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MAPPING OF SOIL PROPERTIES FOR THE STATE OF GOA

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Abstract: **Soil is the most important yet neglected factor in the construction projects. All structures, houses, highways, bridges, dams and even life itself is dependent on soil. Many consumers see soil analysis as a fund loss despite being the cheapest in the construction process, the cost of soil testing is hardly up to one percent of the construction cost. Some contractors also ignore the importance of proper soil research and analysis and base their design on assumed bearing capacity and settlement rate. The present paper is based on mapping all the soil index properties. In this work bore logs are collected from different agencies. The necessary data is extracted from bore logs and mapping of index properties is carried out. These maps will help the engineers and contractors to get a general idea of the soil strata and help them to design the foundations and carry out other construction works.**

Keywords: **GIS, GPS, Index properties, Geotechnical engineering.**

I. INTRODUCTION

The soil is a characteristic material with a variety of physical characteristics, the vast majority of which are not steady and differ from place to place. Index properties of soils are those properties which are primarily used for the identification and classification of soils and which allow the Geotechnical Engineer to predict the suitability of soils as a foundation / construction material (Ramamurthy & Sitharam 2005). Most of the work that was referred included the mapping of few soil properties. Also it was observed that the soil property maps were not available for the state of Goa. In this work an attempt was done to map the index properties of soil. By mapping the soil properties for Goa, it will be very useful for the contractors, geotechnical engineers to predict and suggest the desired foundation and necessary precautions to be taken for improvement of soil and its properties.

II. LITERATURE REVIEW

The Geographic Information System provides powerful tools for inputting data into the database, retrieving selected data items for further analysis, and software modules that can analyze or modify collected data in order to produce the desired information in a specific form (S. Y. Mhaske et al., 2009). The components of the GIS are shown in Figure 1.

Figure 1Basic components of geographic information system (source: www.gisdevelopment.com)

One of the major advantages of the GIS is that it integrates all forms of relevant data either accessible in aerial photographic data, data on remote sensing images, tabular data, etc. These and other data are known to be individual coverage which may be overlaid at the same time, depending on the scope of the analysis (S. Y. Mhaske et al., 2009). Data integration is a link between information in different forms through the GIS as shown in Figure 2.

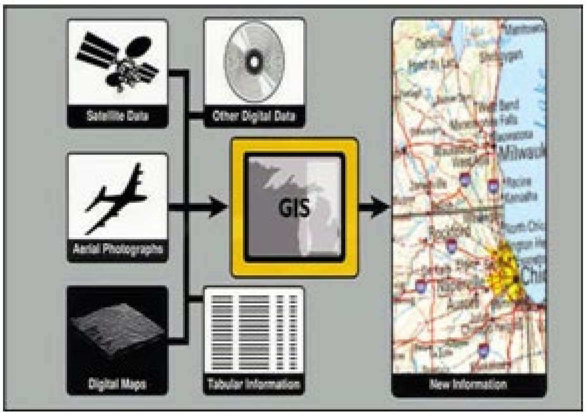

Figure 2Data Integration is the Linking of Information in Different Forms through a GIS (source: http://erg.usgs.gov/isb/pubs/gis_poster/index.html, 2005)

The Global Positioning System is used throughout the world for a wide range of navigation and positioning applications, including navigation on land, in the air and at sea, to identify the precise coordinates of important geographical features as an essential input for mapping and the Geographic Information System (GIS), as well as its use for accurate cadastral surveys, city and city vehicle guidance, earthquake and landslide monitoring, etc. (S. Y. Mhaske et al., 2009).

GPS is primarily a navigation system for positioning in real time. However, with the transformation from ground-to-ground survey measurements to ground-to-space measurements made possible by GPS, this technique overcomes the numerous limitations of terrestrial surveying methods, such as the requirement for intervisibility of survey stations, weather reliability, and night observation difficulties. Such advantages over traditional techniques and operating economy make GPS the most promising surveying tool of the future. With a well-established high accuracy that can be achieved by GPS in the positioning of points separated by a few hundred meters to a hundred kilometers, this unique surveying technique has found important applications in diverse fields (S. Y. Mhaske et al., 2009).

The soil properties can be divided into Index properties and Engineering properties. The main characteristics of engineering are permeability, compressibility and shear strength. A brief overview of the few soil design and index properties is given below (Jumikis 1965, Phadake & Jain 1998):

1. Permeability means the ease with which the water will flow through the soil.
2. Compressibility is related to the deformations which the soil undergoes when it is allowed access to compressive loads.
3. The strength of the shear helps to determine the stability of the slopes, the capacity of the soils and the pressure of the earth on the retaining structures.
4. The specific gravity of the soil solids is the ratio of the density of the given volume of soil solids to the total density of the same volume of pure water.
5. The main characteristics of the soil grains are the size and shape of the grains and the mineralogical nature of the finer fractions. The most significant aggregate property of non-cohesive soils is the relative density, while the cohesion of the soils is the consistency.
6. The moisture content is the amount of water present in the soil voids. It is one of the important factors that will shift the shear strength of the soil.
7. Consistency is the property of materials that demonstrate its resistance to flow. If applied to soil, it means the degree of resistance of fine grained soil to deformation. The water content at which the soil varies from one state to another is referred to as the consistency limits.
8. The dry density of soil mass is the ratio of soil solid mass to soil weight.

For this purpose, soil properties such as specific gravity, moisture content, dry density, wet density and consistency limits such as liquid limits, plastic limits and shrinkage limits are important for the determination of soil engineering properties, which will allow geotechnical engineers to decide on the suitability of soil as basic materials or building materials. If the soil properties are adequately analyzed and the results of soil analysis correctly understood and intelligently applied to the design and construction of earthworks and structural foundations, deficiencies can typically be prevented (S. Y. Mhaske et al., 2009).

III. METHODOLOGY

The work carried out required collection of borelogs, around 200 numbers of borelogs were collected from different agencies.The borelogs were collected from Alcon Constructions, Daftary Descon Engineering Pvt. Ltd., Technik Associates, MILROC Good Earth property and developers, CPWD Goa.The various properties of soil i.e. density, Atterberg's limits, cohesion, angle of friction, water table, specific gravity and soil layer were extracted from soil reports. Database for index properties of soil was created from the boreholes accordingly meeting the requirements of the GIS software (refer Table 1).Overlaying of spatial & non spatial data was done in ArcGIS software in order to obtain the maps. Digitization of the outline of Goa was done using polygon type shapefile. Latitudes and Longitudes of the different borehole locations along with all the soil properties were input in the ArcGIS software to generate all types of maps. With the help of IDW (Inverse Distance

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Weighing) interpolation feature of the software all the maps were interpolated.

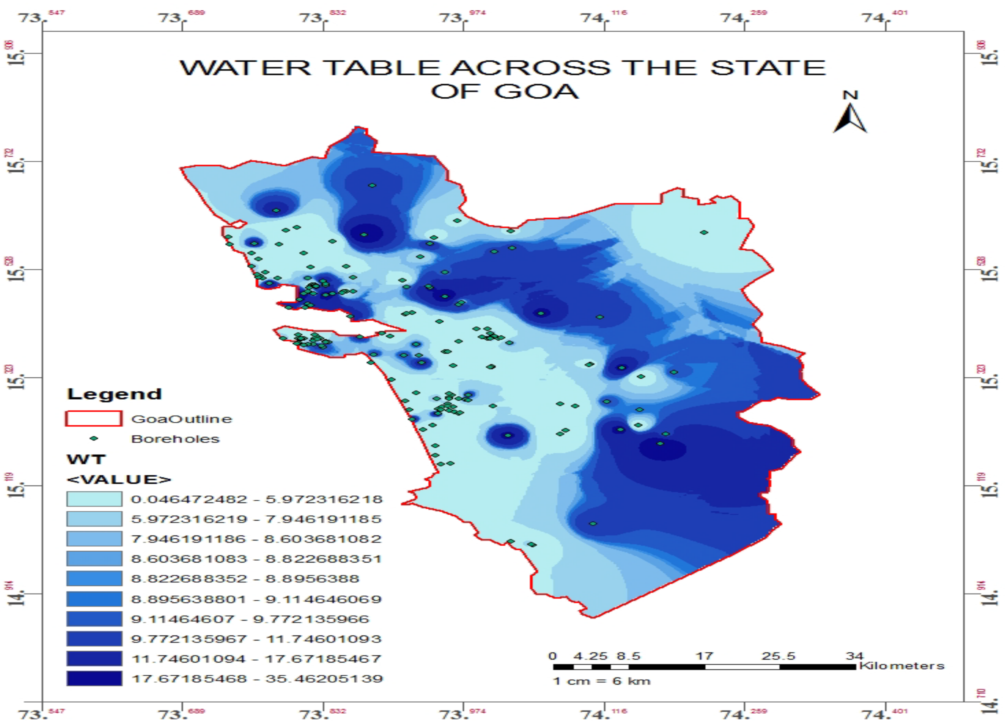
Table 1 Index properties

Place	Depth (m)	Lat	Long	Soil L	Soil Layer	SPT (N)	WT depth (m)	C (kN/m^2)	φ (°)	LL (%)	PL (%)	PI (%)	Υ (gm/cc)	G
Neogi Nagar	1.5	15.498	73.821	2	Lateritic soil with marine clayey silt	2	0.3	15.6	10.2	87.64	40.48	47.16	1.67	2.58
School at Campal	1.5	15.495	73.819	1	Medium sand with silt	13	1.3	0	31.2	0.001	0.001	0.001	1.92	2.72
Caranzalem (Kenny site)	1.5	15.47	73.808	1	Fine sand	16	25.17	0	0.001	0.001	0.001	0.001	0.001	0.001
Tonca, Panaji (Prudential groups)	1.5	15.494	73.825	1	Fine sand with lateritic gravels	15	28.54	0	29.25	0.001	0.001	0.001	1.98	2.68
Panaji (Hotel Nova)	1.5	15.498	73.823	4	Lateritic clayey silt with gravels	4	0.87	16.7	25.6	0.001	0.001	0.001	1.65	2.64
Panaji (Vistar motors portais)	1.5	15.495	73.825	6	Loose silty sand with lateritic gravels	1	1.3	0	0.001	0.001	0.001	0.001	0.001	0.001
Mapusa	1.5	15.607	73.805	5	Stiff silty clay with some sand and lateritic gravels	17	0.43	22.6	14.9	30.4	15.9	14.5	1.87	2.53
Ucassaim, Mapusa	1.5	15.58	73.842	4	Clayey silt	50	1.1	0	23	68	45	23	1.77	2.77
Dry dock , Bainguinim, Old Goa	1.5	15.455	73.814	4	Sandy clayey silt	1	1	0	0.001	0.001	0.001	0.001	0.001	0.001

IV. RESULTS

Typical index properties of Goa are given in Table 1. It is observed that there are the fluctuations in ground water table from 0.3 m to 9.0 m below ground level. The Lateritic formations were available at a depth ranging from 3 m and upto 30 m in different locations in Goa.

The following maps were created for index properties of Goa at a depth of 1.5m.



Map 1 Water table for Goa

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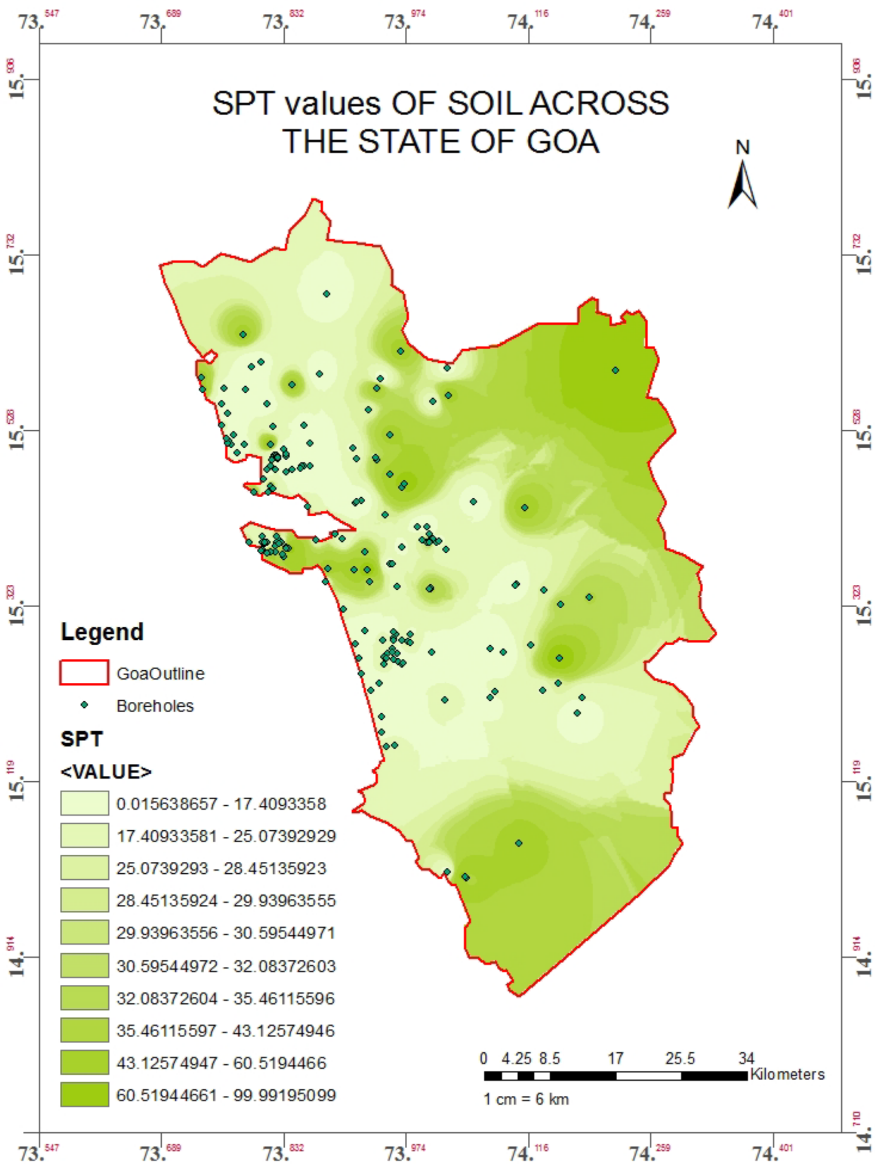
The above Map 1 shows the interpolation of water tables across the map of a Goa.



Map 2 SPT values across Goa

The above Map 2 represents the interpolation of SPT values across the map of Goa at 1.5m depth.

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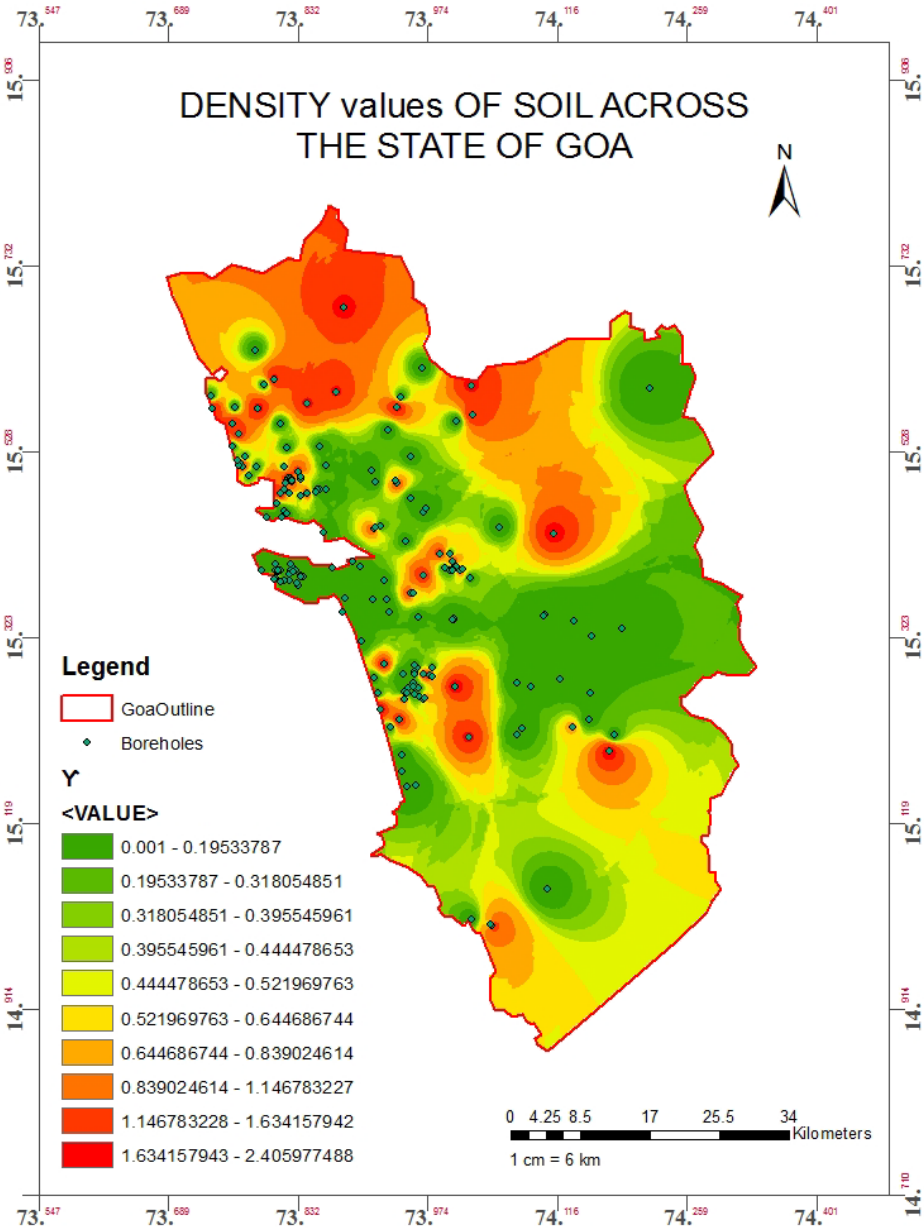

Map 3 Density values of Goa

The above Map 3 shows the interpolation of values of density across Goa at a depth of 1.5m.

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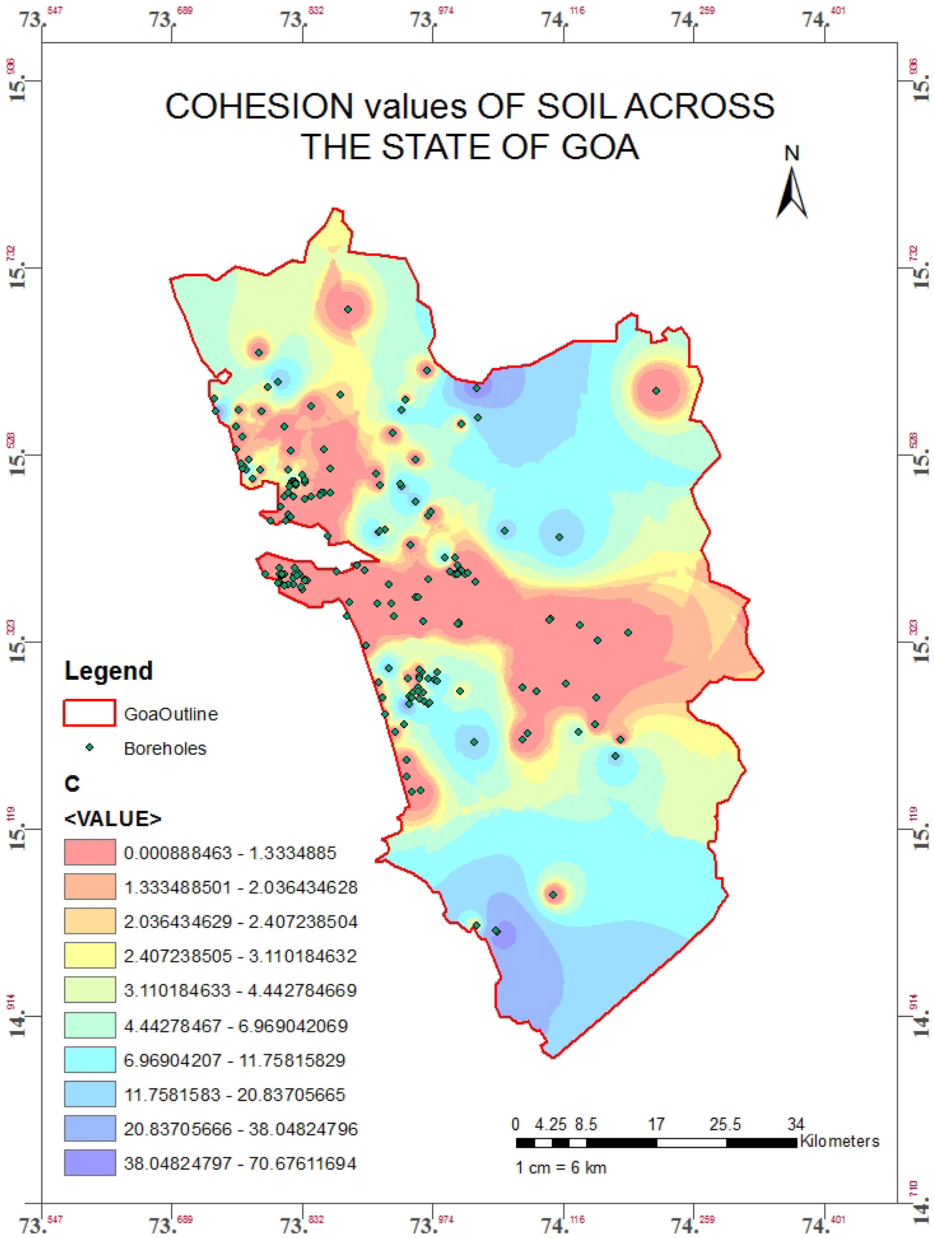

Map 4 Cohesion values of Goa

The above Map 4 shows the interpolation of cohesion values of Goa at 1.5m depth.

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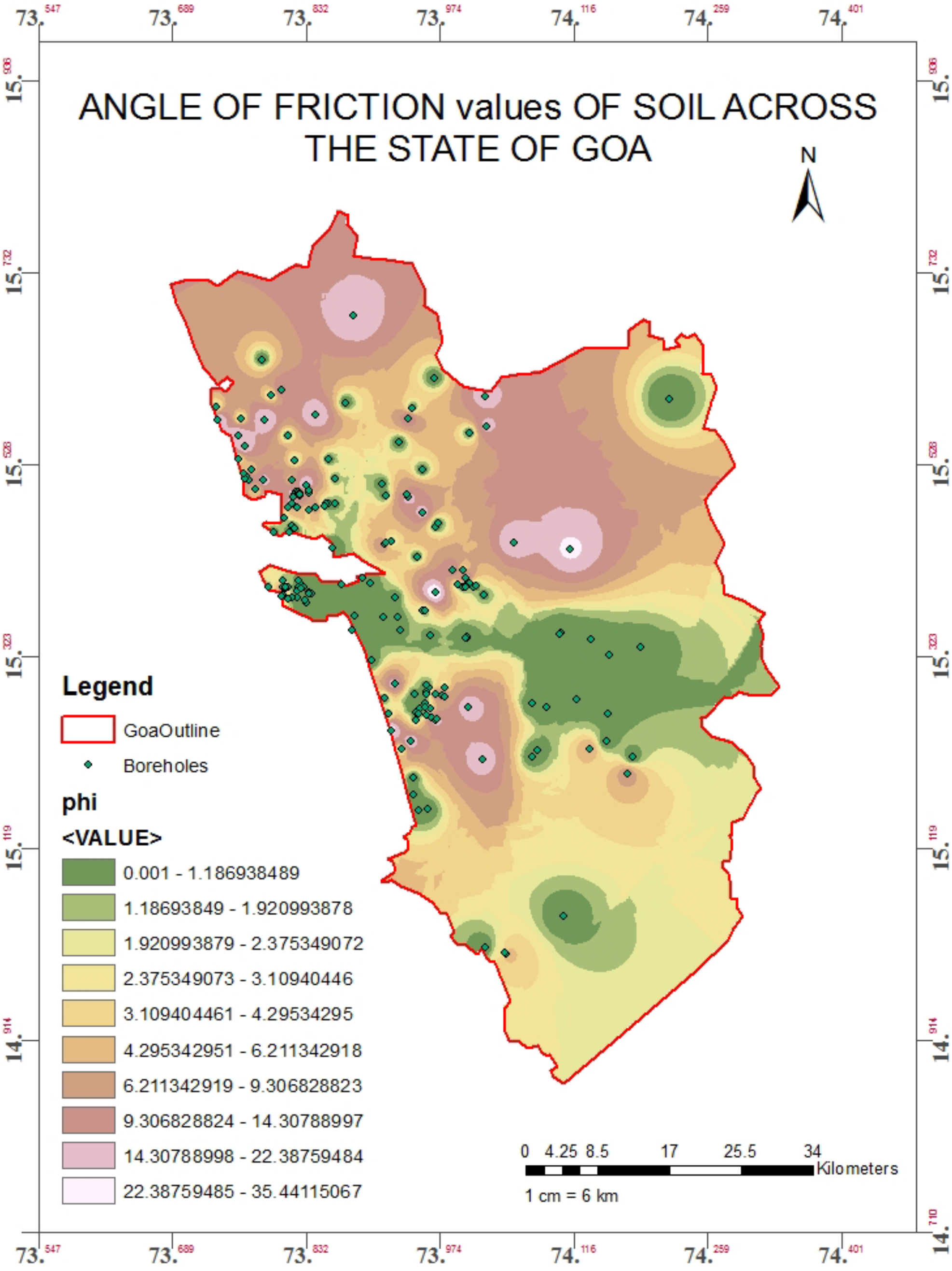

Map 5 Angle of friction values of Goa

The above Map 5 shows the interpolation of angle of friction values of Goa at 1.5m depth.

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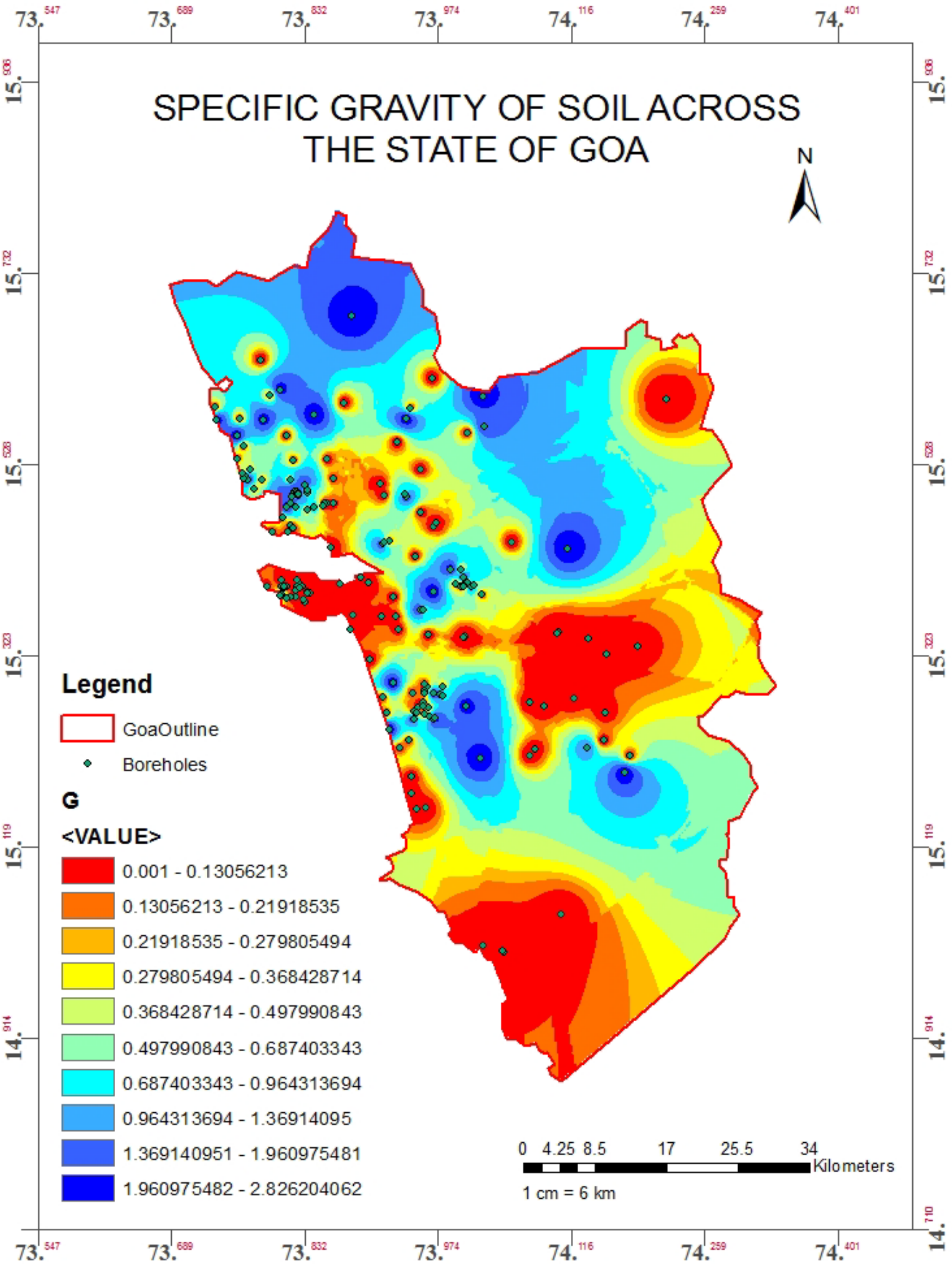

Map 6 Specific Gravity values of Goa

The above Map 6 shows the interpolation of specific gravity values of Goa at 1.5m depth.

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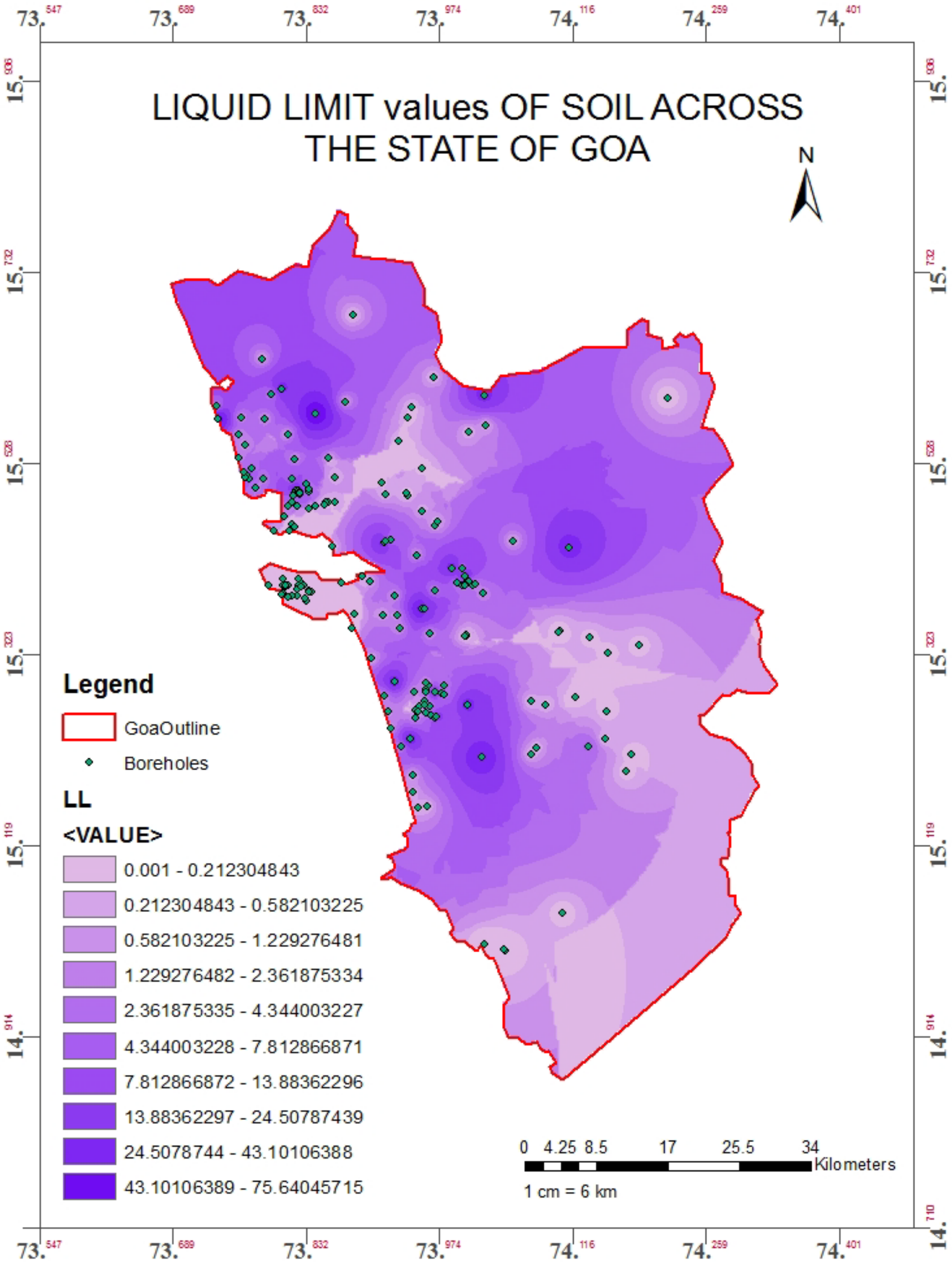

Map 7 Liquid Limits of Goa

The above Map 7 shows the interpolation of liquid limit values of Goa at 1.5m depth.

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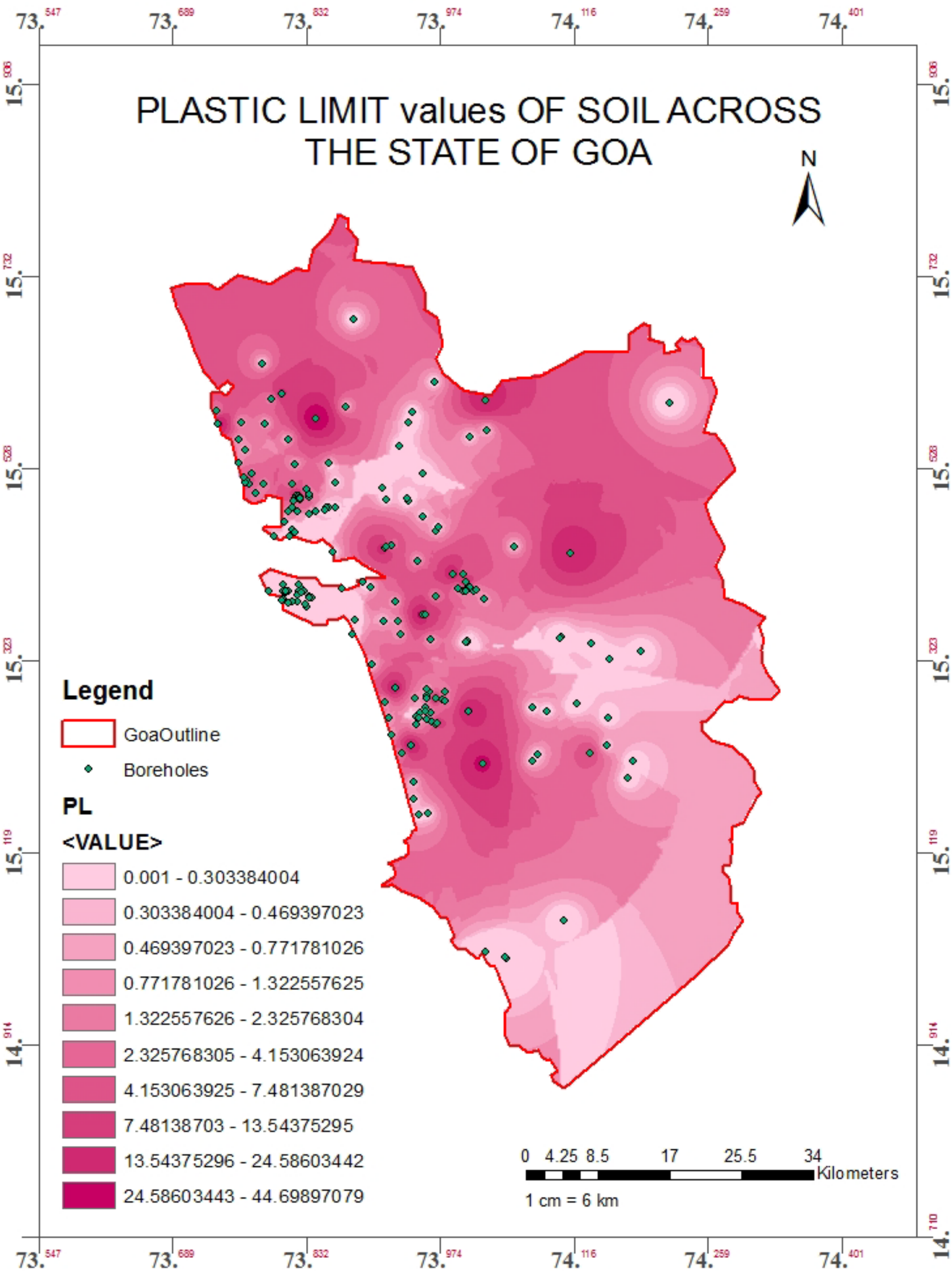

Map 8 Plastic Limits of Goa

The above Map 8 shows the interpolation of Plastic limit values of Goa at 1.5m depth.

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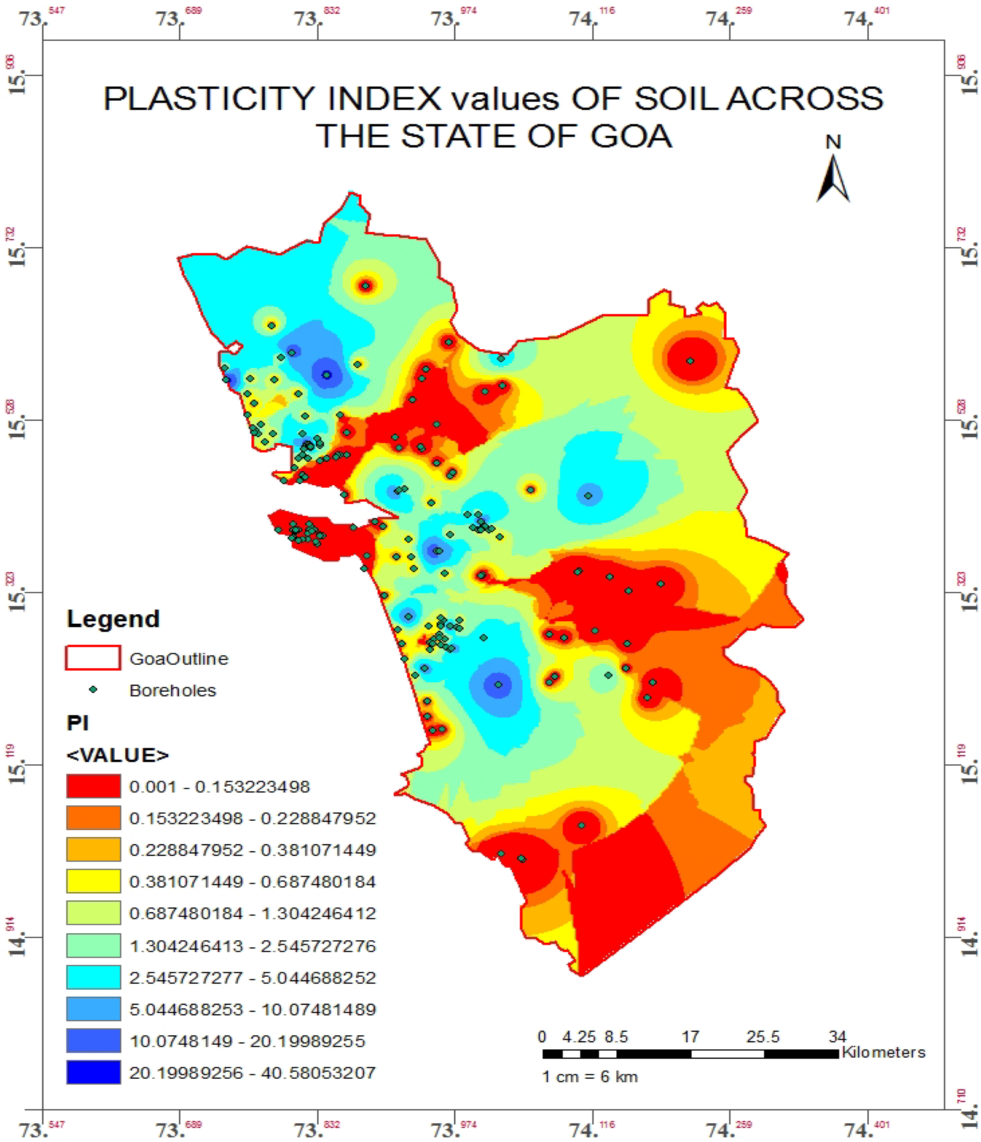

Map 9 Plasticity Index of Goa

The above Map 9 shows the interpolation of plasticity index values of Goa at 1.5m depth.

V. DISCUSSION

Maps were created by using ArcGIS software. The Goa shape files were downloaded and digitized in the software for this work. Polygon type shape file was used to digitize and create the boundary line of Goa. Boreholes were collected from different agencies. The necessary data was extracted from the boreholes and a database was created, to input it in the software for creating different maps. The interpolation feature called as Inverse Distance Weighing (IDW) was used to generate the interpolation maps.

Map 1 shows the water table across the Goa region. It is observed that in coastal areas the water table was found at shallow depths. The water table depth in Goa ranges from 0.3m - 9m. Also, a consideration was made were the water table was not mentioned in the borehole data’s, the highest borehole depth was assumed as water table depth of the particular borehole.

Map 2 represents the SPT values of Goa. At 1.5m depth the SPT values ranged from 1 - 50. From these maps we

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conclude that hard stratum is found at very lower depths i.e. 2.0m to 30+m.

Map 3 shows the bulk densities of Goa. The density values vary from 0.1 - 2.4 gm/cc. It is observed that the density values at 1.5m depth ranged from 0.1 to 2.0 gm/cc.

Map 4 shows the cohesion values that ranged from 0 to 40. Cohesion depends on bonding of fine grained particles, moisture content, and grain size distribution.

Map 5 shows the angle of internal friction values of Goa which varies from 0 - 35 degrees at 1.5m depths. From cohesion and angle of friction values we can predict the type of soils such as cohesive or cohesion less soils, C & φ soils for the state of Goa.

Map 6 shows the specific gravity values of Goa. Many specific gravity values were absent so 0.001 was assumed as the software program suggested.

Map 7 shows the liquid limit values of Goa. The liquid limit values at 1.5m depth ranged between 0.2 - 75 %.

Map 8 shows the plastic limit values of Goa. The values of plastic limits varied from 0.2 - 45 % at 1.5m depth.

Map 9 shows the plasticity index values. Plasticity index is the range of water content where soil exhibits plastic properties. It is the difference of liquid limit and plastic limit. The values of plasticity index at 1.5m depth varies from 0.1 - 40 %.

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