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Surface Soil Moisture Measurement during Pre Monsoon Season of Imphal Valley, Manipur: using Multispectral remote sensing data

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ABSTRACT

The study period pre monsoon prevails from March to May. According to an agricultural year in India this period is considered as summer cropping season. The rain fall also drop down mostly during the months of March and April. Because of seasonal cropping practice, during this period the agricultural fields become open and dry that has direct impact on soil moisture condition. The present study emphasises to evaluate surface soil moisture condition during pre-monsoon in relation to land surface temperature and vegetation cover of Imphal valley using open source multispectral remote sensing data. The extracted result shows that as surface temperature highest in Imphal East followed by Imphal West. Concerning soil moisture Imphal East is more vulnerable to dry soil moisture condition followed by Imphal West. Further the C factor (Cover management factor) is evaluated for the study area as dry soil moisture condition also triggers top soil erosion. The study as tries to establish the correlation between the surface variables to evaluated the dependency ratio.

KEYWORDS: Rainfall, NDVI, surface temperature, soil moisture, C-factor

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INTRODUCTION

Soil water is the major component of the soil in relation to plant growth and agricultural production. The dynamics of soil moisture represent a component of the overall water balance and may be regarded as the single most important variable defining the fresh water availability[1]. Soil moisture plays a critical role in crop growth and vegetation restoration in semi-arid environment and is also an important factor in hydrological modelling[2]. It has been reported that differences in land that produce a change in the soil properties and evapotranspiration are likely to increase soil moisture variability across the landscape[3]. Soil texture is the most influential factor that controls the surface soil moisture condition, however topography, climatic condition, vegetation cover and land use also may have their impact on soil moisture.

Imphal valley is located in the central part of the state covering an area about 1843 sq. km. It virtually comprises of four districts viz, Imphal East, Imphal West, Bishnupur and Thoubal district. Holding 70% of total population of the state, this central part of Manipur also has high population pressure. The valley is very much significant in terms of agriculture due to its topographical condition, rainfall pattern, land use/land cover, and seasonal cropping pattern. Thus the area is primarily taken as a sample site for testing soil moisture measurement during per monsoon period using multispectral open source remote sensing data. The study is carried out for the month of March 2017.

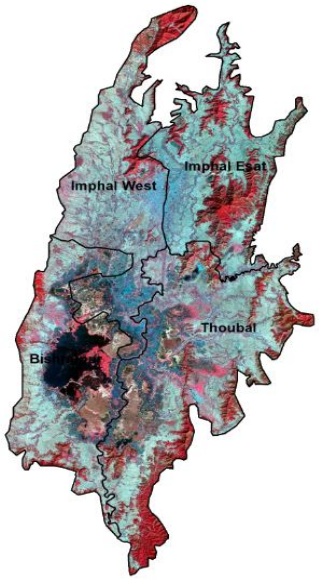

Fig 1: Landsat 8 OLI/TIRS Date: 11March

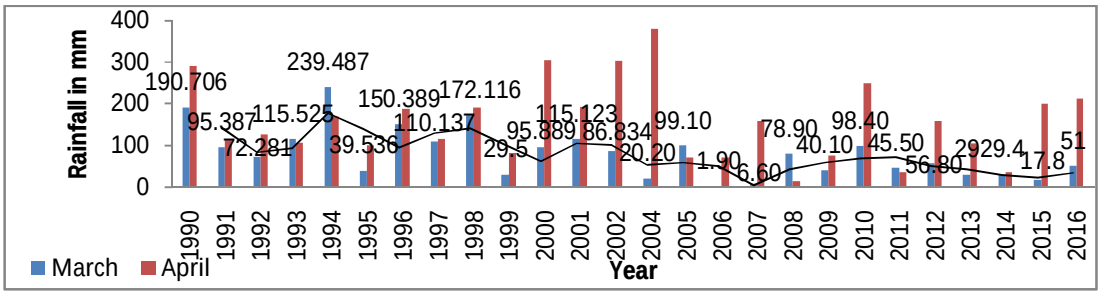

Fig 2: Rainfall pattern in Imphal valley for the month of March and April (IMD)

According to I M D (Indian Meteorological Department) rain fall data, from the year 2004 onwards Imphal valley was recorded a sudden drop down in rain fall mostly in the month of March

in comparison to previous records. In the year 2004 it was only 20.20 mm rainfall received in the month of March and in the year 2006 it was drop down to 1.60 mm. followed by in the year 2007 it was 6.60 mm, in 2015 it was 17.8 mm. Where as in the year 1994 it was recorded 139.48 mm, followed by 1990 it was 190.70 mm, in 1998 it was 172.11 mm.

MATERIALS AND METHODS

The index of soil moisture (SMI) is based on the actual content of water capacity and wilting point[4]. The concept was first put forward by Frank Veihmeyer and Arthur Hendrickson assumed that the water readily available to plants is the difference between water content at field capacity and permanent wilting point. The algorithm that applies here to calculate SMI function is based on NDVI and LST which are calculated using multispectral satellite imagery for each pixel. There are different presenting modes for SMI. The study follows the Michigan Tech Research Institute (2009) that represents SMI values from 0 to 1 where higher values close to 1 represent higher estimated soil moisture levels. The study is based on open source satellite sensor Landsat 8 OLI/TIRS level1. Date: 11March 2017 Path: 135 Raw:43 (Source USGS). Total numbers of Bands are 11. Necessary bands for the calculation of Normalized Difference Vegetation Index (NDVI) are Red (Band 4) and Near Infrared (NIR, Band 5) and thermal Infrared (TIR, Band 10&11) bands are used for the Land Surface Temperature (LST) calculation. The spatial resolution of the used bands is 30 meter for all layers. The study area comes under UTM Zone 46N with WGS84 datum. Selected area of interest is primarily cloud free. In the procedure of Landsat data pre-processing, atmospheric as well as radiometric correction were performed using QGIS SCP plug-in software.

NDVI= (NIR-Red)/ (NIR+ Red)

For extraction of LST, single window algorithm is used: LST= BT/1+w*(BT/P)*ln(e)

Where BT= Satellite Brightness Temperature

W= Wave Length of emitted radiance (11.5μm)

P=h*c/s(1.438*10-2mk),

P=14380,

h= Planck's constant (6.626*10-34 Js),

s=Boltzmann Constant (1.38*10-23 J/K),

c= Velocity of light (2.998x10-8 m/s) [5]

Soil moisture (SMI)= (LSTmax – LST) / (LSTmax – LSTmin) [6]

C factor= (-NDVI+1)/2 [7]

RESULT AND DISCUSSION

NDVI value ranges between 0 to .59 and mean value is 0.295. Most of the area are comes under moderate to high vegetation cover. The healthy vegetation can be seen mostly in hilly ridges of West Imphal, East Imphal and Thoubal district and the value ranges between.59 to.58. Area showing very low vegetation cover is Loktak lake of Bishnupur district, some "*Jhum*" patches of East Imphal and Thoubal district. Regarding LST ranges between 14.89º to 36.01 º C and the mean value is 25.45º C that represents comparatively warm land surface. Towards Loktak Lake, it is showing low surface temperature whereas areas with very high healthy vegetation cover showing very low surface temperature. The notable are some patches of East Imphal and Thoubal, despite of healthy vegetation showing very high surface temperature. It could be due to temperate deciduous forest of mid latitude (20º-50º) and its moderate cooling effect during daytime [8.] About 851.16 sq. km of the total geographical area of the valley comes under low to very low surface temperature. On other hand 709.9 sq. km comes under high to very high surface temperature.

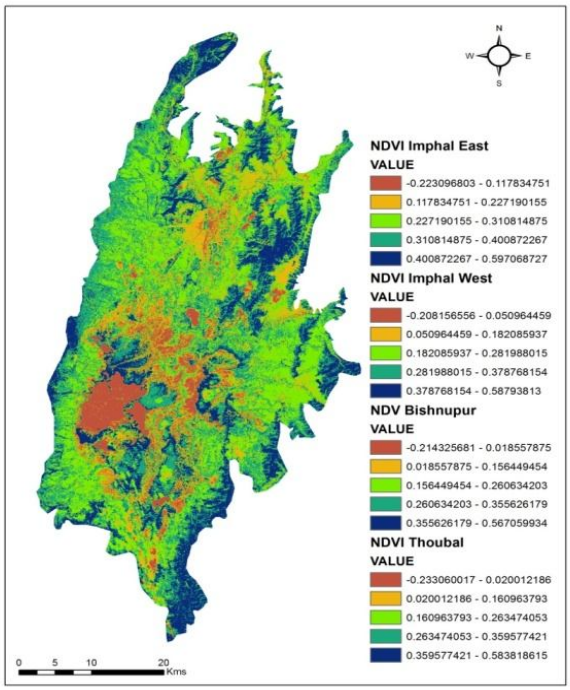

Fig 3: NDVI

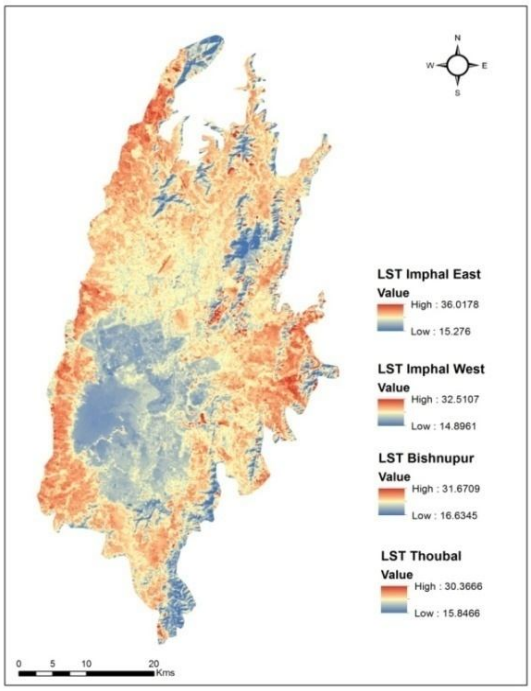

Fig 4: Surface Temperature

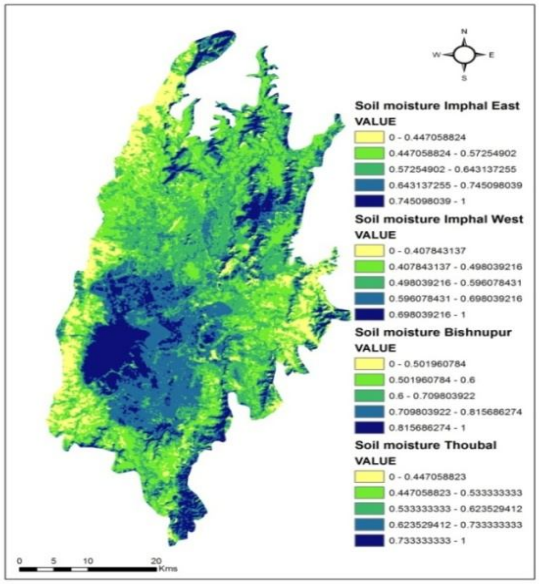

Fig 5: Surface Soil Moisture

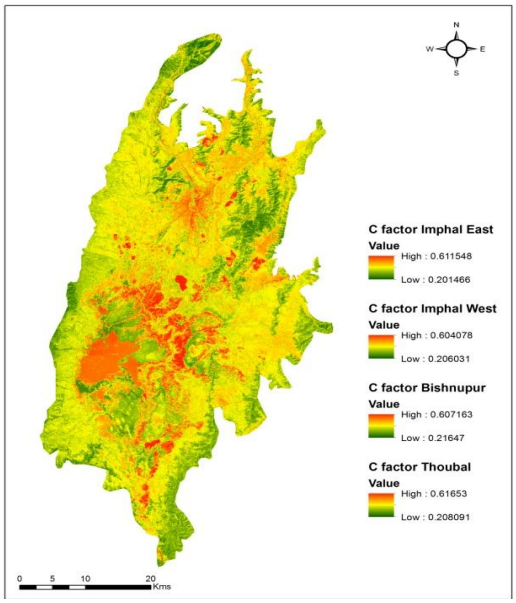

Fig 6: Cover management factor

Combing both surface temperature and NDVI soil moisture is generated that shows most of the valley covered by low to moderate soil moisture during pre-monsoon period. Soil moisture ranges between the values 0 to 1 and the mean value is .5, which shows dry state of soil. A considerable area around Loltak Lake is showing high soil moisture condition, due to its water logged situation. The hilly ridges of West Imphal and Bishnupur district are showing lowest soil moisture condition during this period. The total area comes under dry soil moisture condition about 732.73 sq km and 792.82 sq km comes under high to very high soil moisture condition. By extracting water pixel using SWIR (LISS III, Band 4) area shows highly moist and very much susceptible to flood during monsoon.

Cover management (C) is the ratio of soil loss of a specific crop under the condition of continuous bare fallow[9]. The amount of protective coverage of a crop for the surface of the soil influences the soil erosion rate. C value is equal to 1 when the land has continuous bare fallow and have no coverage. C value is lower when there is more coverage of a crop for the soil surface resulting in less soil erosion[10]. Further calculating the C factor using NDVI it is found that, almost entire valley is moderate cover management condition where soil moisture also showing moderate condition, C is a function of; $C = PLU \times CC \times SC \times SR \times SM$ [11] . Where C is the overall cover management factor, PLU is the prior land use surface, CC is the canopy cover surface, SC is the surface cover sub factor, SR is surface roughness sub factor and SM is the soil moisture sub factor. It shows C factor is a depended variable of Soil moisture.

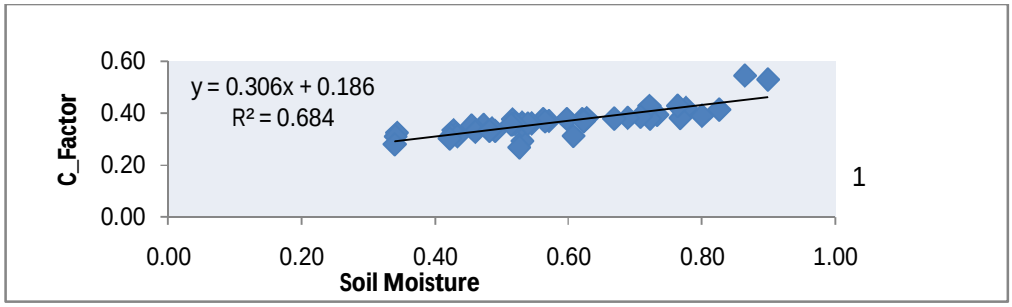

Fig 6: Cover management factor

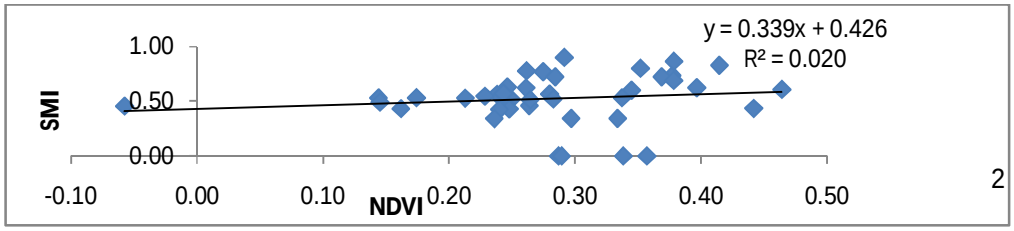

Fig 7: Correlation between Soil Moisture and C Factor

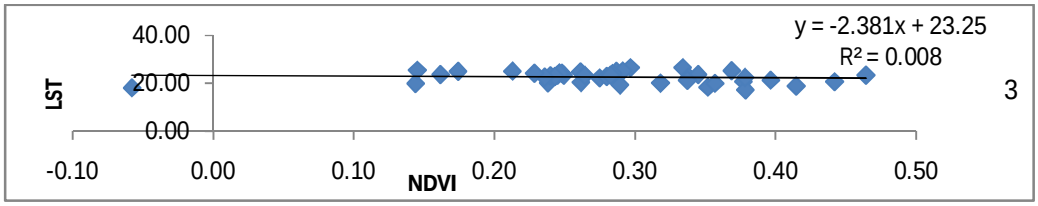

Fig 8: Correlation between NDVI and Soil Moisture

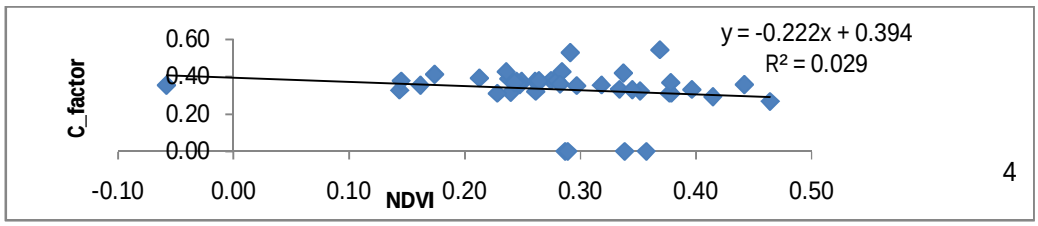

Fig 9: Correlation between NDVI and Land Surface Temperature

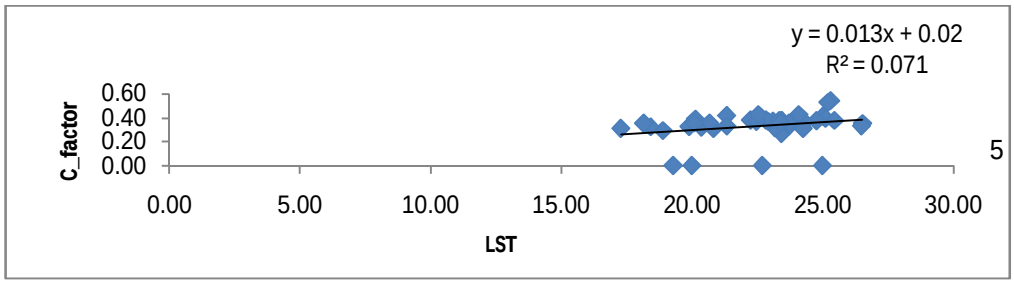

Fig 10: Correlation between NDVI and C- Factor

The above graphs are based on 45 test points that extract values all four layers as NDVI, land surface temperature, soil moisture and cover management factor (C-factor).With the help of co relation regression it is tried to established the relationship between all the variables. It is found out that soil moisture and C- factor are showing significant positive relationship (showing graph no 1). Whereas there is no strong significant relationship can be seen between the other variables (showing 2, 3, 4.and 5). Though the variables have their impact on each other but there is a very low level of significant level between them. This proves that apart from these there are other parameters that have deeper influence in land surface temperature as well as surface soil moisture.

Table 1: Area covered by adopted parameters

Range	NDVI	LST	SMI	C – factor
	Area in Km2	Area in Km2	Area in Km2	Area in Km2
Very High	182.04	245.48	206.98	357.85
High	265.37	457.42	585.84	599.4
Moderate	656.26	558.12	586.63	681.38
Low	619.6	613.03	472.47	283.71
Very Low	388.91	238.13	260.26	189.84

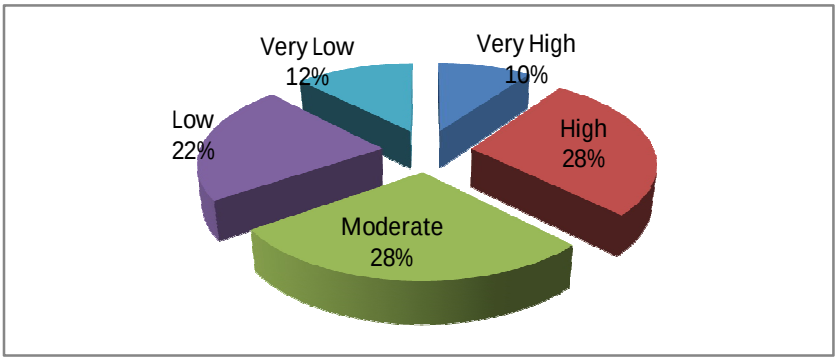

Fig 12: Area under Surface Soil Moisture

Indian agricultural practices mostly based on monsoonal rainfall that makes it very much seasonal. According to Indian agricultural system, North East India agriculture practices is primarily subsistence farming. Most of the crops are cultivated during *Rabi* season (October to March) and *Kharif* season (June to October). The present study is based on summer season (March to June) also called the *Zaid* season. The crops are grown on irrigated land and main products are seasonal fruits and vegetables. Due to Manipur state agriculture system and its geophysical condition the present study is trying to evaluate the land surface conditions during the month of March as the month received less amount of rainfall and agricultural land becomes as seasonal agricultural fellow. Evaluation of surface soil moisture condition can also help better management of agricultural practices for sustainable management of surface water during the pre-monsoon period. The study shows that high vegetation cover represents low surface temperature. Whereas low surface temperature shows high soil moisture condition that also represents low C-factor. About 473.55 sq. km of total valley area comes under low to very low cover management factor, 681.31 sq. km area under moderate type of cover management factor, whereas 957.25 sq. km area comes under high to very high cover management factor Extraction of soil moisture and soil cover management will also help soil erosion study.

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