/ha	Av.K Kg/ha	WHC
1	WYD/LS/1	4.6	0.02	0.71	78.40	75.71	67.70
2	WYD/LS/2	5.2	0.03	0.10	84.00	760.82	68.19
3	WYD/LS/3	4.8	0.03	2.48	103.60	117.38	67.64
4	WYD/LS/4	4.9	0.04	1.91	70.00	172.93	70.98
5	WYD/LS/5	4.9	0.02	1.35	86.80	145.38	54.46

6	WYD/LS/6	4.7	0.02	1.42	75.60	120.06	36.43
7	WYD/LS/7	4.6	0.02	1.13	75.60	189.17	67.92
8	WYD/LS/8	4.7	0.02	1.35	61.60	81.98	51.25
9	WYD/LS/9	4.6	0.02	2.13	58.80	85.90	57.95
10	WYD/LS/10	5.0	0.01	1.77	84.00	283.92	65.61
11	WYD/LS/11	4.9	0.02	1.56	92.40	159.94	57.51
12	WYD/LS/12	4.7	0.02	1.28	86.80	95.20	66.24
13	WYD/LS/13	4.4	0.02	1.28	64.40	137.20	62.16
14	WYD/LS/14	4.5	0.02	1.63	70.00	123.54	57.07
15	WYD/LS/15	4.4	0.02	1.28	70.00	85.23	72.70
16	WYD/LS/16	4.4	0.02	1.20	78.40	52.19	38.34
17	WYD/LS/17	4.6	0.02	0.70	19.60	125.78	49.25
18	WYD/LS/18	4.6	0.04	1.17	8.40	165.98	51.02
19	WYD/LS/19	4.6	0.02	0.23	28.00	169.12	59.21
20	WYD/LS/20	4.3	0.03	1.56	39.20	136.30	72.03
21	WYD/LS/21	4.3	0.02	0.001	16.80	86.46	79.25
22	WYD/LS/22	4.9	0.01	0.31	14.00	59.70	81.25
23	WYD/LS/23	5.2	0.09	1.32	16.80	865.3	61.8
24	WYD/LS/24	5.4	0.06	2.71	39.20	553.28	51.26
25	WYD/LS/25	4.5	0.06	0.86	5.60	102.82	21.60
26	WYD/LS/26	5.0	0.08	2.38	16.80	351.57	61.78
27	WYD/LS/27	4.9	0.05	0.92	39.20	872.63	51.02
28	WYD/LS/28	5.1	0.05	2.11	22.40	620.30	81.25
Secondary and micronutrients(in ppm)							
Sl no	Sample code	Fe	Mn	Zn	Cu	Ca	Mg
1	WYD/LS/1	17.76	4.58	0.25	1.53	20.39	9.21
2	WYD/LS/2	18.32	2.36	0.20	1.31	25.45	7.28
3	WYD/LS/3	14.05	1.59	0.21	1.36	19.08	16.51
4	WYD/LS/4	15.36	2.65	1.35	1.82	44.85	13.01
5	WYD/LS/5	14.92	3.65	0.21	1.35	19.24	12.92
6	WYD/LS/6	13.66	4.88	0.15	1.58	15.90	25.42
7	WYD/LS/7	24.65	2.34	0.33	1.27	22.42	21.91
8	WYD/LS/8	14.39	2.36	0.05	1.23	18.59	14.31
9	WYD/LS/9	36.02	1.29	10.09	0.84	21.08	16.27
10	WYD/LS/10	15.36	6.29	0.42	1.29	65.13	19.21
11	WYD/LS/11	14.69	2.32	0.08	2.03	19.96	16.27
12	WYD/LS/12	16.55	2.54	0.29	0.52	70.39	15.29
13	WYD/LS/13	15.08	3.85	0.42	0.26	30.23	44.73
14	WYD/LS/14	10.36	2.06	0.25	0.27	19.27	12.96
15	WYD/LS/15	7.69	3.21	0.26	1.45	18.97	3.37
16	WYD/LS/16	1.98	2.45	0.09	0.28	7.45	16.21
17	WYD/LS/17	40.72	15.22	0.1	3.38	**	**
18	WYD/LS/18	21.4	28.20	2.18	6.08	**	**
19	WYD/LS/19	128.2	15.50	0.9	4.88	**	**
20	WYD/LS/20	213.3	21.08	3.5	5.14	**	**
21	WYD/LS/21	36.4	23.50	0.96	3.62	**	**

22	WYD/LS/22	97.5	76.70	1.14	14.2	**	**
23	WYD/LS/23	30.64	27.60	3.0	1.57	**	**
24	WYD/LS/24	180.52	51.70	1.63	2.06	**	**
25	WYD/LS/25	110.01	63.30	4.7	0.98	**	**
26	WYD/LS/26	121.37	132.8	4.54	2.20	**	**
27	WYD/LS/27	35.62	39.30	2.63	1.96	**	**
28	WYD/LS/28	53.57	106.30	7.47	0.86	**	**

** Values not available

INTERPRETATIONS

Results of soil sample analysis revealed that the **pH of the area was reduced when compared to preflood conditions and the soils became extremely to strongly acidic.** The samples analysed from the land slide area shows a pH range of 4.3 to 5.4.

Organic carbon % also reduced compared to samples analyzed earlier from this area. The organic carbon content generally ranges from medium to high in landslide samples collected from wayanad district. Similarly the value of phosphorus generally ranges from medium to high.Potassium has a range from low to medium.

In most cases parent material mixed with weathered rocks are exposed. The water holding capacity of the analysed samples aremedium to high indicating good water storage- The samples are low in Available calcium, magnesium and Zinc.

Results of the study in Waynad district can be summarized as below.

- Avoid unscientific land excavations in areas having more than 25 % slope.
- Fragile zone should be strictly avoided while taking up construction activities.
- Stick on to the directions give by Disaster Management Authority, which is seldom practiced.
- Avoid soil erosion permitting crops in heavy slopes which needs frequent intercultural operation and heavy irrigation.
- Proper building rules must be formulated based on the landscape and elevation by each local body to avoid stress in the fragile zone
- Land use pattern of wet land must be restricted to paddy and vegetables.
- The inhabitants in and around dam catchment should be given prior intimation and awareness regarding opening of dam shutters.

Crown cracks developed in Valad Kunnathumal road

A road in Thacharakolly in Thirunelli grama panchayat
destroyed in a landslip.

land subsidence in Boys Town

LANDSLIDES IN WAYANAD DISTRICT

KOZHIKODE

Total Geographic Area : 2,34,641 Ha

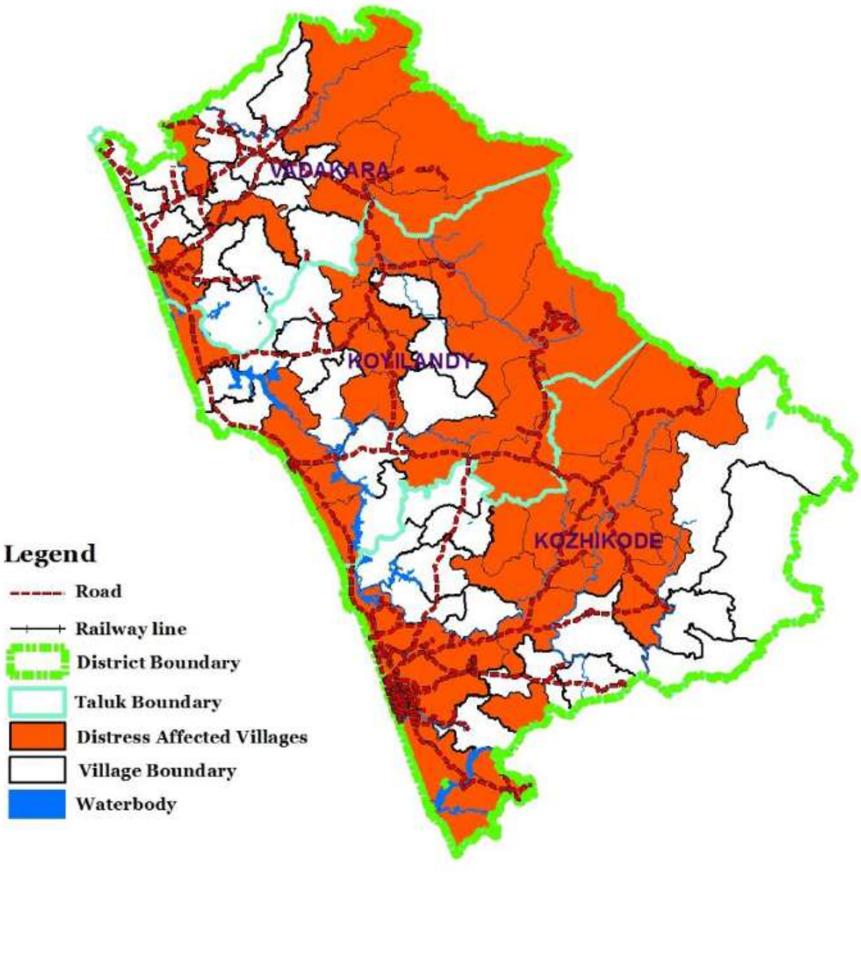
No. of Taluks : 4

No. of Villages : 107

RIVER BASINS

- *Chaliyar*
- *Kadalundi*
- *Kallayi*
- *Korapuzha*
- *Kuttiyadi*
- *Mahe*

DISTRESS AFFECTED VILLAGES



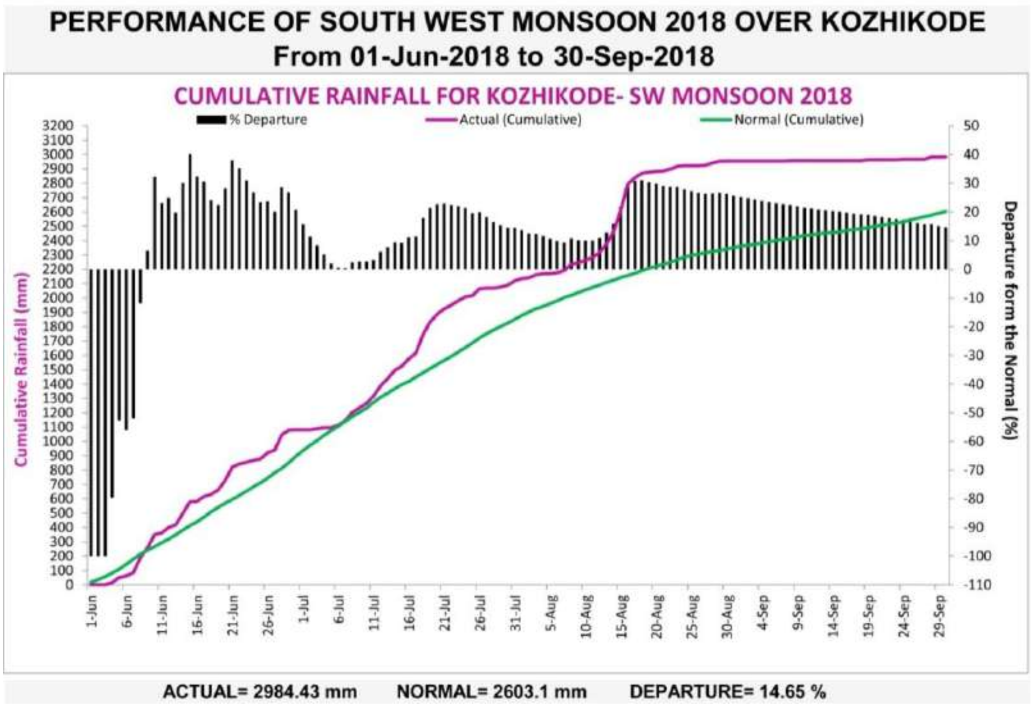
5.12. KOZHIKODE DISTRICT

Kozhikode district is situated on the northern part of Kerala State at a distance of about 400 km from the state capital. It is situated between north latitude 11^0 09' and 11^0 49' and east longitudes 75^0 32' and 76^0 09'. The district is bounded on the north by Kannur district, on the east by Wayanad district, on the south by Malappuram district and on the west by the Lakshadweep sea. The district extends over an area of 2,34,641ha.

The district consists of 4 taluks namely Badagara, Koyilandi, Thamarassery and Kozhikode. There are 118 villages in Kozhikode district.The district is drained by six rivers and their tributaries such as Mahe river, Kuttiady river, Korapuzha, Kallayi, Chaliyar and Kadalundi. Physiographically, Kozhikode district can be divided into five major physiographic units and they are lowland, midland, midupland, upland and highland.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

During the south west monsoon 2018, Kozhikode district received heavy rainfall from June to September causing devastating damages due to occurrence of floods and landslides in the district. The graph shown below that the district received 30% more rainfall during the period which aggravated the damages. The distress was very high from 10th to 20th August because of very high rainfall and the soil was fully saturated due to uninterrupted rainfall from june onwards.



Among the four taluks, all villages in Thamarassey taluk and 38 villages in Kozhikode taluk, 26 villages in Koyilandy taluk and 13 villages in Vatakara taluk are affected by either flood or landslide.

FIELD TRAVERSING AND SOIL SAMPLING

Field traversing of the affected area conducted to evaluate the changes in soil health with special reference to distress affected areas in Perumanna, Peruvayal, Mavoor, Chathamangalam, Kodiyathur, Mukkom, Karassery, Cheruvannur, Koothali, Chakkittappara, Changaroth, Nochad, Olavanna, Feroke, thiruvampadi, kodenchery, payyoli, thurayur, balussery, Kottur, panangad, Kozhikode corporation, Puthupadi, KattiparaPanchayats of the district.

Random soil samples were collected from identified sites while traversing from the flood and landslide affected areas. The depth of sampling was 30cm. A total number of 67 samples were collected from flood affected areas and 10 from Landslide affected areas. The samples were analysed for pH, EC, macro, secondary and micronutrients for flood samples, interpreted and comparison done with available results. The details of samples collected are presented in the table below. The sampling locations in the district are also shown in map

Table 5.12.1

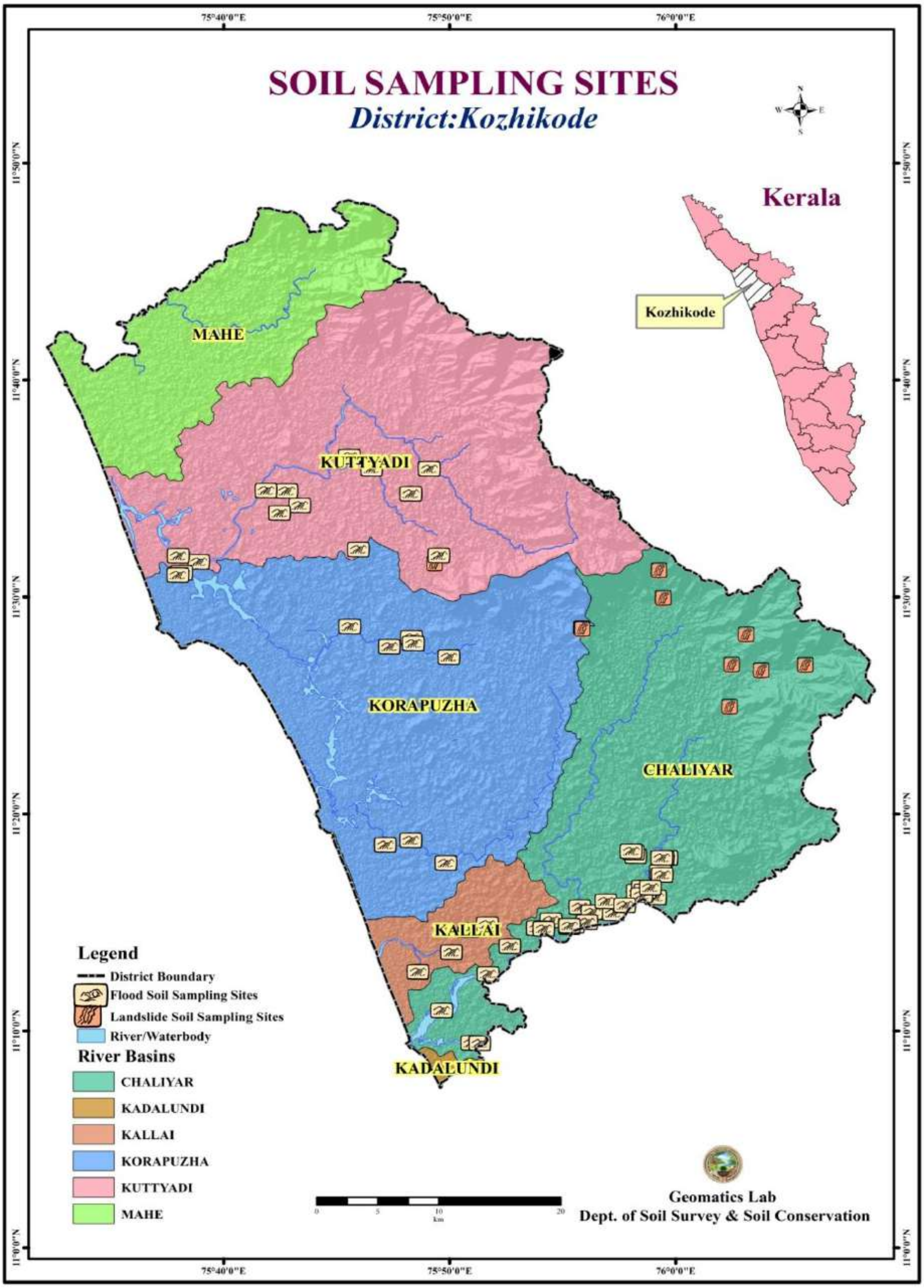
Sampling locations

Sample code	*Panchayat*	*Latitude/ Longitude*	*River basin*	*Distress affected*
KKD/NC/1	Mavoor	11°15’43”N 75°55’47”E	Chaliyar	Flood
KKD/NC/2	Peruvayal	11°15’6” N 75°54’30”E	Kallayi	Flood
KKD/NC/3	Mavoor	11°15’29” N 75°56’19”E	Chaliyar	Flood
KKD/NC/4	Mavoor	11°14’48” N 75°55’19”E	Chaliyar	Flood
KKD/NC/5	Perumanna	11°14’45” N 75°53’54”E	Chaliyar, Kallayi	Flood
KKD/NC/6	Chathamangalam	11°16’26” N 75°58’19”E	Chaliyar	Flood
KKD/NC/7	Mavoor	11°14’51” N 75°55’30”E	Chaliyar	Flood
KKD/NC/8	Kodiyathoor	11°17’14” N 75°59’24”E	Chaliyar	Flood
KKD/NC/9	Karasseri	11°17’59” N 75°59’38”E	Chaliyar	Flood

KKD/NC/10	Karasseri	11°17'58" N 75°59'28"E	Chaliyar	Flood
KKD/NC/11	Kizhakkoth	11°17'20" N 75°59'21"E	Korappuzha	Flood
KKD/NC/12	Mavoor	11°15'01" N 75°56'05"E	Chaliyar	Flood
KKD/NC/13	Kodiyatthoor	11°16'10" N 75°59'8"E	Chaliyar	Flood
KKD/NC/14	Feroke	11°17'12" N 75°59'25"E	Chaliyar	Flood
KKD/NC/15	Mavoor	11°14'51" N 75°55'19"E	Chaliyar	Flood
KKD/NC/16	Kodiyatthoor	11°16'37" N 75°58'33"E	Chaliyar	Flood
KKD/NC/17	Kodiyatthoor	11°18'18" N 75°58'03"E	Chaliyar	Flood
KKD/NC/18	Chatthamangalam	11°16'27" N 75°58'40"E	Chaliyar	Flood
KKD/NC/19	Mukkam	11°18'04" N 75°58'15"E	Chaliyar	Flood
KKD/NC/20	Balusseri	11°28'34" N 75°55'50"E	Korappuzha	Flood
KKD/NC/21	Chatthamangalam	11°16'16" N 75°58'31"E	Chaliyar	Flood
KKD/NC/22	Karassery	11°17'59" N 75°59'24"E	Chaliyar	Flood
KKD/NC/23	Peruvayal	11°14'43" N 75°54'11"E	Chaliyar	Flood
KKD/NC/24	Kodiyatthoor	11°16'37" N 75°58'54"E	Chaliyar	Flood
KKD/NC/25	Kodiyatthoor	11°18'14" N 75°58'09"E	Chaliyar	Flood
KKD/NC/26	Kodiyatthoor	11°18'18" N 75°58'03"E	Chaliyar	Flood
KKD/NC/27	Mavoor	11°15'26" N 75°57'16"E	Chaliyar	Flood
KKD/NC/28	Mavoor	11°15'59" N 75°56'56"E	Chaliyar	Flood
KKD/NC/29	Thurayoor	11°31'38" N 75°38'55"E	Kuttiyaadi	Flood
KKD/NC/30	Kayanna	11°31'33" N 75°49'20"E	Korappuzha	Flood
KKD/NC/31	Payyoli	11°31'07" N 75°38'10"E	Moorad	Flood
KKD/NC/32	Payyoli	11°14'51" N 75°55'19"E	Moorad	Flood
KKD/NC/33	Chakkittappara	11°35'55" N 75°49'07"E	Kuttiyaadi	Flood
KKD/NC/34	Koothali	11°34'46" N	Kuttiyaadi	Flood

		75°47'7.8"E		
KKD/NC/35	Cheruvannur	11°34'55"N 75°41'54"E	Kuttiyaadi	Flood
KKD/NC/36	Cheruvannur	11°34'54"N 75°42'49"E	Kuttiyaadi	Flood
KKD/NC/37	Koyilandi	11°34'55" N 75°41'54"E	Moorad	Flood
KKD/NC/38	Changarotth	11°36'29" N 75°45'35"E	Kuttiyaadi	Flood
KKD/NC/39	Changarotth	11°35'55" N 75°46'34"E	Kuttiyaadi	Flood
KKD/NC/40	Chakkittappara	11°34'55" N 75°41'54"E	Kuttiyadi	Flood
KKD/NC/41	Cheruvannur	11°34'14" N 75°43'24"E	Kuttiyaadi	Flood
KKD/NC/42	Cheruvannur	11°33'53" N 75°42'30"E	Kuttiyaadi	Flood
KKD/NC/43	Kayanna	11°31'55" N 75°49'33"E	Korappuzha	Flood
KKD/NC/44	Mavoor	11°15'48" N 75°57'46"E	Chaliyar	Flood
KKD/NC/45	Nuchhad	11°32'12" N 75°45'59"E	Kuttiyaadi	Flood
KKD/NC/46	Olavanna	11°13'38" N 75°50'06"E	Chaliyaar	Flood
KKD/NC/47	Thurayoor	11°31'54" N 75°38'01"E	Moorad	Flood
KKD/NC/48	Perumanna	11°14'39" N 75°50'52"E	Chaliyar	Flood
KKD/NC/49	Olavanna	11°12'38" N 75°51'43"E	Chaliyar	Flood
KKD/NC/50	Olavanna	11°14'55" N 75°51'41"E	Chaliyar	Flood
KKD/NC/51	Feroke	11°09'27" N 75°51'00"E	Chaliyar	Flood
KKD/NC/52	Cheruvannur	11°10'57" N 75°49'40"E	Chaliyar	Flood
KKD/NC/53	Olavanna	11°13'55" N 75°52'41"E	Chaliyar	Flood
KKD/NC/54	Feroke	11°09'26" N 75°51'21"E	Chaliyar	Flood
KKD/NC/55	Cheruvannur	11°12'44" N 75°48'37"E	Kallayi	Flood
KKD/NC/56	Kottoor	11°28'08" N 75°48'20"E	Korappuzha	Flood
KKD/NC/57	Balusseri	11°27'43" N 75°47'21"E	Korappuzha	Flood
KKD/NC/58	Kozhikode	11°18'35" N 75°47'10"E	Poonoor	Flood

KKD/NC/59	Kozhikode	11°18’48” N 75°48’18”E	Poonoor	Flood
KKD/NC/60	Panangad	11°27’14” N 75°49’59”E	Korappuzha	Flood
KKD/NC/61	Puthuppadi	11°29’58” N 75°59’26”E	Chaliyar	Land Slide
KKD/NC/62	Naduvannur	11°28’39” N 75°45’36”E	Korappuzha	Flood
KKD/NC/63	Kodanjeri	11°28’17” N 76°03’07”E	Chaliyar	Land Slide
KKD/NC/64	Puthuppadi	11°29’58” N 75°59’27”E	Chaliyar	Land Slide
KKD/NC/65	Kattippara	11°26’38” N 76°03’47”E	Poonoor	Land Slide
KKD/NC/66	Thiruvambadi	11°26’52” N 76°05’44”E	Chaliyar	Land Slide
KKD/NC/67	Thiruvambadi	11°26’52” N 76°05’44”E	Chaliyar	Land Slide
KKD/NC/68	Kattippara	11°28’34” N 75°55’50”E	Korappuzha	Land Slide
KKD/NC/69	Thiruvambadi	11°24’57” N 76°02’23”E	Chaliyar	Land Slide
KKD/NC/70	Thiruvambadi	11°27’10” N 76°51’56”E	Chaliyar	Land Slide
KKD/NC/71	Payyoli	11°31’01” N 75°38’00”E	Moorad	Land Slide
KKD/NC/72	Thiruvambadi	11°27’10” N 76°51’56”E	Chaliyar	Land Slide
KKD/NC/73	Puthuppadi	11°31’14” N 75°59’16”E	Chaliyar	Land Slide
KKD/NC/74	Koodaranji	11°26’ 53”N 76°02’29”E	Chaliyar	Land Slide
KKD/NC/75	Panangad	11°27’52” N 75°48’25”E	Korappuzha	Flood
KKD/NC/76	Kozhikode	11°17’45” N 75°49’51”E	Chaliyar	Flood
KKD/NC/77	Kattippara	11°28’32” N 75°55’52”E	Korappuzha	Flood



SOIL SAMPLING SITES
District:Kozhikode
Kerala
Kozhikode
MAHE
KUTTYADI
KORAPUZHA
CHALIYAR
KALLAI
KADALUNDI
75°40'0"E
75°50'0"E
76°0'0"E
11°50'0"N
11°40'0"N
11°30'0"N
11°20'0"N
11°10'0"N
11°0'0"N
Legend
District Boundary
Flood Soil Sampling Sites
Landslide Soil Sampling Sites
River/Waterbody
River Basins
CHALIYAR
KADALUNDI
KALLAI
KORAPUZHA
KUTTYADI
MAHE
0 5 10 20
km
Geomatics Lab
Dept. of Soil Survey & Soil Conservation

Table 5.12.2

Site characteristics

Sample code	Physiography	Landform	Present land use	General observations
KKD/NC/1	Midland	Flood plains	Arecanut, Banana, Coconut	Silt Deposit About 1cm
KKD/NC/2	Midland	Foot slope	Coconut, Banana, Areacanut	No Silt Deposition
KKD/NC/3	Midland	Side slope	Coconut, Areacanut	No Silt Deposition
KKD/NC/4	Midland	Side slope	Coconut, Banana, Areacanut	No Silt Deposition
KKD/NC/5	Midland	Flood plains	Banana	Silt Deposit About 3cm
KKD/NC/6	Midland	Flood plains	Areacanut	No Silt Deposition
KKD/NC/7	Midland	Flood plains	Banana	Silt Deposit About 3cm
KKD/NC/8	Midland	Riverbank	Coconut,Banana, Areacanut	No Silt Deposition
KKD/NC/9	Midland	Flood plains	Banana	No Silt Deposition
KKD/NC/10	Midland	Side slope	Banana	No Silt Deposition
KKD/NC/11	Midland	River Bank	Coconut	Silt Deposition
KKD/NC/12	Midland	Flood plains	Coconut, Banana, Areacanut	No Silt Deposition
KKD/NC/13	Midland	Flood plains	Banana	Silt Deposition 2cm
KKD/NC/14	Midland	Lowland	Coconut	Silt Deposition
KKD/NC/15	Midupland	Side slope	Coconut, Cashew	Silt Deposit About 1m And About 1 Acre of Land destroyed
KKD/NC/16	Midland	Flood plains	Coconut, Banana	No Silt Deposition
KKD/NC/17	Midland	Flood plains	Coconut	Silt Deposition
KKD/NC/18	Midland	Flood plains	Banana, Arecanut	Surface Cracks Observed
KKD/NC/19	Midland	Flood plains	Banana	No Silt Deposition
KKD/NC/20	Midland	Flood Plains	Arecanut	No Silt Deposition
KKD/NC/21	Midland	Flood plains	Arecanut	Silt Deposition
KKD/NC/22	Midland	Flood plains	Banana	Silt Deposition About 7cm
KKD/NC/23	Midland	Flood plains	Paddy	Silt Deposit Of 2cm
KKD/NC/24	Midland	Flood plains	Coconut	Sand Deposition
KKD/NC/25	Midland	Flood plains	Coconut	No Silt Deposition
KKD/NC/26	Midland	Flood plains	Banana	No Silt Deposition
KKD/NC/27	Midland	Side Slope	Arecanut, Coconut	Silt Deposition About 2cm
KKD/NC/28	Midland	Side Slope	Coconut	No Silt Deposition
KKD/NC/29	Midland	Flood Plain	Coconut	No Silt Deposition
KKD/NC/30	Midland	Flood Plain	Coconut	No Silt Deposition

KKD/NC/31	Lowland	Flood plain	Banana	Silt Deposition
KKD/NC/32	Midland	Flood plain	Banana	No Silt Deposition
KKD/NC/33	Midland	Flood Plain	Fallow	No Silt Deposition
KKD/NC/34	Midland	River Bank	Coconut, Arecanut	No Silt Deposition
KKD/NC/35	Midland	Side Slope	Coconut	No Silt Deposition
KKD/NC/36	Midland	Flood Plain	Paddy	No Silt Deposition
KKD/NC/37	Lowland	Flood Plain	Banana	No Silt Deposition
KKD/NC/38	Midland	Flood Plain	Coconut, Arecanut, Banana	No Silt Deposition
KKD/NC/39	Midland	Flood Plain	Coconut, Arecanut, Banana	No Silt Deposition
KKD/NC/40	Midland	Flood Plain	Coconut , Arecanut	Silt Deposition
KKD/NC/41	Midland	Side Slope	Coconut	No Silt Deposition
KKD/NC/42	Midland	Side Slope	Coconut, Arecanut, Banana	No Silt Deposition
KKD/NC/43	Upland	Side Slope	Rubber	No Silt Deposition
KKD/NC/44	Midland	Flood Plain	Paddy	Silt Deposition About 2cm
KKD/NC/45	Midland	Flood Plain	Paddy	No Silt Deposition
KKD/NC/46	Lowland	Flood Plain	Coconut , Jackfruit	No Silt Deposition
KKD/NC/47	Midland	Flood Plain	Coconut	No Silt Deposition
KKD/NC/48	Midland	Flood Plain	Coconut	No Silt Deposition
KKD/NC/49	Lowland	Flood Plain	Coconut, Banana	No Silt Deposition
KKD/NC/50	Lowland	Flood Plain	Coconut	No Silt Deposition
KKD/NC/51	Lowland	Flood Plain	Coconut	No Silt Deposition
KKD/NC/52	Lowland	Flood Plain	Fallow	No Silt Deposition
KKD/NC/53	Lowland	Flood plain	Coconut	No Silt Deposition
KKD/NC/54	Lowland	Flood Plain	Coconut	Silt Deposition
KKD/NC/55	Lowland	Flood Plain	Coconut	No Silt Deposition
KKD/NC/56	Midland	Flood Plain	Coconut ,Banana	No Silt Deposition
KKD/NC/57	Midland	Flood Plain	Banana	No Silt Deposition
KKD/NC/58	Midland	Flood plain	Coconut, Arecanut	Sand Deposition About 1cm
KKD/NC/59	Midland	Side Slope	coconut	Sand Deposition About 2cm
KKD/NC/60	Midland	Flood Plain	Banana, coconut	No Silt Deposition
KKD/NC/61	Midupland	Side Slope	Coconut, Arecanut	Soil Erosion About 1cm depth
KKD/NC/62	Midland	Flood Plain	Banana	No Silt Deposition
KKD/NC/63	Midupland	Side Slop	Coconut, Rubber	Rock And Mud Deposition
KKD/NC/64	Midupland	Side Slope	Coconut, Arecanut	Soil And rock Deposition
KKD/NC/65	Midupland	Side Slope	Rubber, Coconut	Mud And Rock Deposition

KKD/NC/66	Midupland	Side Slope	Arecanut, Rubber	Rock and Soil Deposition
KKD/NC/67	Midupland	Side Slope	Arecanut, Rubber	No Silt Deposition
KKD/NC/68	Midupland	Side Slope	Rubber, Coconut	Soil And Rock Deposition
KKD/NC/69	Midupland	Side Slope	Arecanut, Coconut	Rock And Mud Deposition
KKD/NC/70	Midupland	Side Slope	Arecanut, Rubber	Soil Deposition About 2mtr
KKD/NC/71	Midland	Flood Plain	Banana	No Silt Deposition
KKD/NC/72	Midupland	Side Slope	Arecanut, Rubber	Soil Deposition About 8mtr
KKD/NC/73	Midupland	Side Slope	Coconut, Arecanut	Rock And Soil Deposition
KKD/NC/74	Highland	Side Slope	Rubber	Boulders Deposited
KKD/NC/75	Midland	Flood Plain	Coconut	No Silt Deposition
KKD/NC/76	Midland	Flood plain	Coconut	No Silt Deposition
KKD/NC/77	Mid upland	Side Slope	Rubber	Silt Deposition

CHANGES IN THE DISTRESS AFFECTED AREAS

Physiography and Landscape

In some of the flood affected areas, silt deposition was observed while in majority of flood affected areas, there was no observable change.

Physical and chemical properties of soils

Physical properties

Soil texture

Increase in clay content was noticed in most of the samples. However, silt and sand content was seen increased in some of the samples of flood affected areas.

Water holding capacity, Porosity

In some of the flood affected areas, water logging continued for a long time indicating that the soil permeability has decreased due to clay deposition.

Other Observations

Yellowing of crops mainly banana and arecanut are seen in flood affected areas, especially where these are planted in wetlands.

Soil crusting was observed in some of the wetland areas.

CHEMICAL PROPERTIES

The soil samples collected from the sites were analysed for the chemical properties and the results obtained were compared with available soil data which are given below

Table 5.12.3

pH & Electrical Conductivity

Sample code	pH		EC	
	Post flood	Preflood	Post flood	Preflood
KKD/NC/1	6.1	5.41	0.006	1.26
KKD/NC/2	5.5	5.3	0.008	0.04
KKD/NC/3	6.2	5.81	0.012	0.02
KKD/NC/4	5.2	5.81	0.012	0.02
KKD/NC/5	5.3	5.41	0.016	0.126
KKD/NC/6	5.6	4.8	0.01	0.06
KKD/NC/7	4.8	5.8	0.017	0.06
KKD/NC/8	5.8	5.4	0.02	0.56
KKD/NC/9	4.6	5.8	0.018	0.06
KKD/NC/10	6.2	5.3	0.015	0.04
KKD/NC/11	5.9	5.4	0.01	0.56
KKD/NC/12	5.5	5.41	0.011	0.126
KKD/NC/13	6.4	5.8	0.011	0.06
KKD/NC/14	5.8	5.4	0.022	0.56
KKD/NC/15	4.9	5.41	0.012	0.126
KKD/NC/16	5.9	5.8	0.039	0.06
KKD/NC/17	4.9	5.8	0.024	0.06
KKD/NC/18	4.9	5.8	0.195	0.06
KKD/NC/19	5	5.8	0.113	0.06
KKD/NC/20	5.2	5.8	0.008	0.06
KKD/NC/21	5.8	4.4	0.145	0.06

KKD/NC/22	5.3	5.8	0.086	0.06
KKD/NC/23	3.5	5.8	0.12	0.06
KKD/NC/24	6	5.8	0.158	0.06
KKD/NC/25	6.1	5.8	0.075	0.06
KKD/NC/26	6.3	5.8	0.017	0.06
KKD/NC/27	6.3	5.3	0.062	0.04
KKD/NC/28	5.2	5.3	0.01	0.04
KKD/NC/29	5.5	5.8	0.003	0.06
KKD/NC/30	5.2	5.8	0.003	0.06
KKD/NC/31	4.5	5.8	0.096	0.06
KKD/NC/32	3.4	5.8	1.003	0.06
KKD/NC/33	4.3	5.8	0.134	0.06
KKD/NC/34	5	5.8	0.024	0.06
KKD/NC/35	6	5.8	0.033	0.06
KKD/NC/36	5.2	5.4	0.004	0.56
KKD/NC/37	4.5	5.4	0.004	0.56
KKD/NC/38	5.3	5.8	0.004	0.06
KKD/NC/39	4.8	5.8	0.023	0.06
KKD/NC/40	5.7	5.8	0.011	0.06
KKD/NC/41	5.8	5.3	0.002	0.04
KKD/NC/42	5.8	5.3	0.025	0.04
KKD/NC/43	5.2	5.3	0.002	0.04
KKD/NC/44	4.7	5.4	0.033	0.56
KKD/NC/45	4.7	5.4	0.05	0.56
KKD/NC/46	5.6	5.8	0.002	0.06
KKD/NC/47	4.7	5.8	0.011	0.06
KKD/NC/48	5.2	6.13	0.008	0.017
KKD/NC/49	5.5	5.8	0.004	0.06
KKD/NC/50	4.3	5.8	0.003	0.06

KKD/NC/51	4.7	5.8	0.007	0.06
KKD/NC/52	5.2	5.8	0.016	0.06
KKD/NC/53	6.2	5.8	0.018	0.06
KKD/NC/54	5.1	5.8	0.009	0.06
KKD/NC/55	6.6	5.8	0.004	0.06
KKD/NC/56	5.4	5.8	0.006	0.06
KKD/NC/57	5.8	5.8	0.005	0.06
KKD/NC/58	5.3	5.8	0.009	0.06
KKD/NC/59	5.7	5.3	0.015	0.04
KKD/NC/60	5.4	5.8	0.013	0.06
KKD/NC/61	7.3	5.3	0.018	0.04
KKD/NC/62	5.6	5.8	0.024	0.06

On analysis of the post flood samples, 23 out of 62 samples analysed showed decrease in soil pH. In these samples pH decreased and thus increased the soil acidity. Acidity ranges from strongly to medium acid. In most of the area, farmers started cultivation after application of lime. Considering the electrical conductivity values of post flood samples, all the samples analysed showed reduction in values compared to preflood values and it is not a limiting factor for crop production in post flood samples.

Table 5.12.4

Macronutrients

Sample code	Org. carbon%		Avail. P (kg/ha)		Avai. K (kg/ha)	
	Post flood	Pre flood	Post flood	Pre flood	Post flood	Pre flood
KKD/NC/1	1.15	1.35	66.08	64.96	276.98	207.96
KKD/NC/2	1.09	0.69	41.44	20	129.58	112.1
KKD/NC/3	0.84	1.94	35.84	5.6	63.39	286.38
KKD/NC/4	0.62	1.94	33.6	5.6	71.68	286.38
KKD/NC/5	1.18	1.35	1.12	64.96	195.33	207.2
KKD/NC/6	1.34	0.45	1.12	18	129.7	117
KKD/NC/7	1.31	0.69	137.76	20	481.82	121
KKD/NC/8	0.84	1.64	39.2	10	874.94	132.1

KKD/NC/9	2.3	0.69	50.4	20	138.66	121
KKD/NC/10	1.21	0.69	110.88	20	711.2	122.3
KKD/NC/11	1.83	1.64	66.08	10	158.93	135.2
KKD/NC/12	0.59	1.35	40.32	64.96	61.26	207.2
KKD/NC/13	2.58	0.69	160.16	20	684.54	121
KKD/NC/14	2.02	1.64	5.6	10	148.29	23.1
KKD/NC/15	0.34	1.35	28	64.96	22.4	207.2
KKD/NC/16	1.37	0.69	51.52	20	218.51	122.5
KKD/NC/17	1.96	0.69	43.68	20	150.75	123.5
KKD/NC/18	0.87	0.69	4.48	20	172.03	121.6
KKD/NC/19	2.21	0.69	36.96	20	140.45	228
KKD/NC/20	1.68	0.69	54.88	20	630.11	224
KKD/NC/21	1.9	0.69	96.32	22	854.9	205
KKD/NC/22	3.2	0.69	29.12	20	82.43	211
KKD/NC/23	0.68	0.69	38.08	20	59.25	121
KKD/NC/24	0.62	0.69	6.72	20	98	121
KKD/NC/25	1.46	0.69	52.64	20	121.41	121
KKD/NC/26	1.06	0.69	42.56	20	75.71	121
KKD/NC/27	1.52	0.69	56	20	386.06	136
KKD/NC/28	2.58	0.69	35.84	20	81.2	124
KKD/NC/29	0.36	0.69	7.84	20	233.97	121.2
KKD/NC/30	2	0.69	39.2	20	77.17	129
KKD/NC/31	2	0.69	52.64	20	63.39	153
KKD/NC/32	0.36	0.69	33.6	20	175.17	121.5
KKD/NC/33	1.7	0.69	48.16	20	51.07	153
KKD/NC/34	0.73	0.69	4.48	20	191.07	153
KKD/NC/35	1.67	0.68	49.28	36.3	161.75	124
KKD/NC/36	0.67	1.41	41.44	42.1	272.61	163
KKD/NC/37	2.94	1.35	44.8	35.5	51.97	158
KKD/NC/38	1.3	0.69	26.88	20	232.62	145
KKD/NC/39	2.67	0.69	40.32	20	82.99	224
KKD/NC/40	1.09	0.69	1.12	20	140.34	221
KKD/NC/41	2.18	0.85	1.12	26.1	61.82	115
KKD/NC/42	1.06	0.61	39.2	25.2	159.04	180
KKD/NC/43	1.24	0.69	39.2	20	43.12	163
KKD/NC/44	0.85	1.64	42.56	10	147.73	224
KKD/NC/45	1.06	1.64	30.24	10	255.81	221
KKD/NC/46	0.48	0.69	51.52	20	208.1	152
KKD/NC/47	0.67	0.69	7.84	20	22.96	131
KKD/NC/48	1.24	1.86	71.68	13.44	106.51	261.86
KKD/NC/49	0.82	0.69	1.12	20	122.42	126.1

KKD/NC/50	2.64	0.69	1.12	20	251.78	214
KKD/NC/51	2.48	0.69	17.92	20	58.58	216
KKD/NC/52	2.27	0.69	4.48	20	572.77	220
KKD/NC/53	1.58	0.69	3.36	20	174.83	121
KKD/NC/54	0.73	0.69	1.12	20	73.47	230
KKD/NC/55	0.48	0.69	66.08	20	188.05	121
KKD/NC/56	0.64	0.69	10.08	20	113.46	201
KKD/NC/57	0.97	0.69	1.12	20	281.79	220
KKD/NC/58	1.12	0.69	8.96	20	82.66	121
KKD/NC/59	0.52	0.69	10.08	20	149.3	136
KKD/NC/60	1.97	0.69	6.72	20	168.34	136
KKD/NC/61	0.7	0.69	31.36	20	142.13	121
KKD/NC/62	0.94	0.69	1.12	20	299.38	136

Majority of the Post flood samples showed increase in Organic carbon % and available potassium while comparing the values of pre flood samples. Except few, majority of the samples are medium to high in organic carbon status, available phosphorus and potassium. Deficiency of potassium is seen in some samples collected from midland riverbank and side slopes. Organic matter content increased in 41 out of 62 samples analysed. Phosphorous content increased in 39 out of 62 samples while Potassium content increased in 36 out of 62 samples

Table 5.12.5

Secondary Nutrients & Micro Nutrients

Sample code	Available secondary micro nutrients (ppm)					
	S	B	Fe	Mn	Zn	Cu
KKD/NC/1	52.13	0.32	39.74	13.18	2.68	0.96
KKD/NC/2	0.63	0.02	34.9	19.7	3.78	1.88
KKD/NC/3	73.5	0.06	20.18	2.76	2.9	1.16
KKD/NC/4	63.25	0.1	31	10.82	4.02	1.58
KKD/NC/5	63.38	0.08	77.32	41.38	2.16	6.86
KKD/NC/6	61.63	0.16	78.42	40.62	1.54	5.22
KKD/NC/7	62.25	0.1	75.08	34.88	2.08	3.82

KKD/NC/8	38.88	0.1	79.3	43.16	2.64	3.26
KKD/NC/9	0.13	0.18	82.4	23.44	4.64	1.58
KKD/NC/10	0.13	0.3	47.92	20.72	0.52	0.2
KKD/NC/11	0.25	0.2	60.16	1.02	3.04	5.56
KKD/NC/12	0.13	0.14	89.78	18.64	1.08	8.28
KKD/NC/13	47.38	0.08	82.64	3.14	2.64	6.52
KKD/NC/14	39.5	0.1	79.3	21.06	3.7	3.18
KKD/NC/15	0.25	*	3.3	18.7	3.24	7.96
KKD/NC/16	0.13	*	78.06	14.58	3.64	4.72
KKD/NC/17	0.38	*	84.06	9.3	0.64	8.44
KKD/NC/18	51.38	*	56.64	24.54	0.66	10.28
KKD/NC/19	51.25	*	82.44	18.54	0.14	7.3
KKD/NC/20	0.13	*	80.78	20.66	1.98	2.64
KKD/NC/21	0.63	*	77.08	11.38	0.62	9.1
KKD/NC/22	0.13	*	58.64	12.68	0.64	0.42
KKD/NC/23	0.13	*	49.3	10.58	1.28	1.06
KKD/NC/24	0.25	*	44.78	10.88	1.24	1.58
KKD/NC/25	0.13	*	78.64	6.26	1.7	1.04
KKD/NC/26	0.25	*	47.3	18.36	1.08	0.92
KKD/NC/27	29.13	*	48.02	17.1	1.26	1.04
KKD/NC/28	23.13	*	59.54	24.04	0.9	0.98
KKD/NC/29	0.25	*	79.3	20.72	1.48	1.3
KKD/NC/30	0.13	0.08	47.28	9.26	1.32	1.04
KKD/NC/31	61.25	0.16	65.76	12.64	1.1	0.98
KKD/NC/32	0.13	0.1	58.44	10.56	0.68	1.06
KKD/NC/33	0.13	0.2	33.28	8.56	1.24	1.24
KKD/NC/34		0.14	30.44	17.96	1.48	0.94
KKD/NC/35	27.25	*	56.62	20.72	0.88	1.76
KKD/NC/36		*	29.32	16.44	1.3	1.3

KKD/NC/37	0.38	*	16.48	18.7	1.7	0.56
KKD/NC/38	0.5	*	45.64	22.72	1.76	1.3
KKD/NC/39	0.25	*	72.48	18.64	1.3	1.78
KKD/NC/40	0.13	*	46.72	16.48	1.32	1.04
KKD/NC/41	3.75	*	49.7	14.42	1.44	1.24
KKD/NC/42	22	*	24.96	15.59	1.08	3.78
KKD/NC/43	0.63	*	62.5	13.78	0.72	3.16
KKD/NC/44	0.13	0.32	122.58	3.36	1.38	4.14
KKD/NC/45	*	*	80.42	11.28	0.96	3.34
KKD/NC/46	*	*	80.26	21.62	3.7	3.14
KKD/NC/47	14.25	0.02	102.54	16.98	2.56	3.04
KKD/NC/48	*	0.08	93.28	7.42	1.76	3.16
KKD/NC/49	*	0.3	96.62	11.94	1.88	4.18
KKD/NC/50	*	*	105.7	19.38	5.08	4.48
KKD/NC/51	1	0.1	105.28	12.68	6.9	4.02
KKD/NC/52	92.63	0.1	88.8	25.34	11.02	7.7
KKD/NC/53	3.25	0.18	52.7	10.48	0.58	5.28
KKD/NC/54	*	*	22.29	3.88	1.28	0.9
KKD/NC/55	8.38	*	30.48	16.3	1.94	3.74
KKD/NC/56	1.5	*	23.88	13.24	0.52	0.28
KKD/NC/57	6.88	*	24.72	8.42	2.48	1.34
KKD/NC/58	15.38	*	45.06	10.14	3.5	1.12
KKD/NC/59	13.88	*	39.28	6.42	3.16	1.78
KKD/NC/60	2	0.06	28.36	9.64	0.82	0.92
KKD/NC/61	*	0.1	19.28	12.48	1.94	2.14
KKD/NC/62	4.13	*	15.52	15.82	3.46	2.38

*** Analytical results not available**

On analysing the results, sulphur deficiency is seen in some samples. B is also deficient in the soils analysed. Except one sample, iron is sufficient or at toxic level. The status of iron, manganese, zinc, copper in post flood samples are not limiting for successful crop production in majority of the samples.

IMPACT OF LANDSLIDES

In Kozhikode district, landslides occurred in many locations and heavy loss to life and property occurred. In Karassery panchayat the areas affected include Illythodu, Elampilassery, Thotakkadu, Mysorepatta and Mukkomkadavu accounting to 30 ha area. In the nearby Koodaranji panchayat the different locations including Kalpini, Udayagiri and Srambimala suffered landslides affecting 15 ha area. In Thiruvampadi panchayat Marippuzha, Muthappanpuzha, Punathil, Madrimoola, Olikkal, Chembukadavu, Karimbu, Poomarathumkolli and Thempara areas (18 ha) suffered damage. Kandappanchal Bridge approach road and shoulders also eroded due to heavy monsoon flood. Near Elanthukadavu Bridge river bank retaining wall and side road submerged and collapsed on 9th August 2018

Puduppadi panchayat was one of the worst affected panchayat and 18 ha area in Kannappankundu and Vanaparavam were damaged. The Pavukandi area (3ha) of Kotoor panchayat also witnessed landslide damage. In the Panangad panchayat, Thalayad, Kilikudukki, Mankayam, Tooradumala, Kanthalodemala and Chekidanparamala were the landslide affected locations (6ha). In the Kodenjeri panchayat, Chembukadavu, Nooramtodu, Kannappanchal, Koorotupara, Vattachovidu, Kinaritodu and Pathipara were the landslide affected areas (8 ha). Landslides occurred in Pannieri, Madancheri, Palur, Panom, Aduppil colony, Pannimalakunneil colony in the Vanimeel Panchayat (25 ha). In the Naripatta panchayat Valook, Udumbringimala, Mundomkandam (15ha) are the landslide affected areas. The Choorani and Pakranthalam locations in the Kavilumpara panchayat suffered landslide damage (15 ha). The Mavattom area of the Maruthonkara panchayat (5ha) also witnessed landslides. In the Kayanna panchayat, Uleri, Colony Mukukku and Cherukadu (2ha) were the affected areas. In the Koorachundu panchayat Vattachira, Poovathunchola and Illipilayikunnu (12 ha) suffered landslide damage. The worst landslide affected panchayat is Kattipara where the Karincholamala, Chamaltodu, Povanmala, KalvariandPlathotam (28ha) are the affected locations.

Some of the landslide affected sites included in our study are

1. Landslide in Puthuppady panchayat

Major damage was in Kannappankundu area. One person killed and 19 houses fully damaged and 94 houses partially damaged. The origin of landslide is at Eduthuvachakallu. Due to intense rainfall for 48 hours, the wet soil along with the big boulders and huge rocks slided from a height of 560 m in the forest area. The uprooted trees from Mattikunnu along the drainage lines fell off the severely sloping areas and along with rocks and boulders slipped to the lower areas. These rocks and boulders came through the river side and then ravaged into the cultivated areas at Mariyapuram and thus the river routes were diverted. These rocks and boulders along with water from the rivers destroyed the houses and shops in Kannappankundu town, the bridges were blocked with uprooted trees and huge rocks, thus the river got diverted from the main courses.

In chippilithode area landslide occurred on 13 June 2018 . About 3.5 m width (out of 7m) of the road fully collapsed to a depth of 10m affecting the Inter State vehicle traffic.

2. Landslides in Thiruvambady Panchayat

Landslide occurred in many locations in the panchayat affecting around 18 hectares of land. We studied the Marippuzha area of Thiruvambady Panchayat where landslides occur during the month of August. Heavy rainfall triggered the landslide and debris deposition of around 200m is seen. A bridge in the area collapsed. Crop loss includes banana and rubber. Around 1 ½ Kilometers away from this point, at higher altitude, there was another landslide near the forest area. Another 2 km from the Marippuzha area in the Muthappanpuzha tribal colony area, there was another landslide in the same month. Rocks and boulders were brought down and rock deposition was seen up to 50 cm height. In the same panchayat another landslide was observed near the Pathankayam hydroelectric project area. Boulders were deposited for around half Kilometer length. River bank retaining wall and side road submerged and collapsed

3. Landslide in Kodenchery panchayat

In this panchayat, landslide hit many locations bringing damage to about 8 hectares of land. In the Poovathumchode area of the panchayat, landslides occurred during August. Boulders were deposited upto 2m height. Minor landslide was observed in the Thusharagiri area. Soil deposition was seen in the area.

4. Landslide in Kattipara panchayat

Landslide occurred in Karincholamala area of Kattippara panchayat in the month of June. The Direction of landslide is north to south. Many landslides occurred at short intervals causing heavy loss in the area.An area of 6.2313 Ha was affected as a result of landslip that displaced 1, 24,626 tonnes of landmass. Boulders were deposited in the lower side. Destruction to houses and property was seen 4 houses were completely buried under the landmass which resulted in loss of 14 lives and 8 persons were injured.There was a water storage tank constructed in the Karinjola mala and this could have triggered the landslide.

Debris deposition in the depositional zone

In general, slope of the area changed, debris deposition hinders cultural operation in the depositional zone. Revenue authorities are taking action to remove the debris and sand deposits to make the land suitable for agricultural purposes. No samples were collected from landslide scar for comparative study.

In the landslide affected areas deposition of rocks and boulders in large quantity in the upper reaches and large quantity of sand deposits in the lower portion was observed.

SOILS IN LANDSLIDE AFECTED AREAS

In the landslide affected areas, as per the random study , it is understood that this upper layer of soils are comparatively coarser than the under fine textured layers which implies discontinuity of pores resulting in reduced drainage. Heavy rain occurred in the distress area for a long time promoting faster flow of water into the lower horizon which are high in clay and resulted in stagnation and water accumulation in the lower layers and thereby increasing hydrostatic pressure in the soils.

Most of the soil series encountered in the landslide area is with large boulders in the subsoil and the soil mass is resting on the bare gneissic rock, there is chance of sliding of the whole soil mass at increased pressure situation(on saturation). Under such situation the soil materials saturated with water developed into debris. The resulting slurry of rock and mud pick up trees, houses belongings and crops blocking roads and bridges. Improper earth work which altered the original slopes in the area, continuous cultivation of erosion permitting crops such as tapioca and annual crops, indiscriminate removal of natural vegetation especially deep rooted vegetation are the major contributing factors that affected the stability of land.

In the area minimum tillage should be allowed. Afforestation and adoption of geotextile technology is recommended for slope stabilisation. Construction works should be avoided in such fragile areas.

BRIF DESCRIPTION OF SOIL SERIES IN LANDSLIDE AREAS

In the landslide affected areas, major soil series identified are Pakranthalam, Thiruvambady, Koorachundu and Adivaram. In the forest area landslide occurred in Sankarampuzha, Kakkayam and Charangadsoils series. The brief description of soil series is given below.

Thiruvambadi Series

The soils of Thiruvampadi series are moderately shallow to moderately deep (60-100 cm), well drained, gravelly, red to dark red soils and strongly to very strongly acidic. These soils are formed as a result of weathering of gneissic rocks. They occur on moderately steep to steep upper slopes of denuded hills in the up lands with a slope gradient ranging from 10-33%.The general elevation is up to 600 m above MSL. These soils are well drained with moderate permeability.

They are moderately shallow to moderately deep (60-100cm), moderately coarse to fine textured soils with low fertility occurring on steep slopes and high susceptibility to erosion. Adequate manuring with nitrogen and potassium fertilizers will improve the nutrient status of these soils. Presence of stones and boulders in the sub soil restricts its use for common cultivated crops. It is better to utilize the land for social forestry or as grass land

Adivaram Series

Adivaram series represents deep to very deep, very strongly acidic, dark reddish brown to yellowish red soils developed from gneissic rock. The texture of the surface and subsoil ranges from gravelly clay loam to gravelly clay. These soils are located on moderately steep to steep side slopes of hills on miduplands and uplands with slope gradient above 20%. These soils are moderately well drained.

Due to their occurrence on moderately steep to steep side slopes, these soils are susceptible to moderate to severe erosion hazards and require proper soil conservation measures.

Pakranthalam Series

The soils of Pakranthalam series are very deep, excessively drained, mixed, brown and slightly acid. They occur on steep to very very steep denudational hills with slope gradient above 25%. Excessively drained with moderately rapid permeability.

Cultivated with rubber, coconut, arecanut and banana. The occurance in steep to very very steep slope, high amount of gravels, stone and builders restrict its economic use under annual food crops. They can be economically utilized for cash crops after adopting proper soil conservation measures.

Koorachundu Series

The soils of Koorachundu series are moderately shallow to moderately deep (50-100cm), clayey, reddish brown, medium to moderately fine textured soils and very strongly to strongly acidic. These soils are formed as a result of intense weathering of gneissic rocks. These soils are located strongly sloping to steep side slopes of hills on mid uplands and uplands with slope ranging from 10-33 %. The general elevation is 300-1200 m above MSL. The texture of the surface soil and subsoil ranges from gravelly clay loam to gravelly clay.

These soils are poorly drained with moderately slow permeability. Shallow rooting depth and steep slopes restrict its use for tree crops

In the forest area landslide occurred in Sankarampuzha, Kakkayam and Charangad soil series.

Sankarampuzha Series

Sankarampuzha series represents very deep, well drained, strongly acidic, dark reddish brown to reddish brown forest soils, developed from charnokite rocks on steep to very very steep side slopes of denudational hills with a general slope of above 25%. The texture of the surface soil and that of subsoil ranges from loam to clay with or without gneissic gravels. The general elevation is 300 to 1200m above. Climate is humid tropical. These soils are well drained with moderate permeability.

Though these are very deep, their occurrence on very steep to very very steep mountains makes it highly susceptible to erosion. They have to be retained under thick forest cover.

Kakkayam Series

Kakkayam series represent moderately fine, moderately deep soils with excessive drainage and strong acidity. These soils have dark reddish brown to dark brown surface horizon and brown to reddish yellow subsoil. The texture of the surface soil is sandy loam with or without gravels and that of subsoil is gravelly sandy loam to gravelly sandy clay loam. These soils are developed from charnockite and are located on strongly sloping to very steep slopes of denudational hills with slope above 15%. These soils are formed under humid tropical climate.These soils are excessively drained with rapid to very rapid permeability

Due to their occurrence in strongly sloping to very very steep side slopes these soils are susceptible to erosional hazards and should not be disturbed for normal agriculture practices. These soils are to be retained under forest vegetation.

Charangad Series

Charangad series represents very deep, well drained, very strongly acidic, dark reddish brown to yellowish red forest soils developed from charnockite rock. The texture of the surface soil is gravelly sandy clay loam to gravelly clay and the subsoil texture ranges from gravelly loam to gravelly clay. They occur on moderately steep to very steep side slopes of denudational hills with slope ranging from 15 to 50%.

Though they are very deep, their occurrence on steep side slopes of denudational hills make them highly susceptible to erosion. They have to be retained under thick forest cover.

The results of the study in Kozhikode district can be summarized as below

- The soils are acidic in nature and the acidity ranges from strongly to medium acid. Postflood samples showed increase in acidity
- In majority of the samples, Organic carbon, potassium and phosphorus status ranges from medium to high. Deficiency of available nitrogen, phosphorus and potassium is noticed in some locations. Hence application of these nutrients to be given based on soil test results.
- Deficiency of boron and sulphur are noticed in some of the samples analysed. Other micronutrients are adequate for crop production.

KANNUR

Total Geographic Area : 2,97,112 Ha

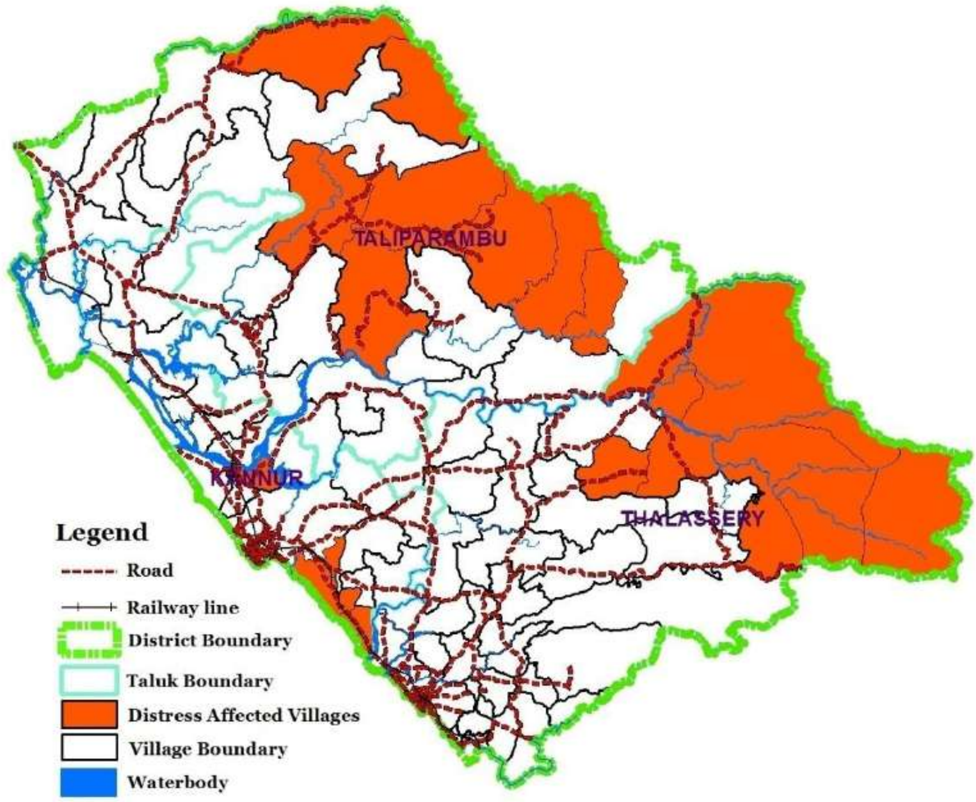
No. of Taluks : 5

No. of Villages : 132

RIVER BASINS

- *Anjarakandy*
- *Kariangode*
- *Kavvayi*
- *Kuppam*
- *Peruvamba*
- *Mahe*
- *Thalassery*
- *Valapattanam*
- *Ramapuram*

DISTRESS AFFECTED VILLAGES



5.13. KANNUR DISTRICT

Kannur district is bounded by the Western Ghats in East (Coorg district of Karnataka State), Kozhikode and Wayanad districts and Mahe on the South, Lakshadweep sea in the west and Kasaragod, on the North. The total geographical area of the district is 297112 ha.

Physiography

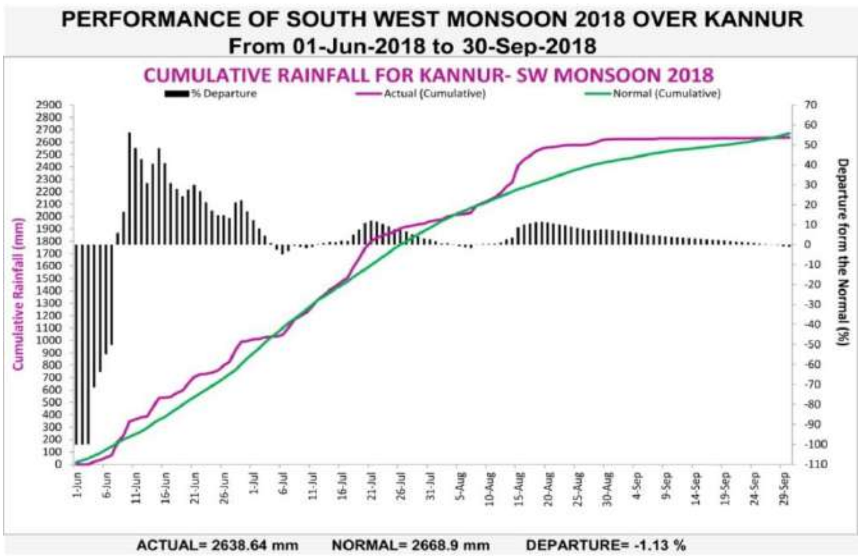
Kannur district is physiographically divided into three distinct geomorphologic units viz the coastal plains and lowlands in the western part, the central undulating terrain comprising the midland region and eastern highland region. The relief is normal to excessive.

Drainage

Kannur district is endowed with a fine river system. Most of the rivers are perennial. The district is mainly drained by the following rivers viz, Mahe, Thalassery puzha, Anjarakandy puzha, Valapattanam puzha, Kuppam puzha, Ramapuram puzha, Perumba puzha and Kariamkodu puzha. General drainage pattern in the upstream side of these rivers is dendritic.

RAINFALL PATTERN DURING THE DISTRESS PERIOD

On comparing the rainfall received during flood period with the normal, the district received rainfall almost equal to the normal cumulative rainfall. From the graph, it can be inferred that the rainfall received during Mid August is higher than normal which caused flood and landslide in the district. The heavy rain in August 2018 hit the district severely and cause widespread damage. Landslides, flood and strong winds caused agricultural and economic loss.



IMPACT OF DISTREES IN THE DISTRICT

Flood affected areas in the district

The taluks mostly affected by the heavy rains of August 2018 are Iritty, Thaliparamba, Thalassery and Payyannur. Midlands, Mid-uplands and uplands of Iritty taluk are severely affected. Among the panchayats in Iritty taluk, Kottiyoor, Ayyankunne, Ulickal and Payyavur were severely affected. The upstream of the Valapattanam river at Iritty and nearby areas witnessed heavy flooding caused by the landslides, deep inside the forest areas

The details of damage were collected from the villages of Aralam, Ayyankunnu, Kanchiar, Kelakam, Kottiyoor, Vilamana, Payam, Keezhur, Vayathur, Nuchiyad, Sreekandapuram, Chengalayi, Kooveri, Kurunathur, Panniyur, Vellad, Naduvil, Eruvezhi, Payyavur and Udayagiri.The extent of damage can be summarized in the table below.

Name of panchayat	Areas affected	Cause of damage	Extent of damage
Kottiyoor	Ambayathode, Nelliyode, Chappamala, Chunkakunne	heavy rains	40 ha
Ayyankunnu		Landslide& mudflow	35 ha damaged of which 20 ha due to land slide and 15 ha downstream due to deposition of soil by mudflow
Aralam		Heavy rain, landslide, Cyclone	25 ha(5 ha by heavy rains and 20 ha by landslide and cyclone)
Ulickal	Kalanki, Kolithatte, Vayathur, Arabikulam ,Kokkade	Strong winds	12 ha of cropped area
Payyavur	Wanjiyam, Adampara, Thenankara, Santhi nagar towards Paithal mala	land slide	4 ha of cropped area

In Sreekandapuram municipality, there was flooding at Podikalam. Waste deposition and gravel sedimentation at the top soil could be observed at the time of soil sampling. But no silt accumulation was noticed in the sampling locations.

In Kannur district there was no prolonged flooding and inundation reported. In low lying areas water impounding occurred only for shorter spans. Hence crop stand was not affected. Arecanut and coconut in valleys of flooded areas are not showing yellowing symptom. Root decay /wilting were not observed.

According to the farmers, in areas where severe landslide occurred, the stream course was changed. Crop loss occurred and standing crops of banana and vegetables were destroyed. Leveling of land, removal of boulders etc are to be taken up for making the land cultivable. In some location linear cracks developed on the soil surface.

FIELD TRAVERSING AND SOIL SAMPLING

Field traversing was conducted to evaluate the changes in soil health in panchayats (viz., Kottiyoor, Kelakam, Aralam, Ayyankunnu, Ulickal, Payyavur, Sreekandapuram) where the intensity of land slide /flood was severe. Altogether 16 soil samples were collected from the distress affected panchayats. Sampling was done at a depth of 20-30 cm. The details of sampling locations and site description are furnished hereunder.

Table 5.13.1

sampling locations and site description

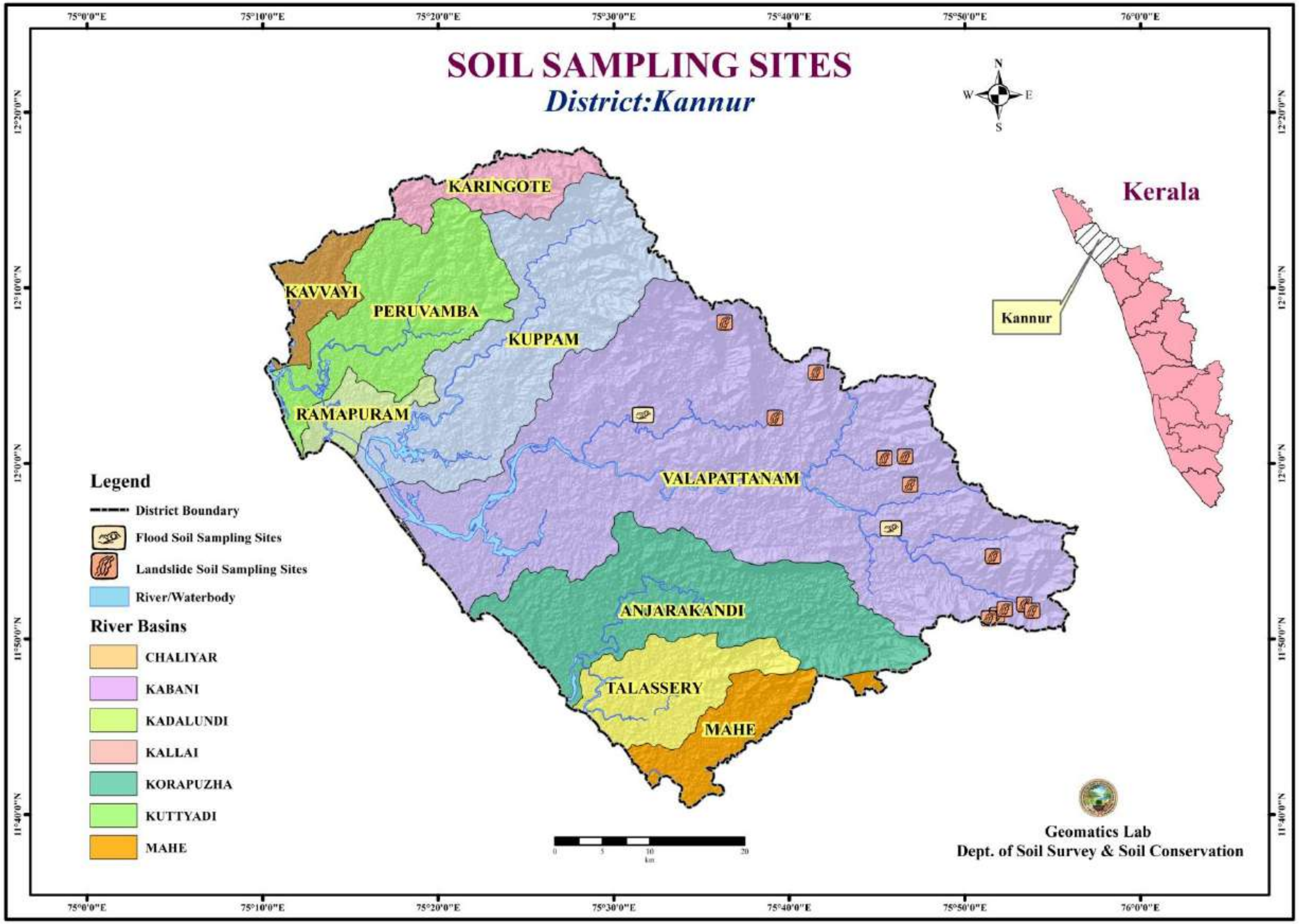
Sl no	Sample code	Sampling locations	Site Description
1	KNR/KTYR/LS-1	11^0 51'59.87'' N 75^0 53'23.37''E	A series of massive **landslides** were occurred at Ambayathode in Kottiyoor Panchayat. Bavali puzha flooded and washed away the crops on the banks of the river. Large volume of debris and rocks moved downhill. Landslide stream formed.
2	KNR/KTYR/LS-2	11^0 51'38.00''N $75^0$53'49.46'' E	**Landslide** occurred at summit portion of Nelliyody hill. Resulted in widening of existing stream channel.Rocks and boulders were deposited in the lower sector of Nelliyody region. Garden land on the sides of the stream along with crops were washed away.
3	KNR/KTYR/LS-3	11^0 51'23.07'' N 75^0 51'50.08''E	Massive **landslide** occurred at summit portion of Nelliyody hill in Kottiyoor Panchayat. soil along with vegetation washed away.
4	KNR/KTYR/LS-4	11^0 51'43.41'' N 75^0 52'15.75''E	Massive **landslide** occurred at steep hills of Kandappunam Memana in Kottiyoor Panchayat. Major crop was Rubber. Multiple cracks seen on the surface in nearby areas.
5	KNR/KTYR/LS-5	11^0 51'11.58'' N 75^0 51'21.37''E	**Landslip** occurred at Chappamala in Kottiyoor Panchayat and land along a stretch of 5.6 km washed away along with crops towards the stream bank.
6	KNR/KLKM/LS-1	11^0 54'44.47'' N 75^0 51'35.7''E	**Multiple cracks** formed on the earth surface Santhigiri in Kelakam Panchayat.
7	KNR/ARLM/FL-1	11^0 56'19.17'' N	Coconut plots in Aralam Farm was inundated

		75^0 45’48.66’’E	following **flooding** of Aralam river. No crop loss reported.
8	KNR/ARLM/LS-2	11^0 58’48.50’’ N 75^0 46’52.84’’E	**Landslide** occurred at nearby Keezhpally in Aralam Panchayat. Crop loss included Cashew, Coconut, Arecanut and Pepper.
9	KNR/AYKN/LS-1	12^0 00’18.71’’ N 75^0 45’24.47’’E	**Landslide** occurred at nearby Bandhachappa in Ayyankunnu Panchayat. Crop loss included Cashew, Coconut, Arecanut and Pepper.
10	KNR/AYKN/LS-2	$12^0$00’24.22’’ N 75^0 46’35.51’’E	**Landslide** occurred at Parakkappara in Ayyankunnu Panchayat . Soil and crops along the stream bank were washed away.
11	KNR/UKL/LS-1	12^0 05’11.94’’ N 75^0 41’31.05’’E	Debris deposited at side slope, Arabilkkulam following the **landslide** at Kolithattu in Ulikkal Panchayat. Existing stream was diverted, crop loss included banana, coconut etc.
12	KNR/UKL/LS-2	12^0 02’37.20’’ N 75^0 39’10.80’’E	Low lying areas of Kokkad in Ulikkal Panchayat were inundated as a result of **flooding** of Vayathur river. Crops damaged included banana.
13	KNR/PYR/LS-1	12^0 08’02.73’’ N 75^0 36’18.33’’E	Mild **landslide** occurred at steep hills of Adampara in Payyavur Panchayat (rubber growing tract). Rock debris transported downstream.
14	KNR/PYR/LS-2	12^0 08’3.11’’ N 75^0 53’23.12’’E	Mild **landslide** occurred at steep hills of Adampara in Payyavur Panchayat (rubber growing tract) . Rock fragments deposited downslope.
15	KNR/SKPM/FL-1	12^0 02’47.89’’ N $75^0$31’41.43’’E	**Flooding** occurred in low lands of Podikkalam in Sreekandapuram Municipality.
16	KNR/SKPM/FL-2	12^0 02’47.03’’ N 75^0 31’41.37’’E	**Flooding** occurred in low lands of Podikkalam in Sreekandapuram Municipality.

All the samples collected are from Valapattanam river basin. Topography, physiography and elevation of sampling sites are given below.

Sample code	Panchayat	Slope %	Physiograpy and elevation	Topographic division	Land use
KNR/KTYR /LS-1	Kottiyoor	27%	Midupland (187 m)	Side slope	Rubber, Coconut(Washed away)
KNR/KTYR /LS-2	Kottiyoor	15%	Upland (334m)	Side slope	Coconut, Arecanut, Pepper (Washed away)
KNR/KTYR /LS-3	Kottiyoor	35%	Upland (440m)	Side slope	Coconut, Arecanut, Nutmeg(Washed away)
KNR/KTYR /LS-4	Kottiyoor	25%	Upland (379m)	Side slope	Rubber(Washed away)
KNR/KTYR /LS-5	Kottiyoor	20%	Upland (574m)	Side slope	Coconut, Arecanut, Rubber (Washed away)

KNR/KLKM /LS-1	Kelakam	20%	Upland (368m)	Upper Side slope	Rubber
KNR/ARLM /FL-1	Aralam	7%	Midland (61m)	Riverbank	Coconut
KNR/ARLM /LS-2	Aralam	22%	Midupland (101m)	Side slope	Cashew, Coconut, Pepper (Washed away)
KNR/AYKN /LS-1	Ayyankunnu	23%	Midland (82m)	Side slope	Rubber, Coconut
KNR/AYKN /LS-2	Ayyankunnu	20%	Midupland (166m)	Side slope	Coconut, Arecanut
KNR/UKL/ LS-1	Ulickal	23%	Midupland (178m)	Side slope	Rubber
KNR/UKL/ LS-2	Ulickal	9%	Midland (43m)	Side slope	cashew
KNR/PYR/ LS-1	Payyavur	27%	Upland (307m)	Side slope	Rubber
KNR/PYR/ LS-2	Payyavur	30%	Upland (301m)	Side slope	Rubber
KNR/SKPM /FL-1	Sreekandapuram muncipality	4%	Lowland (20m)	Valley	Fallow wetland
KNR/SKPM /FL-2	Sreekandapuram muncipality	4%	Lowland (20m)	Valley	Fallow wetland


SOIL SAMPLING SITES
District:Kannur
N
W
E
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Kerala
Kannur
KARINGOTE
KAVVAYI
PERUVAMBA
KUPPAM
RAMAPURAM
VALAPATTANAM
ANJARAKANDI
TALASSERY
MAHE
Legend
District Boundary
Flood Soil Sampling Sites
Landslide Soil Sampling Sites
River/Waterbody
River Basins
CHALIYAR
KABANI
KADALUNDI
KALLAI
KORAPUZHA
KUTTYADI
MAHE
Geomatics Lab
Dept. of Soil Survey & Soil Conservation
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76°0'0"E
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N
11°40'0"N

CHANGES IN SOILS OF THE DISTRESS AFFECTED AREAS

PHYSIOGRAPHY AND LANDSCAPE CHANGES

Severe Erosion was observed at Ambaayathode area of Kottiyoor panchayat. Moderate Erosion was noticed at Kalanki, Arabikulam of Ulickal panchayat. At Kottiyoor and Kalanki areas boulders and huge rocks from top of the summit rolled down and blocked transportation. Landscape changes are confined to small pockets. In Kottiyoor panchayat intermittent cracking was observed in farm fields and homesteads. Geologists are of opinion that the wide cracks pose threat of landslides. At Parakkapara of Ayyankunnu panchayat compression of land piece down along the stream bank was observed(land subsidence).

PHYSICAL AND CHEMICAL PROPERTIES OF SOILS IN DISTRESS AREAS

Physical Properties

The changes in physical properties such as soil texture of sampled soils are furnished in table below.

Table 5.13.2

Soil Texture

Sl. No.	Sample code	Panchayat	Texture	Sand %	Silt %	Clay %
1	KNR/KTYR/LS-1	Kottiyoor	Clay loam	35	34	31
2	KNR/KTYR/LS-2	Kottiyoor	Sandy loam	61	24	15
3	KNR/KTYR/LS-3	Kottiyoor	Clay loam	31	36	33
4	KNR/KTYR/LS-4	Kottiyoor	Clay loam	29	35	36
5	KNR/KTYR/LS-5	Kottiyoor	Clay loam	26	39	35
6	KNR/KLKM/LS-1	Kelakam	Clay loam	29	34	37
7	KNR/ARLM/FL-1	Aralam	Clay loam	32	33	35
8	KNR/ARLM/LS-2	Aralam	Silty Clay loam	25	37	38
9	KNR/AYKN/LS-1	Ayyankunnu	Clay loam	16	48	36
10	KNR/AYKN/LS-2	Ayyankunnu	Sandy Clay loam	29	38	33
11	KNR/UKL/LS-1	Ulickal	Clay loam	53	20	27
12	KNR/UKL/LS-2	Ulickal	Clay loam	28	36	36
13	KNR/PYR/LS-1	Payyavur	Clay loam	37	33	30
14	KNR/PYR/LS-2	Payyavur	Clay loam	29	37	34
15	KNR/SKPM/FL-1	Sreekandapuram muncipality	Sandy Clay loam	54	21	25
16	KNR/SKPM/FL-2	Sreekandapuram muncipality	Sandy clay loam	51	20	29

Among the 16 samples studied clay loam and sandy clay loam are the predominant textural classes encountered. Soils are showing sandy clay loam texture along the banks. Samples in the depositional zone of landslides are richer in finer fraction i.e silt and clay and midway scar is rich in coarse fragments due to leaching down of finer particles from the upslope.

SOIL STRUCTURE

Major structural change affecting permeability and porosity could not be noticed. Soils are moderately permeable.

Table 5.13.3

Soil physical characters

Sl. no	Sample code	Soil depth*	Structure	Permeability
1	KNR/KTYR/LS-1	Very deep(>150cm)	Angular blocky	Moderately permeable
2	KNR/KTYR/LS-2	Very deep(>150cm)	Granular	Moderately permeable
3	KNR/KTYR/LS-3	Very deep(>150cm)	Angular blocky	Moderately permeable
4	KNR/KTYR/LS-4	Very deep(>150cm)	Angular blocky	Moderately permeable
5	KNR/KTYR/LS-5	Very deep(>150cm)	Angular blocky	Moderately permeable
6	KNR/KLKM/LS-1	Very deep(>150cm)	Angular blocky	Moderately permeable
7	KNR/ARLM/FL-1	Deep (100-150 cm)	Subangular blocky (1msbk)	Moderately permeable
8	KNR/ARLM/LS-2	Deep (100-150 cm)	Subangular blocky (1msbk)	Moderately permeable
9	KNR/AYKN/LS-1	Very deep(>150cm)	Subangular blocky	Moderately permeable
10	KNR/AYKN/LS-	Very	Subangular	Moderately

	2	deep(>150cm)	blocky	permeable
11	KNR/UKL/LS-1	Deep (100 - 150cm)	Subangular blocky	Moderately permeable
12	KNR/UKL/LS-2	Deep (100 - 150cm)	Subangular blocky	Moderately permeable
13	KNR/PYR/LS-1	Deep (100 - 150 cm)	Subangular blocky	Moderately permeable
14	KNR/PYR/LS-2	Deep (100 - 150 cm)	Subangular blocky	Moderately permeable
15	KNR/SKPM/FL-1	Deep (100-150 cm)	Granular	Moderately permeable
16	KNR/SKPM/FL-2	Deep (100-150 cm)	Granular	Moderately permeable

CHEMICAL PROPERTIES

The chemical properties such as pH, EC, macro, secondary and micronutrient status of the soil samples were analysed and compared with available data.

DETAILS OF FLOOD PLAIN SAMPLES

Table 5.13.4

pH, Electrical Conductivity and macronutrients

Sl no	Sample no	Post flood					Pre flood				
		pH	EC	OC %	Av P Kg/ha	Av K. Kg/ha	pH	EC	OC%	Av P Kg/ha	Av K. Kg/ha
1	KNR/ARLM/FL-1	5.5	0.012	1.24	1.12	301.62	5.9	0.1	2.13	51.5	152
2	KNR/SKPM/FL-1	5.5	0.012	1.39	3.36	297.58	5.2	0.07	1.791	8.17	33.6
3	KNR/SKPM/FL-2	5.5	0.012	0.81	1.12	308.22	5.4	0.18	1.16	24.41	78.4

Soils are strongly acidic in reaction. EC values are satisfactory for crop growth. Organic carbon and available phosphorus decreased after flood. Potassium values are higher when compared to pre flood data. This may be due to leaching of bases from upper reaches and deposited in the lower reaches which might have contributed increased potassium level.

Table 5.13.5

Secondary nutrients

Sl no	Sample no	Post flood (ppm)			Pre flood (ppm)		
		Av Ca	Av Mg	Av S	Av Ca	Av Mg	Av S
1	KNR/ARLM/FL-1	205.80	97.90	0.63	*	*	*
2	KNR/SKPM/FL-1	311.55	130.65	4.25	*	*	*
3	KNR/SKPM/FL-2	92.25	54.20	2.63	*	*	*

Available Calcium, Magnesium are deficient in majority of postflood samples and sulphur is deficient in all the samples. Preflood values are not available.

Table 5.13.6

Micro nutrients

Sl no	Location (GPS)	Postflood(ppm)					Preflood(ppm)				
		Av Fe	Av Mn	Av Zn	Av Cu	Av B	Av Fe	Av Mn	Av Zn	Av Cu	Av B
1	KNR/ARLM/FL-1	20.56	11.68	1.94	5.28	0.16	12.0	18.3	21.3	4	0.3
2	KNR/SKPM/FL-1	26.54	10.64	0.36	3.94	0.04	13.25	200.0	39.0	17.0	0.36
3	KNR/SKPM/FL-2	87.14	19.30	0.42	13.80	0.06	10.63	161.5	40.0	11.3	0.32

Except Boron and zinc all others are sufficient. Boron and zinc levels are lower than the preflood value.

DETAILS OF LANDSLIDE SAMPLES

The general observations of the sampling sites of landslide affected areas are given below

Table 5.13.7

Site characteristics of landslide affected area

Sl.No	Sampling location	Panchayat	Series	Sample collection point
1	11^0 51’59.87’’ 75^0 53’23.37’’	Kottiyoor	Wanjiyam	Land slide scar
2	11^0 51’38.00’’ $75^0$53’49.46’’	Kottiyoor	Wanjiyam	Mid way- soil/ rock fragment deposition upto 1-1.5 m
3	11^0 51’23.07’’ 75^0 51’50.08’’	Kottiyoor	Wanjiyam	Land slide scar-
4	11^0 51’43.41’’ 75^0 52’15.75’’	Kottiyoor	Wanjiyam	Adjacent to land slide -Source of origin
5	11^0 51’11.58’’	Kottiyoor	Wanjiyam	Mid way-Deposition occured

	75^0 51'21.37''			
6	11^0 54'44.47'' 75^0 51'35.7''	Kelakam	Wanjiyam	Adjacent to the cracks on the surface
7	11^0 58'48.50'' 75^0 46'52.84''	Aralam	Arathil	Depositional point just below the land slide scar
8	12^0 00'18.71'' 75^0 45'24.47''	Ayyankunnu	Arathil	Depositional point just below the land slide scar
9	$12^0$00'24.22'' 75^0 46'35.51''	Ayyankunnu	Kolikkadavu	Mid way
10	12^0 05'11.94'' 75^0 41'31.05''	Ulickal	Chittady	Depositional point
11	12^0 02'37.20'' 75^0 39'10.80''	Ulickal	Sreekandapuram	Depositional point
12	12^0 08'02.73'' 75^0 36'18.33''	Payyavur	Wanjiyam	Mid way
13	12^0 08'3.11'' 75^0 53'23.12''	Payyavur	Wanjiyam	Mid way

Samples collected from Land slide area were compared with the analytical results of samples collected from the adjacent area. The results are presented in the following tables.

Table 5.13.8

pH, Electrical Conductivity and macronutrients

Sl no	Sample Code	Adjacent area					Landslide samples				
		pH	EC	OC%	Av P Kg/Ha	Av K. Kg/Ha	pH	EC	OC%	Av P Kg/Ha	Av K. Kg/Ha
1	KNR/KTYR/LS-1	4.3	0.03	0.52	12.5	187	5.2	0.016	0.54	2.24	265.33
2	KNR/KTYR/LS-2	5.3	0.04	0.8	89	226	5.6	0.011	0.06	1.12	307.55
3	KNR/KTYR/LS-3	5.4	0.04	0.83	5	152	5.5	0.009	0.36	1.12	311.25
4	KNR/KTYR/LS-4	4.3	0.03	0.52	12.5	187	5.5	0.017	0.72	2.24	258.27
5	KNR/KTYR/LS-5	5	0.06	0.72	25.5	122	6.0	0.012	0.27	1.12	262.98
6	KNR/KLKM/LS-1	5.3	0.05	1.17	7.8	218	5.8	0.015	0.81	26.88	268.69
7	KNR/ARLM/LS-2	5.9	0.1	2.13	51.5	152	5.4	0.012	0.06	10.08	317.86
8	KNR/AYKN/LS-1	5.0	0.04	2	44.8	107.5	5.4	0.010	0.03	2.24	297.14
9	KNR/AYKN/LS-2	5	0.04	2	44.8	107.52	5.4	0.011	0.54	2.24	254.02

10	KNR/UKL/LS-1	6	0.28	1.86	4.49	228.93	5.4	0.014	1.15	1.12	238.56
11	KNR/UKL/LS-2	6	0.12	1.78	19.04	185.25	5.4	0.014	1.21	3.36	290.86
12	KNR/PYR/LS-1	5.1	0.02	0.59	8.96	179.2	5.5	0.011	1.93	2.24	262.08
13	KNR/PYR/LS-2	4.9	0.02	1.5	25.08	322.56	5.4	0.014	1.72	1.12	313.26

While comparing with the data of adjacent area, majority of the samples from landslides showed an increase in pH, reduction in acidity, lower phosphorus values and high potassium availability. Landslides typically have elevated soil pH relative to adjacent, undisturbed soils.

Table 5.13.9

Secondary nutrients

Sl no	Sample Code	Adjacent area (ppm)			Landslide samples(ppm)		
		Av Ca	Av Mg	Av S	Av Ca	Av Mg	Av S
1	KNR/KTYR/LS-1	NA	NA	NA	463.50	143.53	1.13
2	KNR/KTYR/LS-2	NA	NA	NA	206.30	84.35	11.13
3	KNR/KTYR/LS-3	NA	NA	NA	282.15	166.33	6.88
4	KNR/KTYR/LS-4	NA	NA	NA	363.60	104.73	3.00
5	KNR/KTYR/LS-5	NA	NA	NA	666.15	167.73	4.13
6	KNR/KLKM/LS-1	NA	NA	NA	344.80	41.43	12.13
7	KNR/ARLM/LS-2	NA	NA	6.78	32.85	36.83	2.00
8	KNR/AYKN/LS-1	NA	NA	3.00	179.00	34.35	0.38
9	KNR/AYKN/LS-2	NA	NA	4.23	478.15	104.90	0.13
10	KNR/UKL/LS-1	NA	NA	135.9	543.60	93.93	12.75
11	KNR/UKL/LS-2	NA	NA	24.41	192.35	97.70	0.63
12	KNR/PYR/LS-1	NA	NA	0.08	328.35	144.98	1.88
13	KNR/PYR/LS-2	NA	NA	0.13	448.50	167.60	3.13

Landslide area and its depositional zone are rich in Calcium. In majority of the samples Magnesium and sulphur are deficient.

Table 5.13.10

Micronutrients

Sl no	Sample code	Av Fe (ppm)	Av Mn (ppm)	Av Zn (ppm)	Av Cu (ppm)	Av B (ppm)
1	KNR/KTYR/LS-1	20.54	7.16	1.28	2.52	0.02
2	KNR/KTYR/LS-2	11.06	8.32	0.92	1.68	0.04
3	KNR/KTYR/LS-3	17.38	5.28	1.56	2.74	0.14
4	KNR/KTYR/LS-4	21.06	22.18	0.30	4.10	0.12
5	KNR/KTYR/LS-5	12.90	16.24	1.88	1.36	0.18
6	KNR/KLKM/LS-1	21.98	11.50	0.44	7.24	0.08
7	KNR/ARLM/LS-2	19.20	0.22	0.60	1.14	0.38
8	KNR/AYKN/LS-1	30.64	5.28	0.68	5.16	0.12
9	KNR/AYKN/LS-2	41.86	24.12	0.14	28.56	0.14
10	KNR/UKL/LS-1	36.68	12.48	1.28	6.93	0.14
11	KNR/UKL/LS-2	26.18	22.64	0.56	3.36	0.08
12	KNR/PYR/LS-1	33.94	14.98	1.94	5.16	0.10
13	KNR/PYR/LS-2	25.90	10.26	0.26	17.26	0.58

Available boron is deficient in all samples and available zinc deficient in some samples. While comparing the data with adjacent area, it is seen that the content of boron decreased in land slide area than the adjoining slopes. While the landslide area have increased availability of other micronutrients such as iron, Manganese, zinc, copper.

There is pronounced heterogeneity in soil physical and chemical conditions following a landslide. The majority of the landslide scar is typically infertile and is represented by undeveloped soils, saprolite, and possibly bedrock.

INTERPRETATIONS AND RECOMMENDATIONS

- 2018 flood caused severe havoc especially in the hilly tracts of Kannur district.
- About 120ha of cropped area was devastated due to land slides alone in the sampled panchayats. Severe crop loss occur especially to banana and rubber.
- On analysis of soil pH and EC, no drastic change was noticed when compared to preflood samples. The soils are extremely to strongly acidic.Liming the soils are recommended.

- The available nutrient status shows that available Phosphorus content in the post flood soils declined drastically and most of the sampling locations showed low available Phosphorus status. Hence supplementing phosphorus is essential for enhancing P availability and to restore the fertility status.
- Application of organic manure, green manure or compost etc are recommended to enhance the organic matter status of the soils and to improve the aggregate stability of soils
- Among the micronutrients, available zinc and Boron was deficient in some post flood samples.

Chapparapadavu town inundated due to overflow of Kuppam river

Ambayathode – Kottiyoor panchayat

KNR/KTYR/LS-1/1 -Depositional point

Kandappunam Nelliyodi- Kottiyoor panchayat

KNR/KTYR/LS-2- Mid way- soil/ rock fragment deposition upto 1-1.5 m

Nelliyodi – Kottiyoor panchayat

KNR/KTYR/LS-3 Land slide scar

Memana- Kottiyoor

KNR/KTYR/LS-4 - Adjacent to land slide scar

Chappamala- Kottiyoor Panchayat

KNR/KTYR/LS-5 Mid way-Deposition occurred

Santhigiri-Kelakam panchayat (cracking)

KNR/KLKM/LS-1/6- cracks on the soil surface

Aralam panchayat KNR/ARLM/FL-1/7

Keezhpally- Aralam panchayat

KNR/ARLM/LS-2/8- Depositional point just below the land slide scar

Ayyankunnu panchayat

KNR/AYKN/LS-1/9 -Depositional point

Parakkappara- Ayyankunnu panchayat KNR/AYKN/LS-2/10

Arabikkulam- Ulickal panchayat KNR/UKL/LS-1/11

Kokkad- Ulickal panchayat KNR/UKL/LS-2/12

Kalanki- Ulickal panchayat

Podikkalam- Sreekandapuram municipality KNR/SKPM/FL-1/15

6. SALIENT FINDINGS AND INTERPRETATIONS

On the basis of the study conducted in thirteen districts of the state, the changes observed in soil quality of post flood samples are discussed below.

EFFECT ON PHYSICAL PROPERTIES OF SOIL

1. Loss of structural stability and soil aggregation

Loss of soil aggregation and reduction in aggregate stability are reported from flood affected areas after flooding. Soil crusting and soil compaction are also noticed in many areas after flooding. During the recent floods, upland soils were under water for days, causing oxygen depletion or reducing conditions, which in turn affected the chemistry of the soil-water system and, consequently, soil aggregation. Loss of soil aggregation impacts agriculture by decreasing soil quality and crop production.

Soil aggregation is the clumping together of soil particles in larger size and is an important soil attribute that is related to the physical-chemical state of the soil, and is one of the essential processes that determine soil quality. Soil aggregate formation leads to improved soil structure (clumps of aggregate sticking together). Increased soil aggregation and soil structure improve water and air movement into and out of the soil. The water and air movements in soil help plants to obtain nutrients and allow improved root respiration needed for optimum crop productivity.

As soil aggregates breakdown, the soil particles plug pores and voids that help the soil to dry and return to normal after flooding. Researchers found a 21% reduction in aggregate stability after 14 days of flooding in cultivated soils that might be irreversible (De-Campos et al. 2009). This is why surface crusting is an issue after flooded soils dry out. It is believed that once the reducing reactions take place in the field and disaggregation has occurred, the process will not reverse itself because the natural drainage will carry away the released chemicals and the chemistry of the soil-water system will not return to the original state. The disintegrated aggregates may clog the soil pores and further degrade the soil structure.

However, reducing conditions only occur for short period of time during the wet season in upland soils, whereas aggregation processes operate for several months causing re-aggregation of soil particles. Changes in redox sensitive elements, alkaline metals, and dissolved organic carbon under reducing conditions contributed to the decrease in aggregate stability. Overall, the aggregate stability of cultivated soils was more affected by the reducing conditions than that of uncultivated soils. This indicates that the management system plays an important role in the stability of aggregates.

A temporary loss of soil structure prevents clay particles from aggregating and forming channels for water infiltration. Cultivation practices such as ploughing or raking the soil will help to break up surface crusting causing re-aggregation of soil particles. Planting of a cover crop would help to improve the soil's physical properties after flooding. The roots of the crops forms channels and enhance water entry and infiltration into the soil after flooding.

2. Soil Texture

Soil texture is the relative proportion of sand, silt and clay particles in soil. During flooding, textural changes are noticed in surface soil due to deposition of sediments. Sediments may be rich in clay, silt or sand. Based on the proportion of these fragments added to native soil, the surface textural properties might have changed. In valleys, clay or silt deposition are mostly noticed while in rivermouth and levees, sand deposition predominates. Consequent to this textural modification, properties of soil like water infiltration, water holding capacity, permeability, porosity etc. might also change.

3. Water-holding capacity (WHC)

Water holding capacity (the amount of water that can be held by soil to be used by plants) depends on the texture, organic matter, structure and percent of sand, silt and clay in the soil. Majority of the soil samples analysed in districts showed medium to high Water holding capacity values.

Landscape changes or slope modification

In many areas flood or landslides caused landscape changes; slope modification by the debris or mudflow during landslides and deposition of sediments by the flood water. Flood and lanslides are natural phenomena / geologic processes through which the landscape gets modified. Due to deposition of sediments especially sand, a beach like landform formed in Palakkad district. In landslide affected areas, eroding of surface soil and deposition on lower valleys or plains caused slope modification of both the areas.

EFFECT ON SOIL CHEMICAL PROPERTIES

1. Nutrient availability

Floods are expected to alter nutrient availability of soils, due to leaching of water soluble nutrients and due to the chemical composition of transported material deposited on the soil.

Soil nutrient dynamics in seasonal floodplain ecosystems are highly complex ,as a result of flood pulses and changing redoximorphic state. Flood pulse refers to the alternating dry and wet conditions in floodplain ecosystems. It facilitates soil nutrient exchange between rivers and their associated floodplains. During floods, soil nutrients dissolve in floodwaters and are transported from seasonal floodplain surfaces into adjacent rivers, and soil nutrients may also be transported from the river into floodplains through lateral flow(A. Gallardo *etal,*2003). Hence flooding can lead to both increase and decrease in soil nutrient content.

Flood deposits organic materials, minerals, and essential nutrients from rivers into land which makes the soil richer, fertile and productive. Flood contributes positively to soil properties through the provision of nutrients that may be lacking in the soil (Stephen etal.1993). Njokuetal 2015 showed that soil properties such as total porosity, moisture content, pH and organic carbon were higher in a soil after flooding than before flooding.

Flooding has changed the nutrient status of our soils. Significant differences in nutrient concentrations were observed within soils before and after the floods. The deficiency of major and secondary nutrients were noticed in many districts after flooding. Flooding and long periods of waterlogging have resulted in the depletion of nutrients especially the water soluble nutrients. Sediments deposited in agricultural lands following flooding were significantly higher in organic matter, nitrogen, phosphorus, sulphur, iron, manganese, copper and zinc. But significantly lower in potassium, calcium, magnesium and boron in top soils.

At the same time floods have removed significant amount of topsoil through sheet erosion. However, the removal of topsoil is always a loss to agricultural productivity as topsoil is the part of the soil horizon with higher level of organic matter and nutrients, and generally have better structure (USDA, 1993). Majority of our soils are highly weathered, low in organic matter content, hence their susceptibility to erosion, flooding and leaching are more.

In landslide areas, especially the topsoils are removed by mud flow or debris flow exposing the sub surface horizon or parent material underneath. Booze-Daniel et al (2009), opines that soils whose surfaces are tampered with or are replaced with sub soils cease to be suitable for crop cultivation, because they contain relatively low organic matter and micro organism activity, lack available plant nutrient and water, have poor soil structure and therefore are often very hard to re-vegetate. This type of soil will require a sound agricultural practice and the use of crop type that will suit that environment.

Soil microorganisms are sensitive to disturbance, and shifts in soil microbial community are expected when anaerobic conditions develop from flooding. Moreover, there are chances of washing out of natural flora during flooding. This may impact nutrient availability through their role in various nutrient cycles.

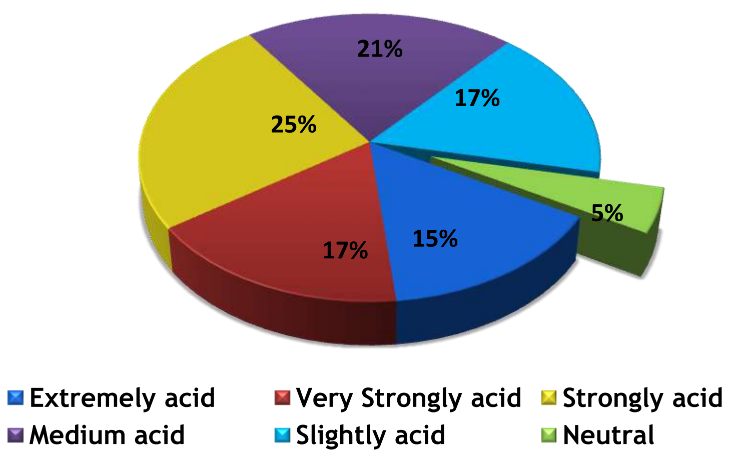
Soil Reaction / pH

The degree of acidity or alkalinity of a soil is expressed as the pH value. Soil reaction is an important property of soil because it provides valuable information for assessing soil condition for plant growth, nutrient cycling and biological activity. It is measured in units of pH. Soil pH measurement is useful because it is a predictor of various chemical activities within the soil. Soil acidity is one of the major problems for agricultural production in many parts of the world [E. J. Kamprath].Adjustments in pH can be made through addition of amendments to the soil based on the soil texture, organic matter content and the crops to be grown.

Soil pH affects the availability of nutrients to plants or crops. Nutrient availability is affected by changes in the solubility of soil minerals. The greatest availability for most nutrients is between pH 6 and 7. Soil pH also affects the activity of beneficial microorganisms, which affects nutrient availability. A strongly acid soil will have low extractable calcium and magnesium and high solubility of aluminium, iron and boron and low solubility of molybdenum. However if pH is too high, the availability of iron, manganese, copper, zinc and especially phosphorus and boron may be affected. Many heavy metals become more water soluble under acid conditions and move downward with water through the soil and in some cases move to aquifers, surface streams or lakes.

On perusal of the data, soil acidity of post flood samples ranges from extremely acidic to neutral. The soils of upper Kuttanad and some portion of lower Kuttanad showed extreme acidic condition. The soil reaction status of the post flood sample analysis showed that 15% of the samples are extremely acid, 17% very strongly acid, 25% strongly acid, 21% medium acid , 17% slightly acidic and 5% neutral indicating the necessity to adopt urgent reclamation measures in the state.

Soil reaction status in post flood soils



60-70 % of samples from upland side slope were in the extremely acid to strongly acid category indicating the soil reaction has become a major limiting factor for crop production in these areas. Especially soils in the upland, due to their physiographic position and topography of the land, are prone to erosion. Due to leaching, basic cations from the soil are lost which may have attributed to increased acidity.

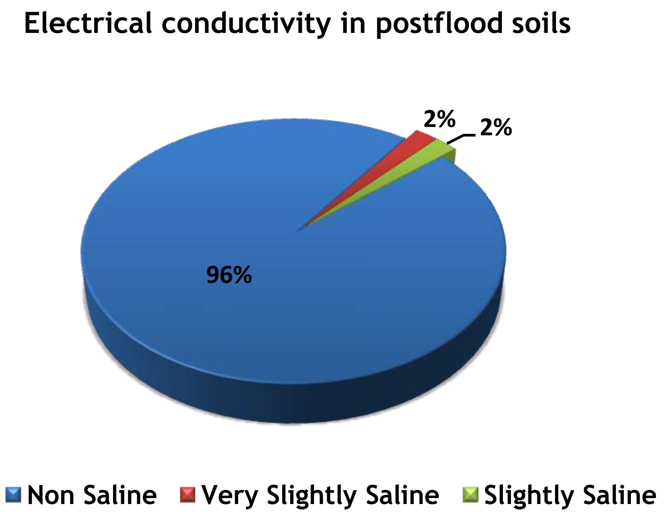
Soils of upper Kuttanad and midland valleys of various districts showed increased acidity after flooding. The post effect of flooding is evident in the reduction in pH values, tending the soils towards acidity. Soil saturated with water causes pH reduction due to organic acid produced from fermentation.

Continuous flooding on farmlands will inevitably result in gradual decrease in soil pH, thereby tending the soil towards increased acidity (B. M. Kalshetty et.al,2012). The reverse is also noticed in the present study. In wet land, despite the original soil pH being either acidic or alkaline prior to flooding, the pH become gradually neutral in post flood condition (The Chemistry of Submerged Soils, Advances in Agronomy, 1972).

The pH range of 4.6 to 5.5 denotes significant soil acidification. Amelioration of soils in this pH range is often necessary if productive yields are to be maintained, and is often economically viable. Liming of these soils are highly essential to achieve sustainable productivity and economy of cultivation.

Electrical conductivity (EC)

Electrical conductivity (EC) is a measure of ionic concentration in the soils and is therefore related to dissolved solutes such as ions and salts. EC is reported in either milli mhos per centimeter or the equivalent deci Siemens per meter (dS/m). When ions (salts) are present, the EC of the solution increases. High value of EC can be toxic to plants and may prevent them from obtaining water from soil. Excess salts in soil can be a detriment to plant health. Salts can also hamper water movement into the soil and increase the occurrence of surface compaction. The electrical conductivity status of the post flood samples analysed are presented below.



Majority of the sampling locations have showed low values for EC indicating that salt content did not cause any detrimental effect to crop production except one or two sampling locations in upper Kuttanad, Monrothuruthu panchayat in Kollam, Pokkali soils in Eranakulam etc. In majority of the soils slight increase in EC values were observed. This is due to the exogenous input of salts, ions and total dissolved solids carried by the flood into the soil. The increased EC values on the flood affected farmlands are similar to the findings of Kalshetty, *et al.*, where EC values of cultivated soil increased on flooding from river Krishna in Bagalkot

District, Karnataka. The EC values recorded are considered normal in most cases. EC values less than 2dS/m are indicative of soils which have low salinity hazards to plants.

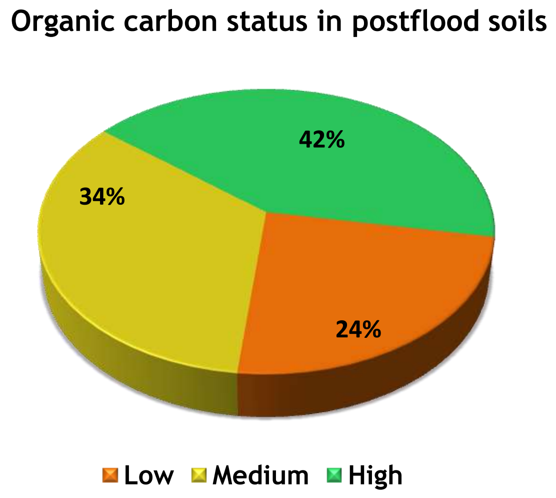
Soil Organic Carbon/Available Nitrogen

Soil organic carbon is one of the most important constituents of the soil due to its capacity to affect plant growth both as a source of energy and a trigger for nutrient availability through mineralization. Soil organic carbon is an important indicator of soil quality and agronomic stability because of its impact on physical, chemical and biological indicators of soils. Organic carbon in agricultural soils contribute positively to soil fertility, soil tilth, crop production and overall soil sustainability (Bauer & Black, 1994; Lal.et.al1997; Reeves, 1997). Soil organic carbon is the net result of carbon input and mineralization of carbon in soil. It is closely linked to soil's water retention capacity, nutrient availability, structural stability and soil compaction.

Changes in the soil physical characteristics resulting from erosion of surface layers and losses of soil particles and nutrients also affect soil organic carbon content and composition. Organic Carbon improves the physical properties of soil. It increases the Cation Exchange Capacity (CEC) and Water Holding Capacity of sandy soil, and it contributes to the structural stability of clay soils by helping to bind particles into aggregates.

Warm temperatures decrease Soil organic carbon content by increasing decomposition rates, while high mean annual precipitation increases accumulation by stimulating the production of plant biomass and associated Soil organic carbon.

The organic carbon status of the post flood samples analysed are presented below. 24% of the samples analysed are under low organic carbon status.(0.50%)



On perusal of the post flood data, it is observed that the organic carbon content of soils ranges from 0.2 to 4% and the status ranges from very low to very high. Majority of the soils analysed showed high status followed by medium status. A reduction in organic carbon was observed in some postflood samples, which could be attributed to the effect of flooding;- as most soil organic content such as organic acids and humus which are the sole source of organic carbon could have been leached out by the impact of the flood. Decreased organic carbon content of soil adversely affects soil quality and fertility since organic carbon is required to stimulate microbial respiration and activities. Low organic carbon content was noticed mainly in the highland side slopes of Wayanad, Valleys of Thrissur and Palakkad district and coastal plains of Eranakulam district.

The increase in organic carbon was also noticed in many sampling locations. This might be due to the deposition of sediments rich in humus. This is in accordance with the findings of Kalshetty, *et al.*, observed increased organic carbon content in flood affected cultivated areas in India

A reduction in soil organic matter observed in the sampling locations is not considered healthy for agricultural soils because organic matter contains humus which is the store and supplier of plant nutrients. It is very essential and important in maintaining soil fertility. Organic matter is an energy supplier (electron donor) for microbial processes [W. Kördel,1997] which can adsorb or form complexes with potentially toxic metals and other compounds decreasing their availability to plant and microbial life ; so a reduction is disadvantageous for agricultural soils.

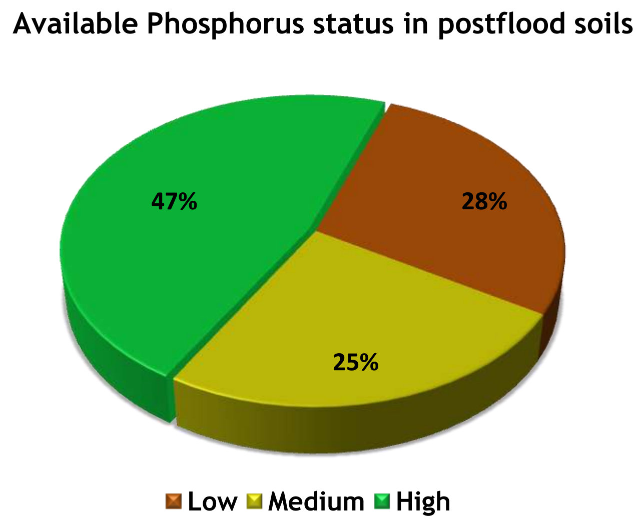
Soil organic carbon content is taken as the indicator of availability of nitrogen to plants. The available nitrogen content in the soil is determined based on the organic carbon present in the soil. Of the three major nutrients, plants require nitrogen in the largest amount. Nitrogen promotes rapid growth, increases leaf size and quality, hastens crop maturity, and promotes fruit and seed development. The reduced organic carbon content in the post flood soils are less than 0.50% indicating the deficiency of available nitrogen in soils .Application of nitrogenous fertilisers and organic manures will improve the soil quality and productivity

Available Phosphorus

Normal plant growth cannot be achieved without phosphorus. It is a constituent of nucleic acids, phospholipids, the coenzymes of DNA and NADP, and most importantly ATP. It enhances seed germination and early growth, stimulates blooming, enhances bud set, aids in seed formation, hastens maturity etc

It is seen that the phosphorus availability in soils have reduced after flood though variations are observed. This may be due to sudden drying after the flood occurrence or change in soil organic matter content, soil pH etc. The available soil phosphorus level showed seasonal fluctuations with levels increasing during the wet season and decreasing when rainfall ceased. In general,the phosphorus content of soils in the sampled areas ranging from 1.12 to 212Kg/ha showed a wide variation from low to high fertility status.

The available phosphorus status of the post flood samples analysed are presented below.



Low phosphorus status was noticed in upper Kuttanad regions of Pathanamthitta and Kottayam district, lowland flood plains of Kozhikode districts, some parts of lower Kuttanad, midlands of Trivandrum and Kollam districts and lowland floodplain of Kollam. Phosphorus deficiency symptoms generally occur in soils with a low phosphorus content. Application of phosphate fertilizer based on rates recommended by soil test will correct this problem.

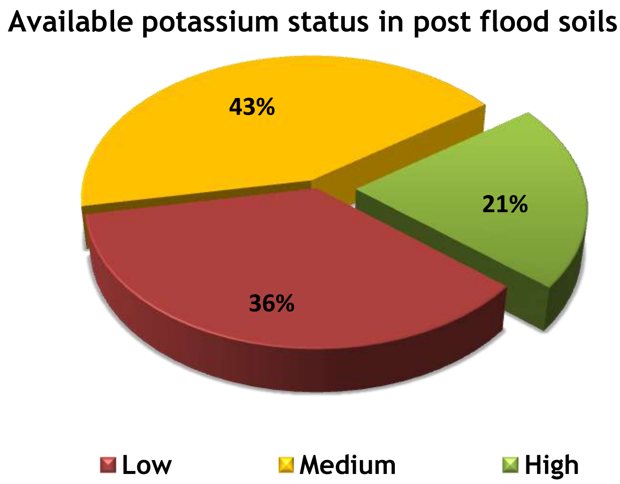
The phosphorus availability is highly dependent on soil pH of the location and P availability will be maximum at a pH of 6.5. The increased clay of soils may also contribute to phosphate sorption and reducing availability. Application of liming materials to neutralise the soils will improve the phosphorus availability of these soils/ locations

The nutrient availability in flooded soils are controlled by redox potential processes driven by the lack of soil oxygen. Gradually, in these flooded soils, phosphorus will become more available either from the reduction or dissolution of iron and calcium phosphates, respectively. This will not lead to increased crop productivity after flooding because oxidation processes will return the phosphates to their original associations. Nathan ,2002 reported that long term repeated flooding might result in inflated soil phosphorus levels.

Available Potassium

Potassium is the third most important plant nutrient along with nitrogen and phosphorus. It is essential for plant growth. Because large amounts are absorbed from the root zone in the production of most agronomic crops, it is classified as a macronutrient. Although not an integral part of cell structure, potassium regulates many metabolic processes required for growth, fruit and seed development.

On perusal of the data of available potassium content in post flooded soils, status vary from low to high. Potassium deficiency is widely seen. Potassium is highly soluble in water and prone to leaching losses. This might have been the reason for low potassium levels. Potassium deficiency is mostly noticed in Palakkad central plains, Lowlands of Thrissur, Eranakulam and Kollam districts and midland flood plain and valleys of Kozhikode district. The available potassium status of the post flood samples analysed are presented below.

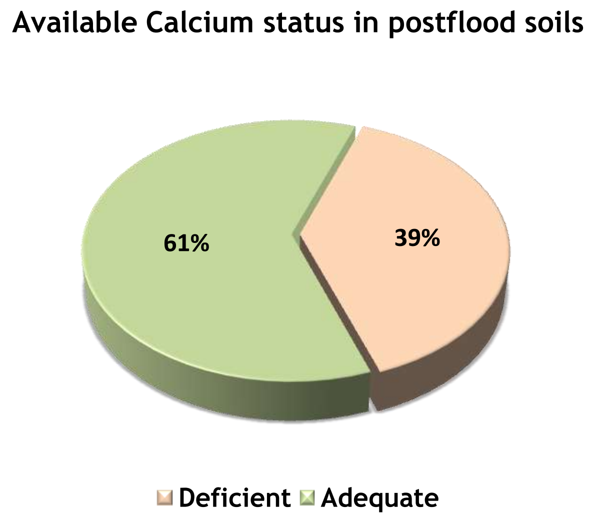


Deficiency is prevalent in some soils while in others potassium content increased substantially after flood. Good soil tilth, adequate soil moisture for K uptake, content of organic matter and clay in the soil and cation exchange capacity of the soil are the factors determining K availability in soil. Soil compactness after flood may affect the availability of potassium. Application of potassium fertilisers is highly essential to achieve/ restore productivity of these soils. Application of organic manures to improve the CEC and liming will also improve the potassium availability of these soils. Potassium is a macronutrient that is not only required for healthy plant growth, but also for proper microbial functioning; therefore reduction in potassium levels in the flood affected soils is a negative impact on soil quality.

Available calcium

Calcium is the most plentiful cation occupying 70% or more of the cation exchange complex of neutral to slightly acidic soil. Calcium is required in large amounts by plants.The role and function of calcium in plants includes stimulation of root and shoot growth and development, activation of plant enzymes, and neutralizes organic acids in plant cells. Calcium is also needed by plants to strengthen cell walls. Where plants have insufficient calcium, cell walls and membranes will weaken and disintegrate, leading to increased disease, fruit rotting, and post harvest problems.

The available calcium status of the post flood samples analysed are presented below. In general calcium content decreased with an increase in moisture content during flooding .Thirty nine % of the sampling locations are deficient in available calcium. This may be due to the leaching of bases in flood water. Calcium deficiency is noticed in Palakkad plains, valleys of Thrissur district, midland sideslopes of Trivandrum and Kannur districts.



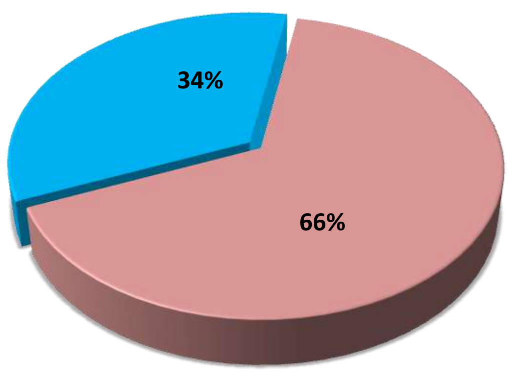
Available Magnesium

Magnesium is a component of several primary and secondary minerals in the soil, which are essentially insoluble, for agricultural considerations. These materials are the original sources of the soluble or available forms of Mg. Magnesium is also present in relatively soluble forms, and is found in ionic form (Mg^{++}) adhered to the soil colloidal complex. The ionic form is considered to be available to crops.

Magnesium, although it is needed in smaller amounts than Calcium, is no less indispensable for plants. Magnesium is involved in the synthesis of proteins and oils. Magnesium also activates more essential enzymes required for energy metabolism than does any other mineral nutrient. Magnesium is the central core of the chlorophyll molecule in plant tissues and is therefore fundamentally involved in the process of plant photosynthesis. If magnesium is deficient, the shortage of chlorophyll manifests itself in poor and/or stunted plant growth. Magnesium deficiencies first appear as unusually light green leaves.

The available magnesium status of the post flood samples analysed are presented below. It is seen that 66% of the samples analysed are deficient in available magnesium.

Available magnesium status in postflood samples



Magnesium deficiency is widely noticed in postflood samples. In soils of miduplands of Palakkad, midlands of Trivandrum, Alappuzha, Eranakulam and Thrissur districts, and lowlands of Ernakulam and Thrissur districts Magnesium deficiency is observed. This may be due to the loss in exchangeable cations during flooding. Low Ca, Mg, K during high flood in the study locations could be a result of leaching and dilution because flooding increases the solubility of mineral nutrients. It could be expected that during a high flood, more soil nutrients dissolve in water and are lost through leaching as water infiltrates the soil.

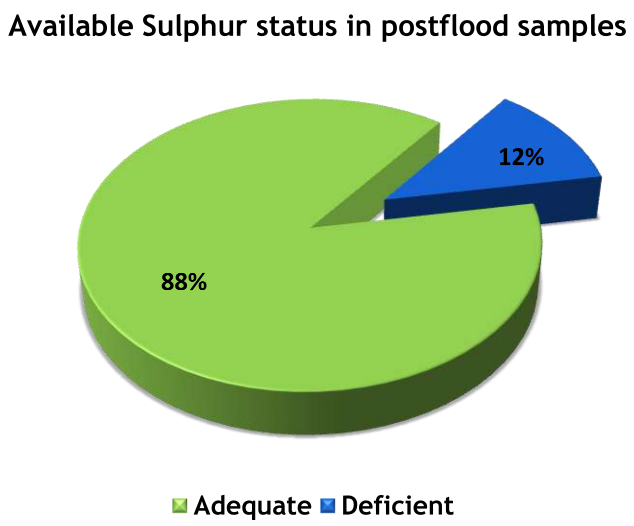
Available Sulphur

Sulphur (S) is an essential plant nutrient required by all crops for optimum production. Plants absorb Sulphur mainly in the form of inorganic sulphate ($SO4^{2-}$)

ions through the roots. Sulphur must be present in soils in sufficient amount in order to meet crop Sulphur requirements (Brady & Weil, 2002).

Increased availability of sulphur postflood may be attributed to the added organic matter content through flooding. An increase in temperature increases the rate of mineralization of both the indigenous and added organic materials in the soils thus contributing to the plant available S. It is also noticed that in majority of the locations showed more available Sulphur content than preflood soil data. On perusal of data, the soils of Idukki and Kozhikode district showed low sulphur status indicating its deficiency in soil. Low organic matter content, leaching loss and soil pH may have attributed the deficiency of sulphur in the soils analysed.

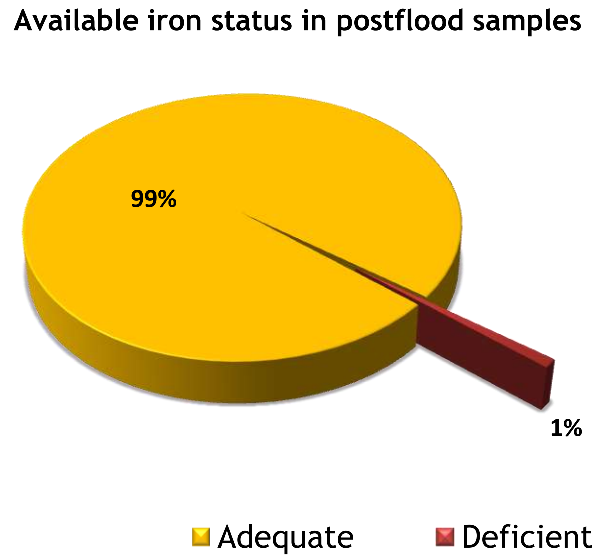
The available sulphur status of the post flood samples analysed are presented below.12% of the analysed samples showed sulphur deficiency.



The deficiency of sulphur in soils may be attributed to several factors. Among these, some of the factors causing sulphur deficiency in the lateritic soils are inherent to soil properties and others are induced by manmade activities. Among these are low native sulphur content, coarse texture, inherent low organic matter content and soil conditions that favour sulphur leaching losses. The deficiency of sulphur can be corrected by application of more organic inputs into the soil and by applying sulphur containing fertilisers such as single superphosphate (SSP) and ammonium sulphate.

Available Iron

Iron (Fe) is required for the formation of chlorophyll in plant cells. It serves as an activator for biochemical processes such as respiration, photosynthesis and symbiotic nitrogen fixation. Iron deficiency is not noticed in any soils. Very high values are noticed in some locations.The available iron status of the post flood samples analysed are presented below.

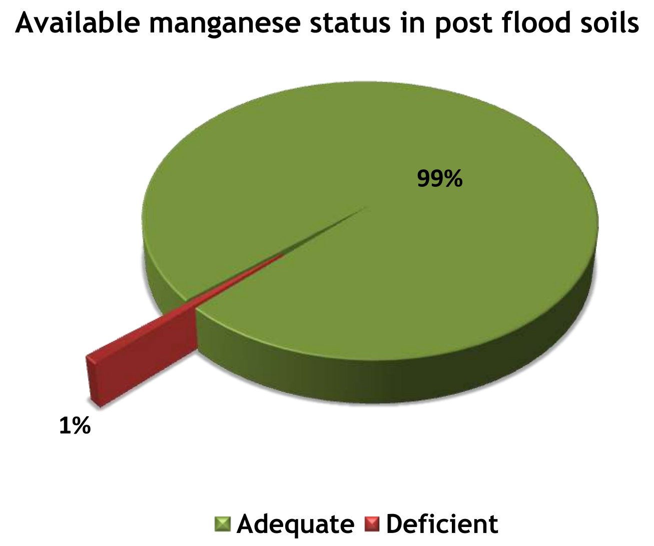


Chinchmalatpure *et al.* (2000) who reported negative significant correlation between Iron and soil pH. Low pH enhances iron availability. The acidic condition prevailing in these soils might have enhanced the availability of iron and deficiency is noticed in negligible samples.

Available Manganese

Manganese is an essential micronutrient and it serves as an activator for enzymes in growth processes. It assists iron in chlorophyll formation. High manganese concentration may induce iron deficiency. Manganese deficiency is noticed in coastal alluvium of Thrissur and Eranakulam districts and some location in low land valleys of Thrissur district. The available manganese status of the post flood samples analysed are presented below.

The increased availability during flooding may be due to the increased soil moisture available and favourable soil pH. High soil moisture and poor aeration increases the availability of manganese due to an increase in solubility. In majority of the cases where the available manganese content of the soils are very high, there are chances of occurrence of Manganese toxicity.

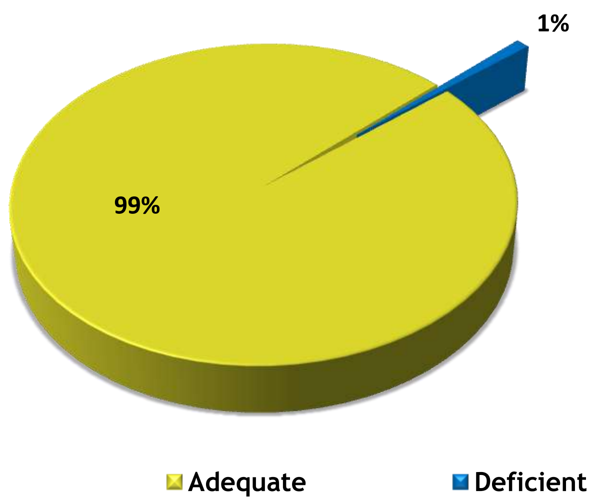


Available Copper

Copper becomes less available when pH increases. However in soils with high organic matter, the availability is more associated with organic matter than to pH. Organic matter hold copper more tightly reducing its availability. Copper deficiency is noticed in 1% samples analysed ie in some samples of Eranakulam, Thrissur, Malappuram, Kannur, Kozhikode and Palakkad districts.

Elevated micronutrients concentrations were observed after prolonged dry periods, while concentrations were generally lowest after periods of heavy rainfall. Complexation of micronutrients by organic matter (Cancela et al. 2002) may explain seasonal micronutrient dynamics. The available copper status of the post flood samples analysed is presented below.

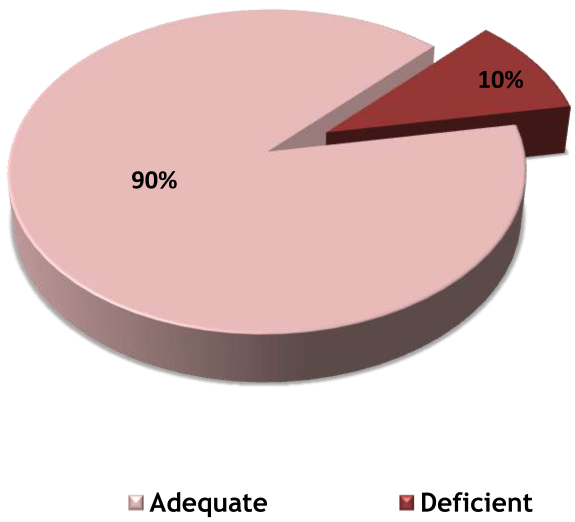
Available copper status in postflood samples



Available Zinc

Zinc is one of the essential micronutrients required for optimum crop growth. Zinc plays an important role in many biochemical reactions within the plants and also a part of several enzymes. It is essential for proper root development and formation of chlorophyll. Zinc availability decreases with increase in soil pH. At pH 5.0 the availability of zinc is high and decreases as pH increases to 9. Zinc deficiency may also occur in sandy soils, soils high in phosphorus, organic matter and in soils were subsoils have been exposed due to land levellling processes/ erosion. Zinc deficiency is seen in plains and side slopes of Palakkad districts, valleys of Thrissur and Ernakulam district. The available zinc status of the post flood samples analysed are presented below.10% of the analysed samples showed deficiency.

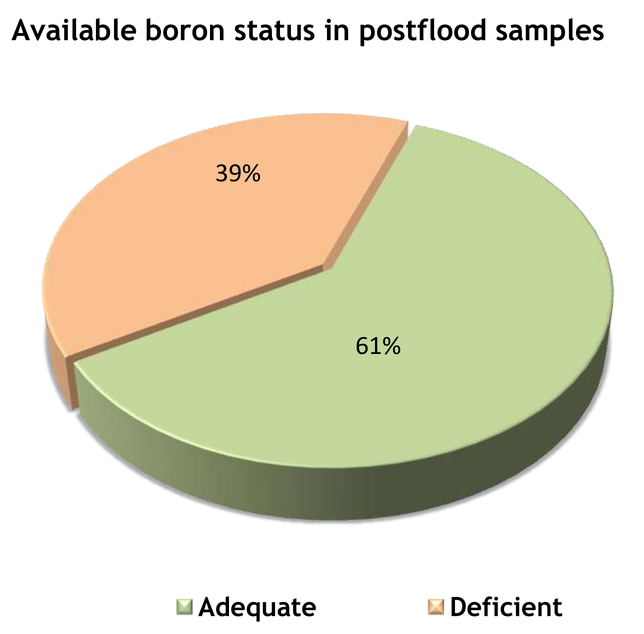
Available zinc status in postflood samples



Available Boron

Boron is one of the essential elements for plant growth and development. The deficiency of B is known to reduce quantity and quality of agricultural produce. Boron availability decreases as pH increases. Organic matter increases boron availability. Highly leached, coarse textured soils tend to have low boron availability. Calcium acts to reduce boron availability. The available boron status of the post flood samples analysed are presented below.39% of the samples analysed showed boron deficient status.

The soils are mostly deficient in boron after flooding. The valleys of Eranakulam, Thrissur, Kozhikode and central plain of Palakkad district showed boron deficiency. Moreover, being highly mobile in the soil (Tisdale et al., 1986), leaching losses further aggravate B insufficiency in the high rainfall regions, frequently leading to development of deficiency symptoms in crop plants.



Heavy metals

Metals cannot be degraded naturally like organic pollutants and accumulate in different parts of the food chain. Soils highly contaminated with metals lack proper structure, aeration, and are low in soil fertility that can result in small microbial biomass, together with poor plant growth in these soils (Clemente *et al.*, 2006). The flood and its resulting high moisture content of the soil could have created favorable conditions in the soil for the metals to be present in forms that are highly available. This could be supported by the findings of Abeh*et al.*, [31] who reported that metal concentrations could be in forms that can easily be made available under favorable conditions. The enhanced concentration of metals ie iron, manganese, copper etc. in soil after flood might be due to this. While analysing samples of Thrissur and Eranakulam district, the concentration of cadmium in the soils exceeded the maximum permissible limit in some locations .

2. Cation exchange capacity

Cation exchange capacity is the total amount of cations held in a soil in such a way that they can be removed only by exchanging with another cation in the natural soil solution. It is the measure of the ability of the soil to retain cations, some of which are plant nutrients. Soils which have a low CEC cannot store large amounts of plant nutrients and must be replenished more regularly.

Very low CEC values are recorded for soils in landslide areas ie the soils collected from landslide depositional zone indicating coarse texture and highly leached condition of the soils. Reduced organic matter in the soils could have also accounted for the reduction in cation exchange capacity, since organic matter contributes to the cation exchange capacity of the soil by increasing adsorption sites for cations. Reduced cation exchange capacity is not favorable for agricultural soil because it limits the availability of essential positively charged macro and micro nutrients to be adsorbed on soil particles, since few negatively charged sites will be available to attract them.

3. Exchangeable bases

The five most abundant cations in soil are hydrogen, sodium, potassium, calcium and magnesium. Among these, Sodium, Potassium, Calcium and Magnesium are classified as exchangeable bases. The higher the amount of exchangeable base cations, the more acidity can be neutralized in soil in the short time perspective. The availability to plants also depends on this.

Sandy soils and acid soils that have been strongly leached often have very low levels of exchangeable Calcium and Magnesium, and plant growth may be limited as a result (Abbott,1989). It is evident from the results that the soils of landslide area have low exchangeable base status due to intense leaching.

EFFECT OF FLOODING ON FLORA AND FAUNA

1. Effect on plant growth

Flooding results in shortage of food crops due to loss of entire harvest and the destruction of soil quality. In all districts flooding caused widespread agricultural loss though direct or indirect effect on crops. Crops such as banana, nutmeg, tuber crops, paddy, vegetables etc. are the most affected crops. Nutmeg in flood affected areas were severely damaged. Yellowing and rotting were seen even after the floods. In banana Nendran variety is the most suffered while verities such as Palayamkodan, Njalipoovan etc. thrived the situation. Young plants were most severely affected by the impounding of water for days or weeks.

Flooding in garden lands can cause the plants to become stressed and even die due to the presence of excessive amounts of water. There are many ways that flooding can damage plants. When a soil is flooded (anaerobic conditions), microorganisms use the available soil oxygen to survive. Free oxygen in the soil is usually depleted within a couple of days after flooding. The longer the soil is flooded, the lower the soil O_2 levels become. Oxygen deficiency is likely the most important environmental factor that triggers growth inhibition and injury in flooded plants. It impedes respiration in the roots leading to the build-up of carbon dioxide, methane and nitrogen gases. Ultimately, the roots suffocate and die. Toxic compounds such as ethanol and hydrogen sulphide can also build up in the soil and damage plants. If leaves and stems are submerged, photosynthesis can be inhibited and plant growth can slow or even stop.

The deposition of soil and rocks onto plants during flooding can damage plants, as can the exposure of roots to the air by the washing away of surrounding soil. Also, even after the flood waters recede the damaged plants can be more vulnerable to other stresses. For example, trees with substantial root damage are more likely to be uprooted in windy weather.

Plants that are suffering from excessive water stress are more prone to infection by disease causing organisms such as fungi or insects. Also, excessively wet soil tends to favour the growth of soil microbes such as *Fusarium sp. Phytophora sp* and *Rhizoctonia solani*, which can infect plant roots leading to diseases such as root and crown rot. There are reports of incidence of fungal and bacterial infection immediately after the flood.

The damage caused to plants by flooding differs depending on the age of the plants. Established healthy plants are generally more tolerant than young or very old plants. The longer the time of submergence, the more likely that damage to plants will be fatal. Even once the flood waters recede it will take weeks for the soil to dry out and plants continue to suffer damage in the meantime.

2. Perishing of earthworms/ microfauna after flooding

After flooding the day temperature was very high and surface crusting resulted from less aeration of soils. Earthworms are usually seen near the surface of the soil. Moreover they need organic matter to thrive. Low organic matter status, lack of aeration of soil and prevailing high day temperature etc might be the reasons for perishing of microfauna like earthworms immediately after flood.

LANDSLIDE

Landslides are simply defined as down slope movement of rock, debris and/ or earth under the influence of gravity. This sudden movement of material causes extensive damage to life, economy and environment. *Cruden (1991)* defined landslides as a movement of mass of rock, earth or debris down a slope.

1. Identifying Landslide Areas

The identification and prediction of a landslide is essential to minimize or control the hazard. Usually this is done by using costly procedures as surveying, monitoring or soil testing, which are not affordable or feasible in rural regions with almost no resources. Therefore, simpler but still effective methods have to be used to assess the stability of slopes and decide if a given location is safe for construction.

The following features may be used to identify probable landslide prone areas.

- Existing or old landslides or places of historic landslides
- Areas at the base of slopes
- Within or at the base of minor drainage hollows
- At the base or top of a fill slope
- At the base or top of a cut slope
- Any sloping ground in an area known to have a landslide problem
- V-shaped valleys, canyon bottoms, and steep stream channels
- Fan shaped areas of sediments and boulders accumulation at the outlet of canyons
- Areas with large boulders (2 to 20 feet diameter) perched on soil near fans or adjacent to creeks
- Steep hill slopes above a home or hamlet
- Logjams in streams above a home or hamlet
- Steepened road cuts, sunken or down-dropped road beds
- Areas that have been extensively disturbed by excavation into steep slopes
- Moderately steep slopes that are exposed to high water flow
- Burn areas, intensively irrigated agricultural field, canyon, hillside, mountain and other steep areas that are vulnerable to landslides

2. Potential landslide risk indicators

The following simple observations may assist in assessing potential landslide hazards. It is important to note that some of these features can also be due to causes other than landslides. Hence inspection by officials must be resorted to for conformity of the problem.

- swelling clays.
- Saturated ground or seeps in areas that are not typically wet
- New cracks and scarps or unusual bulges in the ground, roads or pavements
- Movement of ancillary structures such as decks and patios in relation to a house.
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- Soil moving away from foundations
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines or retaining walls
- Sunken or displaced road surfaces
- Rapid increase in creek water levels, possibly accompanied by increase in turbidity (soil content)
- Sudden decrease in creek water levels though rain is still pouring or just recently stopped
- Springs, seeps or saturated ground in areas that are not typically wet
- Thorough cracks in walls, gaps between roof and wall etc.
- Damage to building elements

In most cases in the field, one may find the presence of combination of landslide risk indicators.

(Source: Training manual, National institute of Disaster management)

In the recent monsoon season, the occurrence of landslides in our state has been an indicative of the susceptibility of our soils to landslides in cases of extreme precipitation. Instability of slopes is the main reason for landslides. Loss of forest vegetation, cutting of steep slopes for road construction, high rise building on the top of slope and unscientific construction in the environmentally fragile zone etc. contributed the occurrence of landslides in our state. In the case of rainfall induced landslides, when the soil reaches maximum saturation, there may be chances for sliding especially in the case of clayey sub soils.

3. Sliding of landslide plains

Heavy rains typically cause landslides by temporarily raising the water table to near the surface. A rising water table results from a greater rate of surface infiltration into the unsaturated (vadose) zone than the rate of deep percolation (Keller, 1996; Dhakal& Sidle, 2004; Chen, 2006).The most extreme case of a rising water table occurs when it reaches the surface, indicating that a potential landslide mass is entirely saturated. Saturation of soil increases the pore pressure. Pore pressure slightly forces the soil grains apart and thus reduces inter-grain friction, cohesion, shearstrength, and resisting forces (Sidle & Swanston, 1982). Additionally, the driving forces increase due to the extra weight and pressure of water (Peterson *etal.*, 1993; Chen *etal.*, 1999).

Seepage of water from external sources, such as reservoirs, canals, culverts, and septic tanks, can also increase pore pressure and weight on a slope, thereby increasing the likelihood of a landslide.

Water can also reduce soil stability by rapid draw down, or by altering the physical structure of clays. Rapid draw down occurs when the water level of a river or reservoir lowers quickly, usually at a rate of atleast 1 m per day (Kojan& Hutchinson, 1978; Keller, 1996).

DEVELOPMENT OF VERTICAL SOIL CRACKS

Soil cracks extending to kilometres are reported from Wayanad, Thrissur, Idukki and Palakkad districts which made the inhabitants of the area panic after the flood. According to the Geological survey of India it is an indication of the susceptibility of the region to landslide occurrence. If they remain unsealed, water will infiltrate into the soil through these vertical cracks and will increase pore water pressure of the soil underneath and this might enhance the chance to sliding. Hence it is recommended that these cracks are to be closed with bentonite clay to prevent infiltration of water in case of rainy events.

It is high time to study the susceptibility of our soils especially in westernghat region to landslide due to steep topography and changing rainfall pattern of the state and geology. Many soil properties (physical/index) like soil depth, drainage, infiltration, stoniness/ gravelliness, particle size distribution, plasticity (plastic limit/liquid limit), moisture content etc will decide the susceptibility of a soil to landslides in case of intense very heavy rainfall events.

SUMMARY

- *A random study has been conducted in thirteen districts of Kerala to assess the impact of flood and landslides on soil quality during September 2018 immediately after the flood. The results of the study can be summarised as follows.*
- *The flood has deteriorated soil quality by impairing its physical and chemical properties.The topsoil erosion and sediment deposition has changed the characteristics of soils of both upland and lowland .*
- *Soil compaction, soil crusting, loss of aggregate stability etc are noticed after flooding which have a negative impact on aeration, water infiltration and the life of microbes and microfauna inhabiting the soil.*
- *Soil acidity remains a major problem of Kerala soils even after the flood and needs urgent reclamation measures to restore productivity especially in the upland soils.*
- *Poor organic matter status is seen in many areas which has to be supplemented with organic manures, green manures etc. Green manure crops and cover crops are to be grown and incorporated into the soil.*
- *Deficiency of potassium, calcium, magnesium and boron is widely noticed. Localised deficiency of zinc, phosphorus is also noticed. In most of the areas content of sulphur, iron, manganese in soil are very high. There may be chances of toxicity of these nutrients. Soils of Idukki and Kozhikode district show comparatively low sulphur content.*
- *Application of lime/dolomite will improve soil structure, improve aeration and reduce acidity and also supplement calcium and magnesium to the soil.*
- *Since the native microbes suffered due to flooding, fortification of organic manures with biofertilizers and microbial inoculants is highly beneficial to revamp the microbial status of soil. This will enhance the*

microbial activities in soil and improve the nutrient availability to crops.

- *Top soil erosion and Silt deposition consequent to flooding has changed the nutrient status of the soil. Hence soil testing is essential to identify the nutrient status in these soils.*
- *In the case of nutrient deficiency in flood affected areas, resort to foliar application for better efficacy of applied nutrients.*
- *Vertical Cracks which appear on the surface of landscape in upland areas is an indication of susceptibility of those soils to the landslide/ land slip. In these areas extreme care should be given before planning any intervention affecting slope stability.*
- *Heavy metal studies done in the districts of Thrissur and Eranakulam district revealed the occurrence of Cadmium above permissible limit in some locations indicating cadmium pollution in soil.*
- *In the case of landslide affected areas, heterogeneous soil properties are noticed in the landslide site from source, scar, chute to depositional zone. Depositional zone showed abundance of minerals like potassium.*
- *In the case of rainfall induced landslides, characteristics of the soil is a major factor determining the susceptibility to landslides. Detailed studies are to be conducted in Wayanad and Idukki districts where the occurrence of landslides are more*
- *In the era of climate change, extreme rainfall events are going to become increasingly common. Uncontrolled developmental activities at the expense of the environment will severely exacerbate the impacts of climate change. In many areas anthropogenic activities have enhanced the severity of this natural hazard. So it is high time we harmonize our actions as much as possible with the environment.*

- *With the changing climate and changing patterns of rainfall, the behaviour of rivers also change and may deviate from the normal water course and flow through inhabited areas as happened during recent flood. Our land use policy has to be reformed in such a way to accommodate these changes. The flood plains and riverbanks should exclusively be demarcated for growing agricultural crops rather than housing.*
- *The very steep slopes of environmentally fragile areas are to be kept under thick vegetation and cultivation in these areas has to be strictly prohibited which may provoke phenomena like landslide, landslip, land subsidence etc.*

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