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भाकृअनुप
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हर कदम, हर डगर
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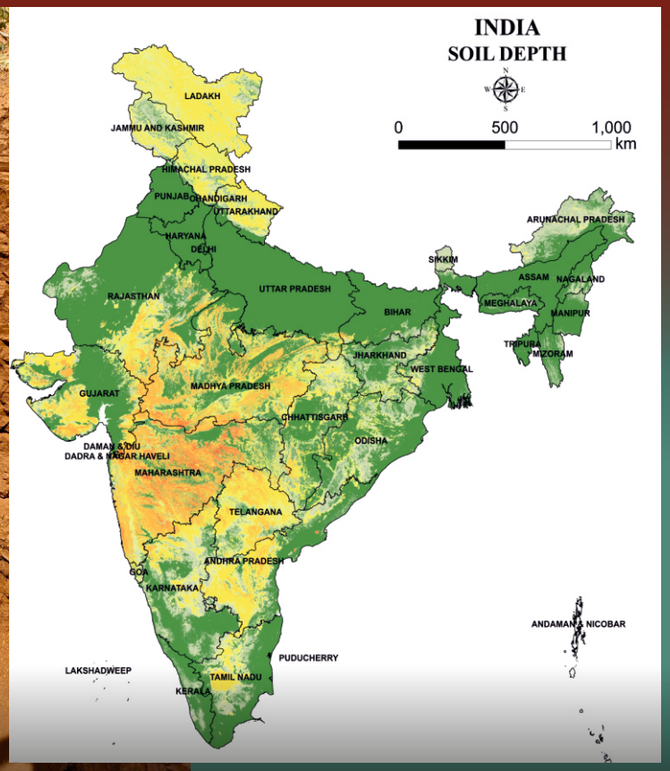
Agrisearch with a human touch

Soil Depth Map of India



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About the Soil Depth Map of India

The 90 m resolution digital soil map of India was generated by collating and modelling a robust spatial dataset containing 25798 points spread across the length and breadth of the country, and accumulated over a period spanning 45 years. The environmental covariates employed in the digital soil mapping approach include terrain variables generated with SRTM DEM, long term climate data from Worldclim, and long term seasonal NDVI derived from MODIS. Soil data collected from each Indian state were compiled to build the state-specific model. Though the administrative boundaries of the federal states separated the ensemble of global models from each other, the data from all the bordering districts of the neighboring states were also used to ensure seamless integration sans abrupt changes at state boundaries. Various machine learning models namely, random forest, support vector regression, cubist, and extreme gradient boosting were tested. Random forest algorithm outperformed others. The models were validated with 20% data points from each state. Further, for each state, the models were developed again with the best algorithm identified. The mosaic of the predicted maps generated a seamless soil depth raster with depth ranging from 6-250 cm with uncertainty range of 0-187 cm.

Spatial database on soil depth

Spatial point data on soil were collected from various project reports, legacy data, and ongoing projects at the Bureau. The depth of the solum was considered up to the depth of either AC or BC horizon.

To prepare a seamless soil depth map across the states, samples considered for a state or regional prediction model consisted of the samples from the states as well as from the bordering districts of the neighboring states. For example, Maharashtra (fig 1) has a database of 6525 samples out of which 2775 samples are from neighboring states.

Sample data considered for each state/region were then split into calibration and validation sets before modeling, with the latter including approximately 20 percent samples. The validation samples were identified using conditioned latin hypercube sample modeling which ensured that the validation samples cover the variations in the total samples.

Environmental Covariates

A total of 46 environmental covariates including terrain, vegetation, and climate were used for the modeling purpose (Table 1). The terrain variables were generated with SRTM 90 m data using SAGA GIS software. The long-term seasonal vegetation parameters were generated using 250 m MODIS 16 days composite time series NDVI data for years 2000 to 2023. Before deriving the seasonal parameters, the data were smoothened using Savitzky-Goley filtering. For climatic parameters, long term Bioclimate data (1 km) from Worldclim were used. As the samples were also collected from the neighbouring states, the environmental covariates were also derived for the same area as indicated in the figure 1. All the covariates were resampled to 90 m for seamless stacking.

Table 1: Variables used in digital soil mapping

Climatic Variables			24	MRRTF	Multi Resolution Ridge Top Flatness
1	Bio1	Annual Mean Temperature	25	MRVBF	Multi Resolution Valley Bottom Flatness
2	Bio2	Mean Diurnal Range	26	MSP	Mean Slope Position
3	Bio3	Isothermality	27	NH	Normalized Height
4	Bio4	Temperature Seasonality	28	RSP	Relative Slope Position
5	Bio5	Max Temperature of Warmest Month	29	StH	Standard Height
6	Bio6	Min Temperature of Coldest Month	30	Slp	Slope %
7	Bio7	Temperature Annual Range	31	SlH	Slope Height
8	Bio8	Mean Temperature of Wettest Quarter	32	TWI	Topographic Wetness Index
9	Bio9	Mean Temperature of Driest Quarter	33	VD	Valley Depth
10	Bio10	Mean Temperature of Warmest Quarter	34	VDCN	Vertical Distance to Channel Network
11	Bio11	Mean Temperature of Coldest Quarter	**Vegetation Variables**		
12	Bio12	Annual Precipitation	35	kNDVImax	Long term maximum NDVI of kharif season
13	Bio13	Precipitation of Wettest Month	36	kNDVImean	Long term mean NDVI of kharif season
14	Bio14	Precipitation of Driest Month	37	kNDVImin	Long term minimum NDVI of kharif season
15	Bio15	Precipitation Seasonality	38	NDVImax	Long term maximum NDVI
16	Bio16	Precipitation of Wettest Quarter	39	NDVImean	Long term mean NDVI
17	Bio17	Precipitation of Driest Quarter	40	NDVImin	Long term minimum NDVI
18	Bio18	Precipitation of Warmest Quarter	41	rNDVImax	Long term maximum NDVI of rabi season
19	Bio19	Precipitation of Coldest Quarter	42	rNDVImean	Long term mean NDVI of rabi season
Terrain Variables			43	rNDVImin	Long term minimum NDVI of rabi season
20	CNBL	Channel Network Base Level	44	sNDVImax	Long term maximum NDVI of summer season
21	CND	Channel Network Distance	45	sNDVImean	Long term mean NDVI of summer season
22	Ele	Elevation	46	sNDVImin	Long term minimum NDVI of summer season
23	LS	LS - factor			

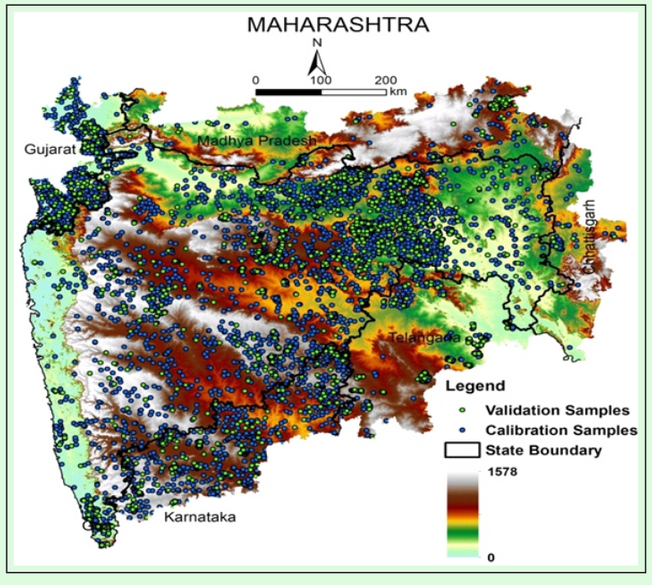

Fig.1: Sample locations in Maharashtra and neighbouring states

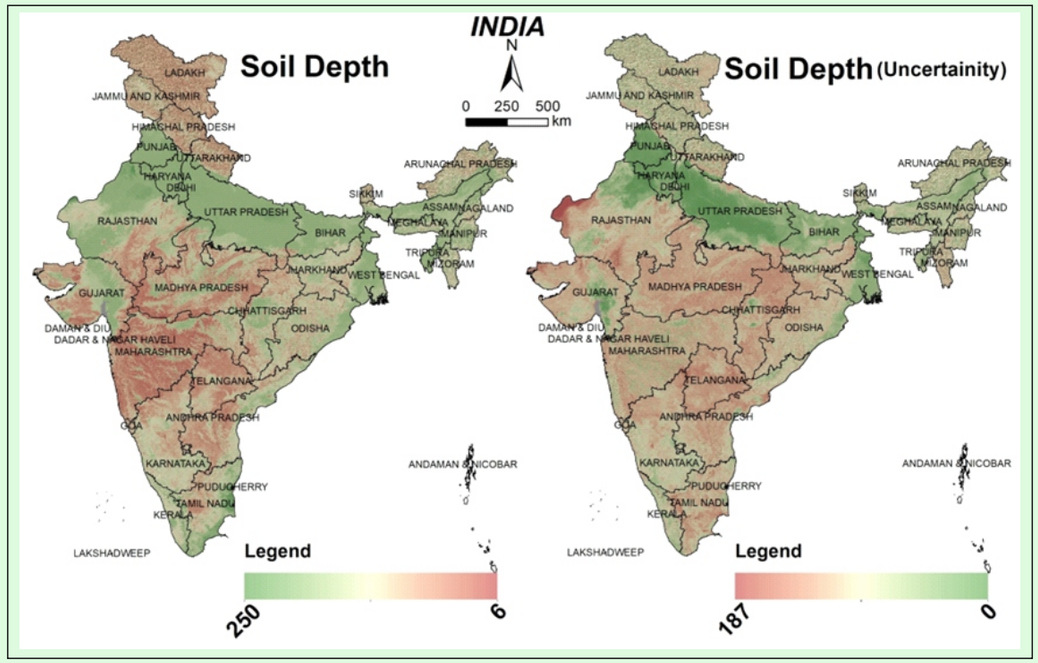

Fig.2: Predicted soil depth of India with uncertainly

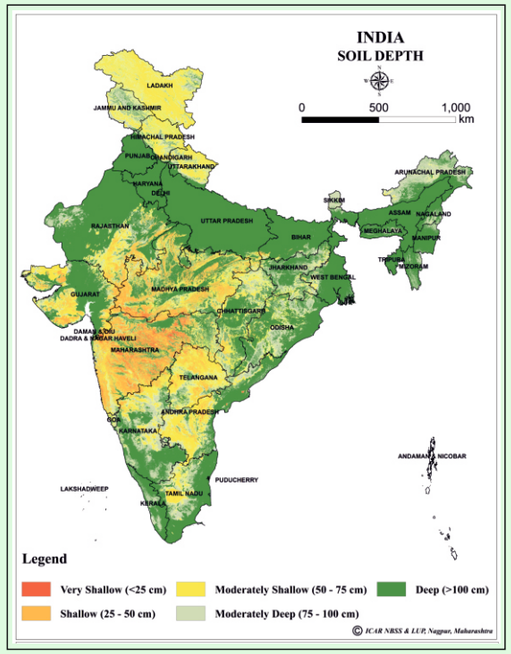

Fig.3: Soil depth class map of India

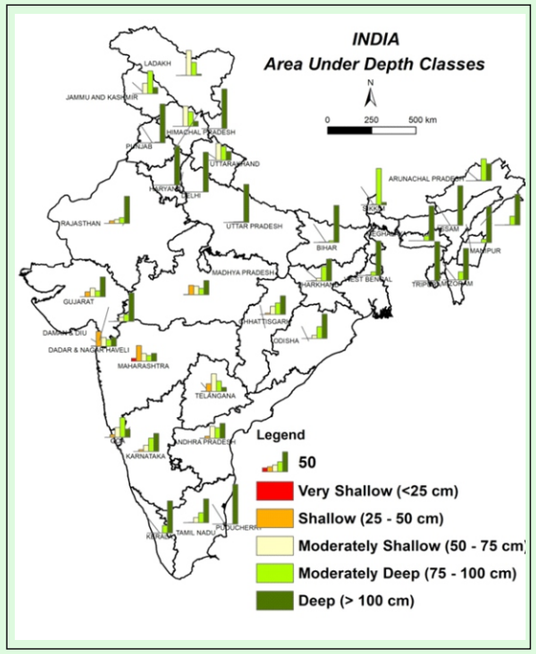

Fig.4: Area under different soil depth classes in India

Soil Depth

Soil depth along with uncertainty rasters were generated for each state/ region with respective RF models. The soil depth map of India was then generated by mosaicking all the depth rasters (Figure 2).

Table 2: Areal distribution (% TGA) of different soil depth classes in India

State	Very Shallow	Shallow	Moderately Shallow	Moderately Deep	Deep
ANDHRA PRADESH	0.2	5.4	30.4	26.4	37.7
ARUNACHAL PRADESH	0.0	0.0	2.2	55.0	42.8
ASSAM	0.0	0.0	0.0	0.3	99.7
BIHAR	0.0	1.0	0.9	4.7	93.4
CHANDIGARH	0.0	0.0	0.0	0.0	100.0
CHHATTISGARH	0.0	3.6	20.2	29.1	47.1
DADAR & NAGAR HAVELI	1.1	37.4	22.3	16.7	22.5
DAMAN & DIU	0.0	0.6	10.3	17.2	71.9
DELHI	0.0	0.0	0.0	0.0	100.0
GOA	0.1	6.1	24.3	49.4	20.1
GUJARAT	0.2	12.5	22.4	14.9	50.0
HARYANA	0.0	0.0	0.2	0.6	99.2
HIMACHAL PRADESH	0.0	0.2	50.7	36.4	12.7
JAMMU AND KASHMIR	0.0	0.1	26.5	57.6	15.9
JHARKHAND	0.0	1.0	7.1	36.5	55.4
KARNATAKA	0.1	4.5	16.1	34.1	45.3
KERALA	0.0	0.0	0.0	19.0	80.9
LADAKH	0.0	0.7	63.0	32.8	3.5
MADHYA PRADESH	1.3	24.4	22.0	16.2	36.1
MAHARASHTRA	7.1	39.3	19.2	14.5	20.0
MANIPUR	0.0	0.0	0.0	8.3	91.7
MEGHALAYA	0.0	0.0	0.0	12.7	87.3
MIZORAM	0.0	0.0	0.0	20.6	79.4
NAGALAND	0.0	0.0	0.4	21.9	77.7
ODISHA	0.0	0.8	8.0	29.6	61.6
PUDUCHERRY	0.0	0.0	0.0	0.0	100.0
PUNJAB	0.0	0.0	0.3	1.7	98.0
RAJASTHAN	0.0	6.5	10.3	14.6	68.6
SIKKIM	0.0	0.0	1.5	92.1	6.4
TAMIL NADU	0.0	0.9	13.4	25.4	60.3
TELANGANA	0.7	18.9	44.5	26.0	9.9
TRIPURA	0.0	0.0	0.0	0.7	99.3
UTTAR PRADESH	0.0	0.7	1.7	1.8	95.8
UTTARAKHAND	0.0	0.3	42.7	34.6	22.5
WEST BENGAL	0.0	0.2	2.0	10.0	87.8