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Spatial variability of soil nutrients and GIS-based nutrient management in upland of Tamil Nadu: A case study from Valapadi Block, Salem district

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Abstract
Spatial distribution of soil nutrients is not normally considered for small holder farms in Tamil Nadu resulting in blanket fertilizer application which leads to low efficiency of some applied nutrients. This study focuses on applying geospatial analyses to map from 39 revenue villages of Valapadi block of Salem district, Tamil Nadu to identify nutrient distribution. Soil samples were taken from these 640locations and analysed soil reaction, EC, OC, major nutrients viz. nitrogen (N), phosphorus (P) and potassium (K) and micro nutrients (Fe, Mn, Cu and Zn). Spatial models of the contents were generated through geo statistical analysis to map the status of N, Pand K nutrients across the locations. Study results indicated that proportion of area of soils are neutral (56.1%) and non saline. Low OC was distributed in 68.2% area and low in available N (91.5%), P (39%) and K (52.8%) respectively. The soils are deficient in Zn (37.3%) and sufficient in Fe (75.6%), Cu (80.7%) and Mn (97.0%).Distribution pattern for P, K, Cu and Mn were rated of low to high and mapped. Outcome of this study could enhance site-specific nutrient recommendation in upland of Tamil Nadu.

Keywords: Fertility status, mapping, spatial variability, upland, Tamil Nadu

Introduction
Soil is a dynamic natural body which develops as a result of pedogenic natural processes during and after weathering of rocks. It consists of mineral and organic constituents, processing definite chemical, physical, mineralogical and biological properties having a variable depth over the surface of the earth and providing a medium for plant growth (Biswas and Mukherjee, 1994) [2]. Soil is a heterogeneous, diverse and dynamic system and its properties change in time and space continuously (Rogerio *et al.,* 2006) [10]. Soil which is a natural resource has variability inherent to how the soil formation factors interact within the landscape. However, variability can occur also as a result of cultivation, land use and erosion. Salviano (1996) [11] reported spatial variability in soil attributes as a result of land degradation due to erosion. Spatial variability of soil properties has been long known to exist and has to be taken into account every time field sampling is performed and investigation of its temporal and spatial changes is essential.

Agriculture is the main economic activity in the upland of Tamil Nadu. majority of the population in the region are smallholder farmers and about 80% of the land area is used for cropping. The soils are poor in nutrient levels due to improper fertilizer rates application and poor land management contribute to the low contents of nutrients in these soils. This had resulted to persistently low crop yields (Vasu *et al.,* 2017) [16]. To increase the productivity of these soils for enhanced crop yields and increase the income of smallholder farmers, spatial distribution of the soil nutrients needs to be mapped and based on the results of the distribution, appropriate fertilizer needs could be recommended for village wise intervention. In addition, adoption and implementation of soil fertility management concepts may vary, it is, therefore, necessary to assess the soil nutrient levels within locations where smallholder farmers are cropping (Srinivasan *et al.,* 2020) [14]. The mapped results of the soil nutrient assessment could then be used for effective monitoring of changes that might occur between cropping systems and seasons overtime.

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Monitoring of the nutrient levels will enable stakeholders to assess soil fertility improvement or otherwise in such localities. The tedious and costly conventional methods needed to obtain soil nutrient information will also be reduced when nutrient levels are mapped because those conventional methods are no more affordable (Behrens and Scholten, 2006) [1]. Accordingly, mapping of the nutrient levels will provide spatial soil nutrients information that can be used as a decision support tool. Hence, developing spatial distribution maps of soil nutrients is important in upland soils and it will help refine agricultural management practices, improve sustainable resource use as well as provide a base against which future soil nutrients can be recommended at site-specific locations (Fairhurst *et al.,*2004) [3]. Keeping in this facts case study was attempted in Valapadi block of Salem district of Tamil Nadu to assess the spatial soil fertility status for management.

Materials and Methods
Study area
Valapadi block is located on the central part of Salem districtin Tamil Nadu (Fig.1). It is bounded by Ayodypattanam block in the West, Dharmapuri district in the North, Peddanaickanpalayam block in the East, Panamarathupatti and Namagiripettai block of Namakkal district in the South. The area lies between $11^0 31' 53''$ to and $11^0 52' 05''$ North latitude and $78^0 59' 21''$ and $78^0 28' 28''$ east longitude. The annual rainfall of 892.3 mm and mean annual temperature of 26.8 ^{0}C. The total geographical area of the block is 18,551 hectares, which constitutes about 2.4% of the area of the district. The block has 39 revenue villages. The major crops cultivated are tapioca, sorghum, coconut, groundnut, cotton and vegetables.

Field Studies
Detailed soil survey was carried out in Valapadi block of Salem district covering an area of 18,551 hectares at 1:10000 scale, Soil series at phase level classification were done and the boundaries were incorporated in respective village level cadastral maps of the block. A total of 640 surface soil samples were collected from 39 revenue villages at 0-15 cm soil depth by adopting standard procedures. The Geo references were marked in each sampling site and mapped.

Soil analysis
The soil samples were collected village wises (15 cm depth), air dried, processed, sieved using 2 mm sieve and used for determination of soil physical and chemical characteristics viz., Soil pH and EC were determined using the procedures as described by Jackson (1973) [4]. Soil organic carbon was determined by the wet oxidation method (Walkley and Black, 1934) [18]. The available nitrogen (N) was estimated through alkaline permanganate method as suggested by Subbiah and Asija (1956) [15]. The assessment of available phosphorus by using 0.5M NaHCO$_3$ extract as described by Olsen *et al.* (1954) [8] and available potassium was estimated by flame photometer after extraction with Neutral normal ammonium acetate solution (pH 7.0). The available micro nutrients (Fe, Mn, Cu and Zn) were extracted using DTPA (Lindsay and Norvell, 1978) [5] and their concentrations were determined using atomic absorption spectrophotometer.
Making use of the number of samples in each category, the percent sample category and Nutrient Index Value (NIV) were computed using the formulae furnished below.

$$\text{Percent sample category} = \frac{\text{No of low or medium or high category}}{\text{Total number of samples}} \times 100$$

Nutrient index and fertility rating:
Nutrient index value was calculated from the proportion of soils under low, medium and high available nutrient categories, as represented by

$$NIV = \frac{(PL*3)+ (PM*2)+ (PH*1)}{100}$$

Where,
NIV =Nutrient Index Value
P_L, P_M and P_H are the percentage of soil samples falling in the category of soil samples falling in the category of low, medium and high nutrient status and given weightage of one, two and three respectively (Ramamoorthy and Bajaj,1969) [9]. The nutrient index values were rated in to various categories viz., low (<1.67), medium (1.67- 2.33) and high (>2.33) for OC and available N,P,K. For available micronutrients, the ratings are very low (<1.33), low (1.33-1.66), marginal (1.66-2.00), adequate (2.00- 2.33), high (2.33-2.66) and very high (>2.66). The villages are categorized into different fertility ratings based on percent sample category and NIV.

Generation of soil fertility maps
Database on soil available nutrient status was imported in to GIS environment and soil fertility maps generated by Krigging method using Arc-GIS software version 10.1 only highly variable soil properties (pH, OC, P, K, Cu and Mn) rest will be omitted. The available nutrients were generated by categorizing the fertility status as 'Low', 'Medium' and 'High' by showing appropriate legend.

Results and Discussion
pH and Electrical conductivity
The pH of the surface soil ranged from 6.0- 8.9 with an overall mean of 7.7 and about 43.9% of the samples were found to be alkaline (Tables. 1 and 2). Percent sample category indicated that 0 percent under acidic, 56.1 percent under neutral and 43.9 percent under alkaline pH. The electrical conductivity of the soil ranged from 0.1 to 0.5 dsm^{-1} with a mean of 0.13 dsm^{-1}.All the village soils of Valapadi block are non saline in nature, which might be due to proper land management and inherent properties of soil (Sharma *et al.,* 2008) [13].

Organic carbon
The organic carbon status of the soil samples ranged from 0.1 to 1.81 with a mean value of 0.44 percent (Table. 1and 2). The status was high in singipuram village (1.81%) followed by Thirumanur, Ponnarampatti and Belur (1.37%) and the least was observed in Keeraipatti village (0.1%). Organic carbon status 68.2, 27.7, 2.6 percent found to be low, medium and high respectively. Nutrient index values ranged from 0.4 to 1.27 with low to high fertility rating (Table. 3). These results confirmation with the findings of Maragatham *et al.* (2014) [6].

Available N, P and K
The available nitrogen status in the surface soils ranged from 54.3 to 615.5 kg ha^{-1} with an overall mean value of 170.7 kg ha^{-1} (Tables 1and2). Among the villages highest percentage of

low available N status (100%) recorded in 21 villages. Nutrient index value for available nitrogen ranged from 1.0 to 1.93 (Table. 3). The overall fertility rating for available nitrogen status was found to be low. As majority of soils are light textured, alkaline and calcareouness in nature, the applied nitrogenous fertilizer would have resulted in low amount of available N in the soil. These results confirmation with the findings of Sharma *et al.* (2008) [13].

The available phosphorus ranged from 2.2 -128.4 kg ha^{-1} with over all mean value of 24.2 kg ha^{-1}. The overall percent category under low, medium and high was 39, 23.6 and 37.4 respectively. Among the villages higher percent of available P was observed in Somampatti, A. Valapadi, Kavarkalpatti and sendrayampalayam villages. Higher percentage of low category was reported in Mettur, Chinnakuttimaduvu, Kumarapalayam, Sandhumalai villages. This high status of P in majority of the soils may be attributed to continuous application of phospatic fertilizers to crops, which would have resulted in buildup of phosphorus. These results are confirmation with the findings of Sharma *et al.* (2008) [13].

The overall range values recorded for available potassium status in the surface soils of different villages of Valapadi block were 62 to1235 kg ha^{-1} with a mean values of 393.5 kgha^{-1}.Among the villages highest available K was observed in Pungamaduvu, Keeraipatti and Chinnakuttimaduvu villages. The lowest K status was observed in Mannaykanpatti, Neermulli kuttai and Singipuram villages. The percent of sample category under low, medium and high ranged from 10.5, 36.7 and 52.8 percent respectively. The higher status of available K is attributed to the prevalence of illite - a potassium mineral in these soils. These results are in confirmation with findings of Maragatham *et al.* (2014) [6].

Available micro nutrients
The range and mean values of micronutrients status in the soils of Valapadi block villages revealed (Table. 4) that the available zn status from 0.1 to 20.1 mgkg^{-1} with mean value of 1.6 mgkg^{-1}. Among the villages, highest available Zn was observed in Tukkiyampalayam, Jamboothumalai, Vepiilaipattipudur, Kumarapalayam and Keeraipatti villages. The lowest Zn status was observed in Vettaikaranur followed by Kumarapalayam and Pudupalayam villages. The available zinc status was 37.3 percent deficient 28.3 moderate and 34.4 percent sufficient respectively. Nutrient index value for available zinc ranged from 1.0 to 3.0, present results (Table.5) are in the line with findings of Velu *et al,* (2008) and Sellamuthu *et al* (2015) [12]. The conversion of zinc cations to their oxides or hydroxides at higher pH, which are known to have lower solubility might be the reason for low zinc status, while the available copper status varied from 0.2 to 18 mgkg^{-1} with a mean value of 2.2 mgkg^{-1}. Among the villages, highest available Cu was observed in S. valapadi, Karungalpatti and Sandhumalai villages. The lowest Cu status was observed in Kattuveppillaipatti followed by Kumarasamiyur and Pudupalayam villages. Nutrient index value for available copper ranged from 1.1 to 3.0 (Table. 5). The available copper

status was found to be 19.3 percent deficient, 30 percent moderate and 50.7 percent sufficient in the villages of Valapadi block. Agricultural practices can add copper to soils through application of manure or inorganic fertilizers (Novoa-Munoz *et al.,* 2007) [7].

The available Fe status varied from 1.1 to 113 mgkg^{-1} with a mean value of 11.9 mgkg^{-1}. Among the villages, highest available Fe was observed in Kavarkalpatti, Sendrayanpalayam, Mannaickanpatti and Sandhumalai villages. The lowest Fe status was observed in Thirumanur followed by Singipuram and Malayalapatti villages. The available iron overall status was 24.3 percent deficient, 34.6 percent moderate and 41.1 percent sufficient. Nutrient index value for available iron ranged from 1.15 to 3.0. The available Mn status varied from 1.1 to 44.8 mgkg^{-1} with a mean value of 15.9 mgkg^{-1}. Among the villages, highest available Mn was observed in S. valapadi, Kavarkalpatti, Sendrayampalayam village followed by Mannaickanpatti and Sandhumalai villages. The lowest Mn status was observed in Thirumanur followed by Singipuram and Kolathukombai villages. Available Mn status was 3.0 percent deficient 10.7 percent moderate and 86.3 percent sufficient respectively. Over all mean values revealed that the available Cu, Fe, and Mn levels are sufficient to meet the crop demand. On average available zinc was predominantly deficient in all the villages (37.3). Almost all the villages had sufficient iron availability.

Spatial mapping of soil pH, EC and organic carbon
With regard to soil pH, the soils are predominantly alkaline followed by neutral. Out of total area 56.1 and 43.9 percent of the area is under neutral and alkaline respectively (Fig. 2). In the case of EC cent percent of the area is under non saline condition. The organic carbon status was predominantly low, accounting 68.2 percent of the total area followed by medium (27.7%) and high (2.6%) status (Fig. 3).

Spatial mapping on available N, P, K and micro nutrients
The soil fertility maps pertaining to 4 parameters (P, K, Cu and Zn) are depicted in Figure 4 to 6 and the percent under different fertility category is furnished in Table 6. Almost 90 percent area was under low available nitrogen and 8.5 percent found to be medium category. In the case of available phosphorus the status was under low, medium and high was 39, 23.6 and 37.4 kg ha^{-1} respectively. About 52.8 percent of the area was under higher available K and 36.7 percent under medium category. With respect to available Zn status 37.3 percent area under deficient category 28.3 percent under moderate category and 34.4 percent area under sufficient category. In the case of available Cu, sufficiency was observed in 50.7 percent sufficient status while moderate status was19.3 percent and deficient 30 percent was observed. About 41.1 percent of the area is under sufficient status for available Fe followed by 34.6 percent moderate and 24.3 percent deficient status. With respect to soil available Mn status 86.3 percent sufficient followed by 10.7 percent moderate and 3.0 percent deficient status.
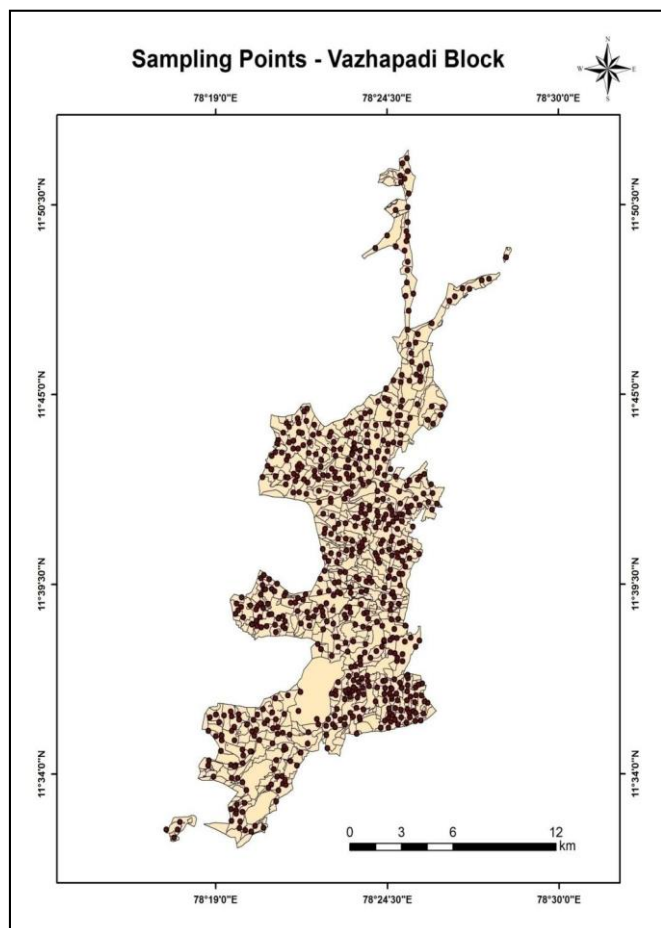
Fig 1: Location map and Sampling points of Study area

Fig 3: Spatial distribution of available soil organic carbon contents in study area

Fig 2: Spatial distribution of available soil reaction in study area

Fig 4: Spatial distribution of available soil phosphorus contents in study area

Fig 5: Spatial distribution of available soil potassium contents in study area
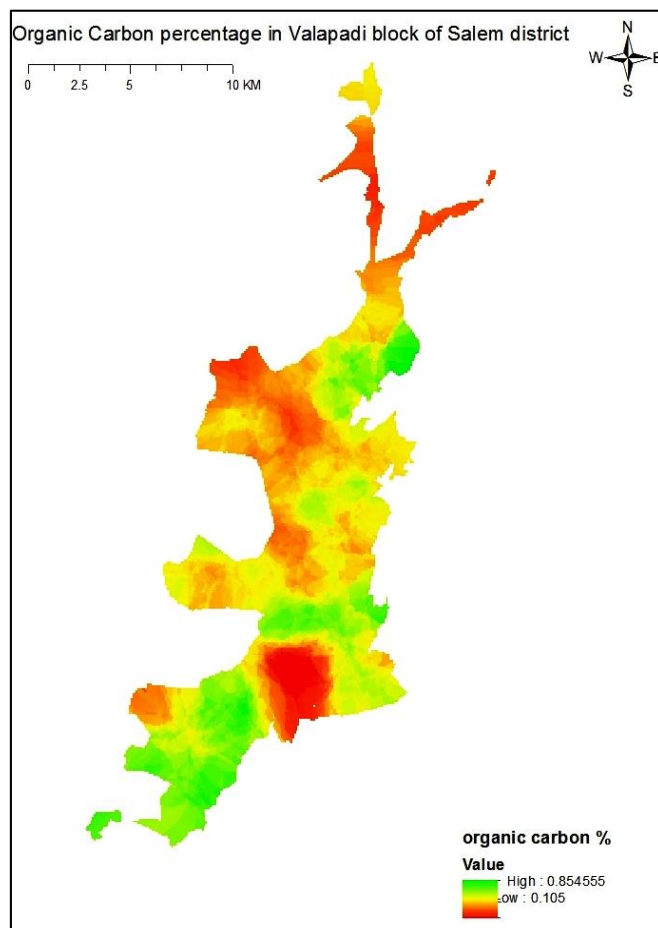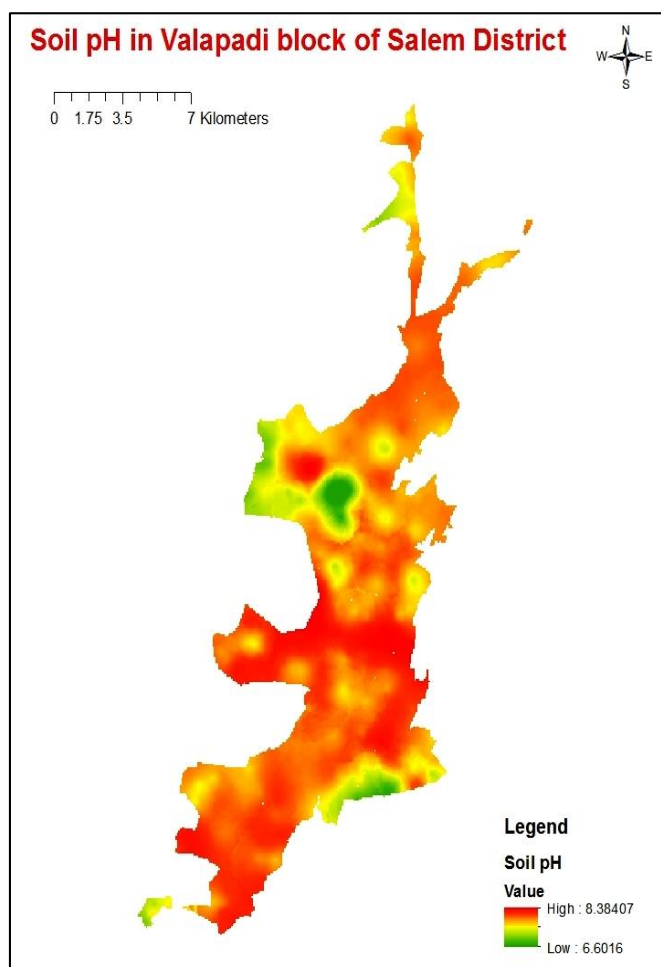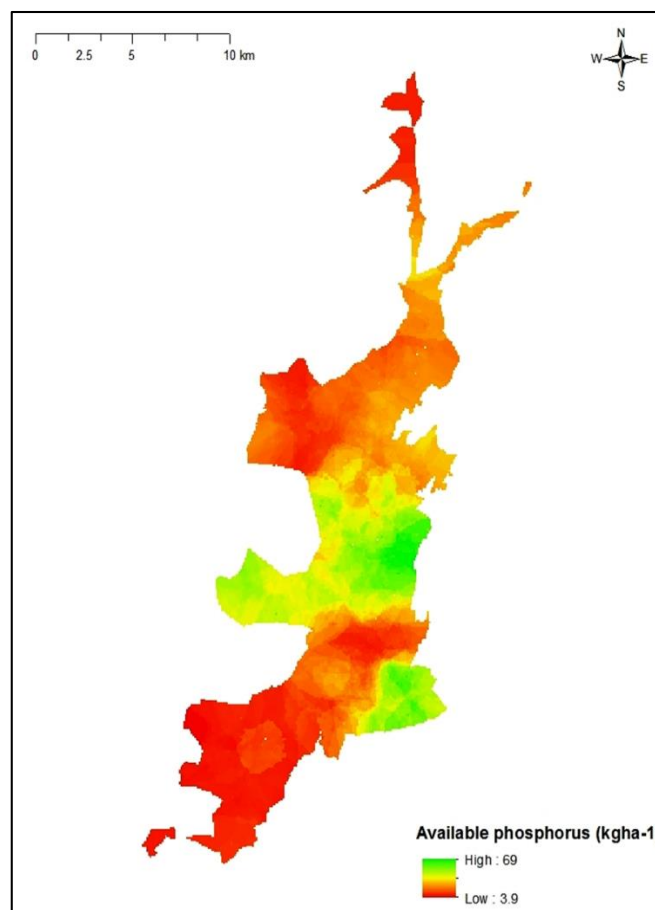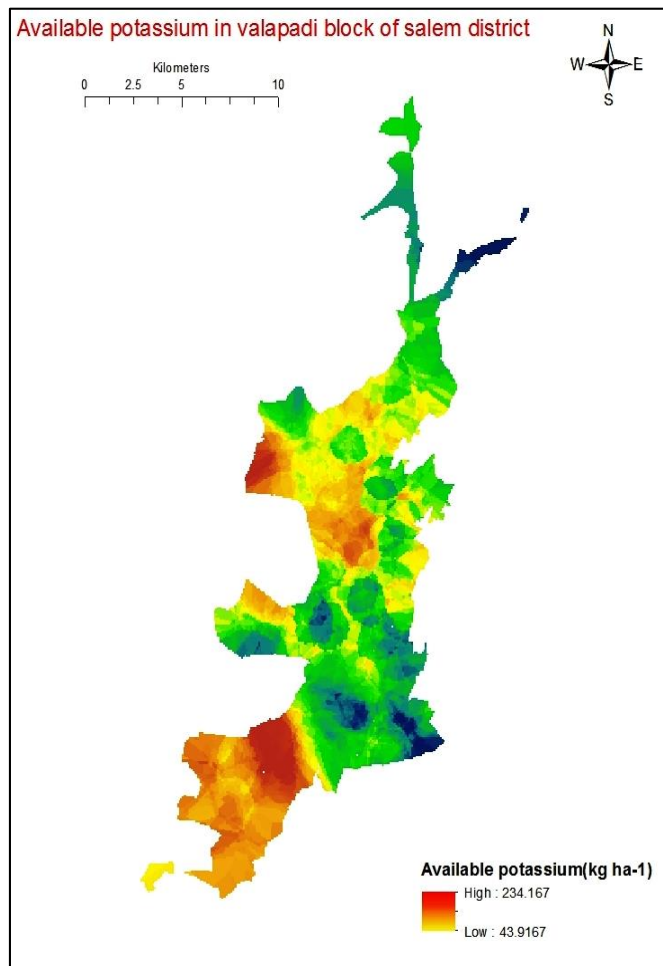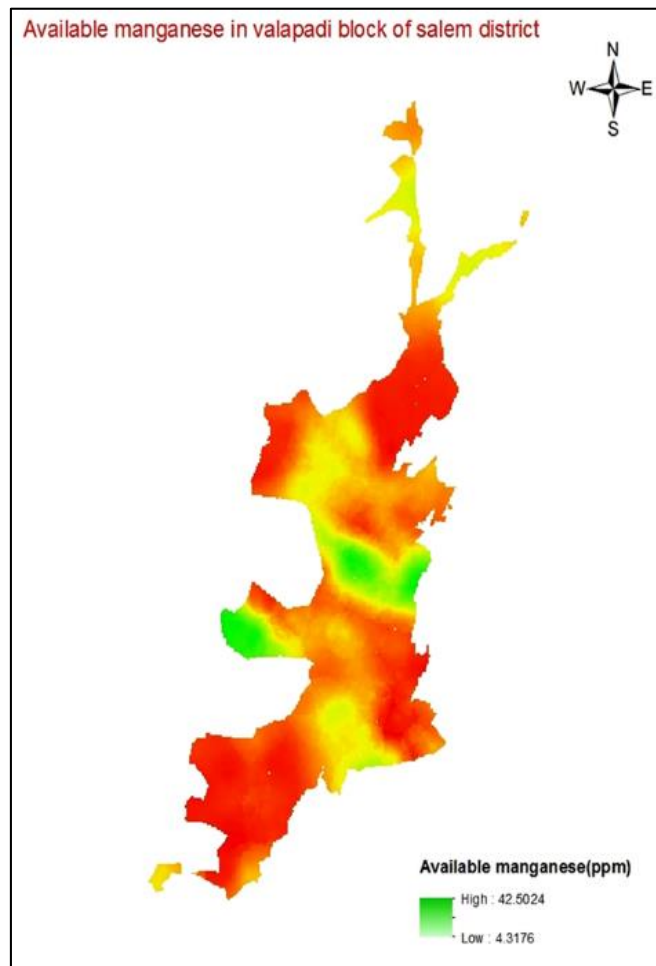

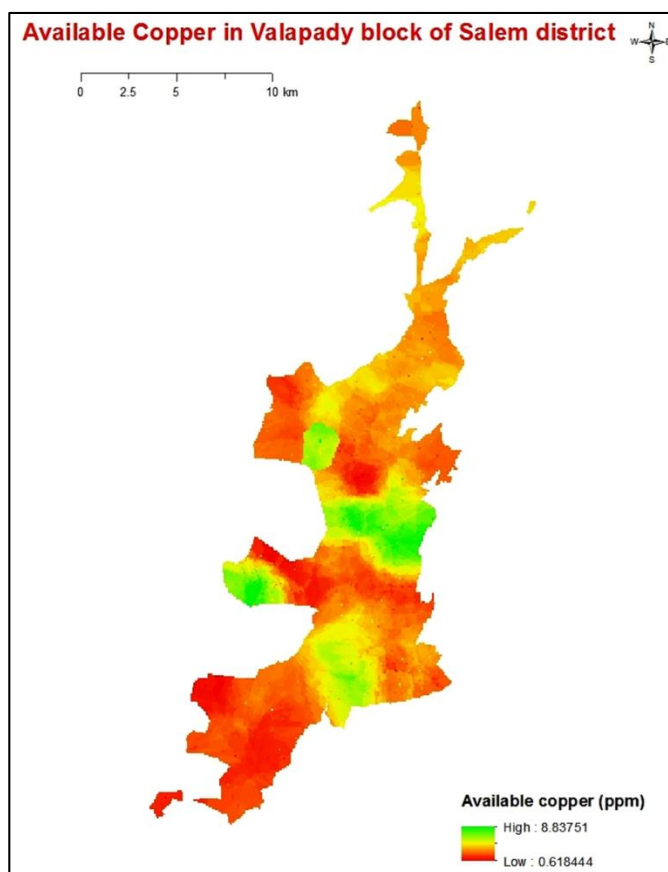**Fig 6:** Spatial distribution of available soil manganese contents in study area

Fig 7: Spatial distribution of available soil copper contents in study area

Table 1: Range and mean of available nutrients in study area

Soil properties	Range	Mean
pH	6.0-8.9	8.0
EC(dsm^{-1})	0.1-0.4	0.2
OC(%)	0.1-1.8	0.4
Available N (Kg ha^{-1})	54-511	173
Available P (Kg ha^{-1})	12-128	16.3
Available K (Kg ha^{-1})	49-1235	363.7
Available Fe (mgkg^{-1})	1.2-113	13.3
Available Mn (mgkg^{-1})	0.1- 44.4	15.1
Available Cu (mgkg^{-1})	0.2-18	2.2
Available Zn (mgkg^{-1})	0.2-20.1	1.2

Table 2: Area percent categorized in village wise

Villges	pH			EC	O.C(%)			N			P			K		
	Ac	Ne	Al	NS	L	M	H	L	M	H	L	M	H	L	M	H
Athanurpatti	0	80	20	100	80	20	0	100	0	0	0	60	40	10	60	30
A.Valapadi	0	10	90	100	77.7	22.3	0	100	0	0	0	0	100	0	33.3	66.7
Belur	0	93	7	100	70.5	29.5	0	96.5	4.5	0	7.4	33.4	59.2	11	37.4	51.5
Chandrapillaivalasai	9	67	33	100	93.9	6.1	0	93.9	6.1	0	78.8	21.2	0	0	45.5	54.5
Chinnakuttimaduvu	0	100	0	100	50	0	50	100	0	0	100	0	0	0	0	100
C.N.palayam	0	100	0	100	92.6	7.4	0	100	0	0	33.4	51.9	14.7	3.7	51.9	44.4
Jamboothumalai	0	100	0	100	25	75	0	75	25	0	50	50	0	0	0	100
KankattiAla	0	100	0	100	100	0	0	77.7	22	0	77.7	22.3	0	0	11.1	88.9
Karungalpatty	0	0	100	100	33.3	66.4	0	100	0	0	66.6	33.4	0	33	0	66.4
Kattuveppilaipatti	0	38.7	61.3	100	65.6	34.4	0	93.2	6.8	0	0	3.5	96.5	14	56	30.2
Kavarkalpatti	0	68.8	31.2	100	68.8	31.2	0	87.5	13	0	0	0	100	13	18.8	68.7
Keeraipatty	0	100	0	100	100	0	0	100	0	0	20	20	60	0	0	100
Kolathukombai	0	80	20	100	100	0	0	86.7	13	0	80	13.3	6.7	0	6.7	93.3
Kumarapalayam	0	100	0	100	33.3	66.7	0	100	0	0	100	0	0	33	66.7	0
Kumarasamiyur	0	90	10	100	90	10	0	50	50	0	0	70	30	20	60	20
Kurichi	0	93.8	6.2	100	57.1	42.9	0	95.9	4.1	0	22.4	42.8	34.8	10	46.9	42.9
Malayalapatti	0	60	40	100	60	40	0	100	0	0	60	20	20	0	100	0
Mannarpalayam	0	45	55	100	65	35	0	95	5	0	0	20	80	5	45	50
Mannayakkanpatti	0	86.6	13.4	100	73.4	26.6	0	6.7	93	0	0	6.7	93.3	40	40.2	19.6
Mettur	0	33.3	66.7	100	44.4	55.6	0	100	0	0	100	0	0	0	11.1	88.9
Mutthampatti	0	0	100	100	82.7	17.3	0	95.7	4.3	0	17.4	4.4	78.2	0	39.2	60.8
Neermulikuttai	0	100	0	100	72.8	27.2	0	100	0	0	11.2	50.4	38.4	50	50	0
Periyakuttimaduvu	0	57.2	42.8	100	71.5	28.5	0	100	0	0	71.5	28.5	0	0	42.9	57.1
Ponnarampatti	0	80	20	100	100	0	0	100	0	0	60	7.5	32.5	0	10	90
Pudhupalayam	0	27.3	72.7	100	80	20	0	100	0	0	6.67	93.3	0	20	80	0
Puluthikuttai	0	100	0	100	88.8	0	11	100	0	0	11.1	33.3	55.6	0	33.3	66.7
Pungamaduvu	0	100	0	100	100	0	0	85.8	14	0	71.5	0	28.5	0	0	100
Sandumalai	0	50	50	100	100	0	0	100	0	0	100	0	0	0	0	100
Sendrayanpalayam	0	40	60	100	30	10	0	100	0	0	0	0	100	0	30	70
Singipuram	0	31.6	68.4	100	36.8	63.2	0	97.3	2.7	0	60.5	26.3	13.2	0	44.7	55.3
Somampatti	0	55	45	100	65	35	0	100	0	0	0	0	100	0	30	70
Svalapadi	0	60	40	100	65	35	0	100	0	0	0	0	100	20	55	25
Thekkalpatti	0	50	50	100	50	50	0	83.4	17	0	77.8	16.7	5.5	0	77.8	22.2
Thirumanur	0	82.9	17.1	100	62.9	37.1	0	71.5	29	0	86	14	0	23	48.6	28.4
Thukkiampalayam	0	60	40	100	6.7	53.5	40	100	0	0	3.4	23.8	72.8	3.4	23.8	72.8
Vepillaipatty	0	60	40	100	35	65	0	95	5	0	80	15	5	50	45	5
Vepillaipattypudur	0	100	0	100	71.5	28.5	0	100	0	0	57.2	28.6	14.2	29	71.4	0
Vettaikaranur	0	100	0	100	100	0	0	100	0	0	0	20	80	20	50	30
Vilaripalayam	0	70	30	100	60	40	0	80	20	0	10	90	0	0	10	90

(Ac-Acidic, Ne- Neutral, Al-Alkaline, Ns-Non saline, SS-Slightly saline, S-Saline, L-Low, M-Medium, H-High)

Table 3: Nutrient index and fertility ratings of OC and Macro nutrients

Villges	N	P	K	O.C	N	P	K	O.C
Athanurpatti	1	2.4	2.2	1.2	Low	High	medium	Low
AValapadi	1	3	2.7	1.22	Low	High	High	Low
Belur	1.05	2.51	2.4	1.29	Low	High	High	Low
Chandrapillaivalasai	1.06	1.21	2	1.06	Low	Low	medium	Low
Chinnakuttimaduvu	1	1	3	1.5	Low	Low	High	Low
Chinnamanaikanpalayam	1	1.81	2.4	1.07	Low	Medium	High	Low
Jamboothumalai	1.25	1.5	3	1.75	Low	Medium	High	medium
KankattiAla	1.22	1.22	2.8	1	Low	Low	High	Low
Karungalpatty	1	1.33	2.32	1.66	Low	Low	medium	Low
Kattuveppilaipatti	1.06	2.96	2.16	1.34	Low	High	medium	Low
Kavarkalpatti	1.1	3	2.56	1.31	Low	High	High	Low
Keeraipatty	1	2.4	3	1	Low	High	High	Low
Kolathukombai	1.1	1.26	2.93	1	Low	High	High	Low
Kumarapalayam	1	1	1.67	1.66	Low	Low	Low	Low
Kumarasamiyur	1.5	2.3	2	1.1	Low	Medium	medium	Low
Kurichi	1.04	2.12	2.34	1.43	Low	Medium	High	Low
Malayalapatti	1	1.6	2	1.4	Low	Low	medium	Low
Mannarpalayam	1.05	2.8	2.45	1.35	Low	High	High	Low
Mannayakkanpatti	1.93	2.93	1.79	1.26	medium	High	medium	Low
Mettur	1	1	2.88	1.56	Low	High	High	Low
Mutthampatti	1.04	2.6	2.6	1.17	Low	High	High	Low
Neermulikuttai	1	2.27	1.5	1.27	Low	Medium	Low	Low
Periyakuttimaduvu	1	1.28	2.14	1.28	Low	Low	medium	Low
Ponnarampatti	1	1.72	2.9	0.4	Low	Medium	High	Low
Pudhupalayam	1	1.93	1.8	1.2	Low	Medium	medium	Low
Puluthikuttai	1	2.45	2.66	1.21	Low	High	High	Low
Pungamaduvu	1.14	1.57	3	1	Low	Low	High	Low
Sandumalai	1	1	3	1	Low	Low	High	Low
Sendrayanpalayam	1	3	2.7	1.1	Low	High	High	Low
Singipuram	1.02	1.52	2.55	1.63	Low	Low	High	Low
Somampatti	1	1	2.7	1.35	Low	Low	High	Low
Svalapadi	1	3	2.05	1.35	Low	High	medium	Low
Thekkalpatti	1.16	1.27	2.22	1.5	Low	Low	medium	Low
Thirumanur	1.28	1.14	2.05	1.37	Low	Low	medium	Low
Thukkiampalayam	1	2.69	2.33	1.4	Low	High	medium	medium
Vepillaipatty	1.05	1.25	1.5	1.65	Low	Low	Low	Low
Vepillaipattypudur	1	1.57	1.71	1.28	Low	Low	medium	Low
Vettaikaranur	1	2.8	2.1	1	Low	High	medium	Low
Vilaripalayam	1.2	1.9	2.9	1.4	Low	Medium	High	Low

Table 4: Area percent category of soil available Micro nutrients in village wise

Villages	Fe			Mn			Zn			Cu		
	D	M	S	D	M	S	D	M	S	D	M	S
Athanurpatti	0	70	30	0	0	100	80	20	0	10	70	20
AValapadi	0	66.7	33.3	0	11.1	88.9	78	22	0	0	22	78
Belur	3.7	77.7	18.6	0	0	100	48.1	51.8	0	11.1	40.7	48.2
Chandrapillaivalasai	3.1	51.5	45.4	0	0	100	9	36.4	54.9	15.2	30.3	54.5
Chinnakuttimaduvu	50	50	0	0	0	100	50	0	50	50	0	50
C.N.palayam	0	7.4	92.6	0	3.7	96.3	22.2	70	8	8	8	84
Jamboothumalai	0	50	50	0	0	100	0	0	100	75	25	0
KankattiAla	55.5	11.1	33.4	0	0	100	22.2	11.1	67	0	22	78
Karungalpatty	0	100	0	0	0	100	33.3	33.3	33.4	0	0	100
Kattuveppilaipatti	3.5	31	65.5	0	10.3	89.7	79.1	10.3	11	89.4	10.6	0
Kavarkalpatti	0	0	100	0	0	100	31.3	37.5	31	6.3	6.3	87.4
Keeraipatty	40	60	0	0	0	100	0	0	100	0	40	60
Kolathukombai	80.4	13.3	6.3	6.7	0	93.3	20	40	40	13.4	66.7	19.9
Kumarapalayam	66.7	33.3	0	0	33.3	66.7	0	0	100	0	33.3	66.7
Kumarasamiyur	30	50	20	10	10	80	90	10	0	80	10	10
Kurichi	6.1	42.8	51	0	12.2	88	71.4	24.5	4.1	12.2	22.4	65.4
Malayalapatti	80	20	0	20	80	0	60	20	20	60	40	0
Mannarpalayam	10	55	35	15	40	45	75	20	5	45	20	35
Mannayakkanpatti	0	0	100	0	0	100	6.7	53.6	39.3	0	6.7	93.3
Mettur	0	55.5	44.4	11.1	44.4	44.5	55.5	22.2	22	0	55.5	44.5
Mutthampatti	8.7	21.8	69.5	0	4.4	95.6	64.6	30.5	4	8.8	56.5	34.7
Neermulikuttai	11.2	66.7	22.1	0	5.6	94.4	55.6	22.2	22	11.1	44.5	44.4
Periyakuttimaduvu	28.4	14.3	57.3	0	0	100	57.2	28.6	14	28.6	57.2	14.2

Village												
Ponnarampatti	7.5	37.5	55	0	0	100	5	40	55	5	15	80
Pudhupalayam	6.6	53.3	40.1	0	0	100	86.6	13	0	66.6	33.4	0
Puluthikuttai	11.2	0	88.8	0	0	100	0	55.5	44	0	22.2	77.8
Pungamaduvu	28.6	28.6	42.8	0	0	100	28.6	57.2	14	0	43	57
Sandumalai	0	0	100	0	0	100	0	100	0	0	0	100
Sendrayanpalayam	0	0	100	0	0	100	10	50	40	0	0	100
Singipuram	84.2	15.8	0	42.1	52.6	5.3	7.9	0	89.1	13.2	31.6	55.2
Somampatti	0	15	85	5	20	75	50	30	20	45	10	45
Svalapadi	0	0	100	0	0	100	5	30	65	0	0	100
Thekkalpatti	78.4	21.6	0	0	11.2	88.8	39.2	33.6	27	39	39	22
Thirumanur	85.5	11.5	3	0	20	80	31.3	34	35	40	37	23
Thukkiampalayam	60.1	39.9	0	6.6	23.3	70.1	0	0	100	0	16.7	83.3
Vepillaipatty	40	50	10	0	15	85	30	55	15	10	30	60
Vepillaipattypudur	28.6	57.2	14.2	0	0	100	0	0	100	0	43	57
Vettaikaranur	30	50	20	0	0	100	100	0	0	10	90	0
Vilaripalayam	10	20	70	0	20	80	50	40	10	0	70	30

(D-Deficient; M-Moderate; S-Sufficient)

Table 5: Nutrient index and fertility ratings of micro nutrients

Villages	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Athanurpatti	2.3	3	1.2	2.1	Adequate	Very high	Very low	Adequate
AValapadi	2.33	2.9	1.22	2.78	Adequate	Very high	Very low	Very high
Belur	2.14	1	1.5	2.37	Adequate	Very low	Low	High
Chandrapillaivalasai	2.42	3	2.46	2.39	High	Very high	High	High
Chinnakuttimaduvu	1.5	3	1.5	2	Low	Very high	Low	Marginal
C.N.Palayam	2.93	2.96	1.86	2.76	Very high	Very high	marginal	Very high
Jamboothumalai	2	3	3	1.25	Marginal	Very high	Very high	Very high
KankattiAla	1.79	3	2.45	2.78	Marginal	Very high	High	Very high
Karungalpatty	2	3	1.98	3	Marginal	Very high	marginal	Very high
Kattuveppilaipatti	2.62	2.89	1.32	1.1	High	Very high	Very low	Very low
Kavarkalpatti	3	3	2	2.81	Very high	Very high	marginal	Very high
Keeraipatty	1.6	3	3	2.6	Low	Very high	Very high	High
Kolathukombai	1.26	2.86	2.2	2.06	Very low	Very high	adequate	Adequate
Kumarapalayam	1.33	2.66	3	2.66	Very low	High	Very high	High
Kumarasamiyur	1.9	2.7	1.1	1.3	Marginal	Very high	Very low	Low
Kurichi	2.44	2.88	1.33	2.53	High	Very high	Very low	High
Malayalapatti	1.2	1.8	1.6	1.4	Very low	Marginal	marginal	Low
Mannarpalayam	2.25	2.3	1.25	1.9	Adequate	Adequate	Very low	marginal
Mannayakkanpatti	3	3	2.31	2.93	Very high	Very high	adequate	Very high
Mettur	2.44	2.78	2.78	2.44	High	Very high	Very high	High
Mutthampatti	2.6	2.95	1.39	2.25	High	Very high	Low	High
Neermulikuttai	2.1	2.94	1.66	1.44	Adequate	Very high	Low	Low
Periyakuttimaduvu	2.28	3	1.57	1.85	Adequate	Very high	Low	Marginal
Ponnarampatti	2.47	3	2.5	2.75	High	Very high	High	Very high
Pudhupalayam	2.3	3	1.13	1.33	Adequate	Very high	Very low	Low
Puluthikuttai	2.76	3	2.44	2.77	Very high	Very high	High	Very high
Pungamaduvu	2.14	3	1.85	2.57	Adequate	Very high	marginal	High
Sandumalai	3	3	2	3	Very high	Very high	marginal	Very high
Sendrayanpalayam	3	3	2.3	3	Very high	Very high	adequate	Very high
Singipuram	1.15	1.62	2.75	2.42	Very low	Low	Very high	High
Somampatti	2.85	2.7	1.7	2	Very high	Very high	marginal	marginal
Svalapadi	3	3	2.6	3	Very high	Very high	High	Very high
Thekkalpatti	1.21	2.88	1.88	1.83	Very low	Very high	marginal	Marginal
Thirumanur	1.17	2.8	2.04	1.8	Very low	Very high	adequate	Marginal
Thukkiampalayam	2.63	3	1.9	2.83	High	Very high	marginal	Very high
Vepillaipatty	1.7	2.85	1.85	2.5	Very high	Very high	marginal	High
Vepillaipattypudur	2.42	3	3	2.57	High	Very high	Very high	High
Vettaikaranur	1.9	3	1	1.9	Marginal	Very high	Very low	Marginal
Vilaripalayam	2.6	2.8	1.6	2.3	High	Very high	Low	Adequate

Table 6: Percent area under different fertility categories

Parameters	Acidic/non saline /low/deficient	Neutral/slightly saline/medium/moderate	Alkaline/saline/high/ Sufficient
pH	0	56.1	43.9
Electrical conductivity	100	0	0
Organic carbon	68.2	27.7	2.6
Available nitrogen	91.5	8.5	0
Available phosphorus	39	23.6	37.4
Available potassium	10.5	36.7	52.8
Available iron	24.3	34.6	41.1
Available manganese	3	10.7	86.3
Available zinc	37.3	28.3	34.4
Available copper	19.3	30	50.7

Conclusions

The soil fertility maps clearly revealed that, major area of Valapadi block of Salemdistrict, upland of Tamil Nadu is alkaline, non saline and low in O.C; low, medium and high in available N,P and K respectively. Among the micronutrients, Zn is predominantly deficient. The deficient nutrients have to be restored through chemical fertilizers and/or organic manures to maintain sustainable soil fertility status.

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