Highly informative point sources of data: soil health cards for interpolated soil maps

D. V. K. Nageswara Rao

The potential of soil for producing crops is largely determined by the environment so that it provides for root growth. Soil mapping is the process of delineating natural bodies of soils, classifying and grouping the delineated soils into map units, and capturing soil property information for interpreting and depicting soil spatial distribution on a map. A soil fertility map serves a specific agricultural use and provides a way to interpret soil maps in a manner that is understandable and usable by farmers, local government and national planners[1]. Soil properties in nature are spatially highly variable[2] and for their accurate estimation this continuous variability should be considered. In addition, the traditional methods of soil analysis and interpretation are laborious and time-consuming, thus becoming expensive. It is a fact that the conventional soil resource maps are prepared probably once, with little scope for revision from time to time because of being expensive. In India, a large majority of soil maps were prepared by conventional methods[1] with little or no activity to update the database for monitoring soil fertility at any scale.

Similarly, application of modern spatial prediction of soil properties is less known in India, wherein geostatistical methods help generate digital soil maps easily. Geostatistical techniques are widely recognized as important spatial interpolation tools in land resource inventories[3]. They have been widely applied to evaluate spatial correlation in soils and to analyse the spatial variability of soil properties, such as soil physical, chemical and biological properties[4]. However for geostatistical applications, there is a requirement of point sources of information and the soil health cards (SHCs) issued to farmers by a Government of India scheme (www.soilhealth.dac.gov.in), started in 2015, which is a great source of information. These cards contain details about 12 soil parameters, viz. pH, electrical conductivity (dS m^{-1}), organic carbon (%), available nitrogen (N), phosphorus (P), potassium (K), sulphur (S), zinc (Zn), iron (Fe), manganese (Mn), copper (Cu) and boron (B). Soil fertility theme maps, generated using the information available through this scheme would not only be the latest but also have the scope for revision as a policy, unlike the existing soil maps which are older with little or no scope for revision. The added advantage with this dataset is that the soil sampling sites are geo-tagged using the latest technology of geographical positioning, which enhances the reliability of repeated sampling with higher accuracy in representing the sites of soil collection[1].

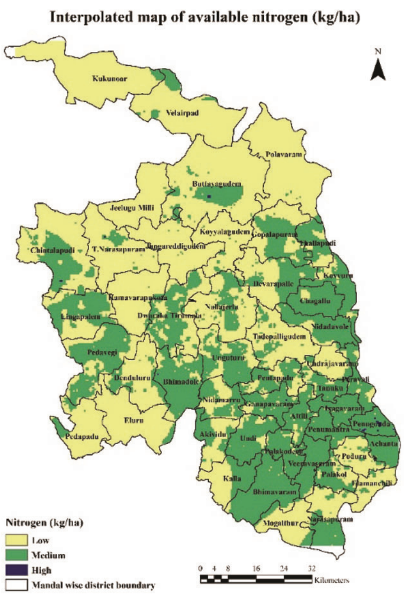

Figure 1. Interpolated map.

In order to extract information, 12,961 SHCs issued in West Godavari district, Andhra Pradesh (issued up to 2018 cycle), after curation and outlier analysis, were utilized to generate 12 different soil theme maps[5] in addition to the geo-coordinates required for interpolation. Also, 70% of data points were used for interpolation while the remaining for validation. Figure 1 shows the interpolated raster map of available N using inverse distance weighting method. The ratings (kg ha^{-1}): low (<250), medium (251–500) and high (>500) were used for classification. From the raster image, it was calculated that 61.5% and 38.4% of total pixels (46,043 pixels) were low and medium respectively, while just 0.1% of the pixels were high in available N. The percentage of pixels under different classes in 48 sub-district administrative units (mandals) was also extracted (Figure 2). It was observed that in 24 mandals (50% of 48 mandals), a large part of the area was under low available N category. Similarly, a large area under medium range of availability was distributed in the delta region where irrigated crops are grown. Similar information was extracted for the remaining soil attributes using appropriate ratings or ranges for classification. This information is useful for assessment of spatial distribution crop and performance to device corrective steps to realize the uniform best. In the absence of precise land-use planning, there is a need for soil-based crop management over crop-based soil management, and high-resolution soil maps help in this regard. These maps assist the administration in devising plans for location-based supply of nutrients and amendments. Similarly, supply of salinity-, acidity- and sodicity-tolerant varieties of crops can well be planned based on maps of peculiar soil conditions. These maps are of significance in the production of customized fertilizer materials and in site-specific crop management. In the digital maps, every pixel will have all these 12 soil variables so that site-specific fertility management could become a possibility. As a policy, the validity of SHCs is set at three years and one can use these maps with considerable reliability than the old maps, which are not updated. Nevertheless, issuance of SHCs is a unique system and is the best freely available point source of information for making good resolution theme maps.

Another application method[6] helped studying NDVI (normalized difference vegetation index) of rice vegetation in terms of yield and edaphological conditions, obtained from interpolated soil maps. Point vectors (n = 136) representing various rice fields in the delta area of West Godavari were developed and the soil attribute values to these points were extracted (Figure 3). NDVI values, as on 25 February 2018 obtained from Sentinel-2 data (10 m resolution), coinciding

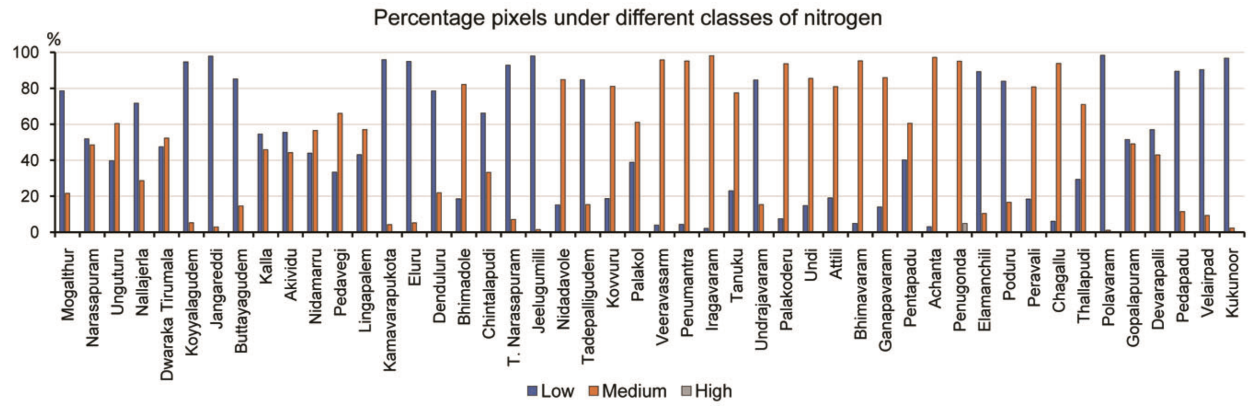

Figure 2. Distribution of pixels under classes of available N in different mandals.

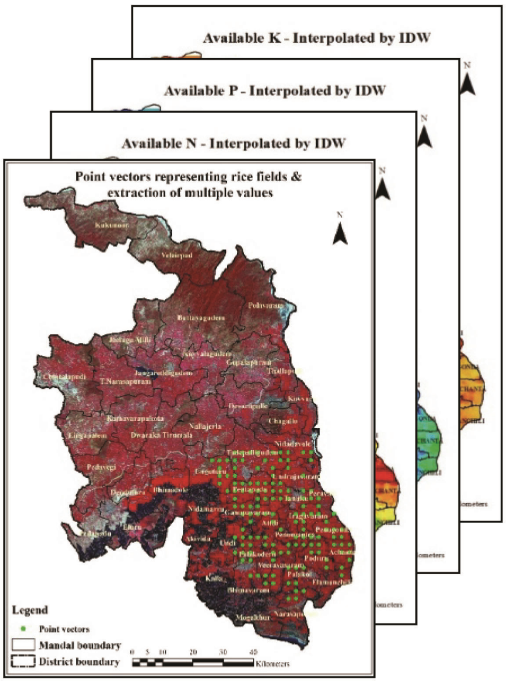

Figure 3. Extraction of multiple values to point vectors.

with maximum growth stage were also extracted. There was a significant positive relation between NDVI and grain yield, obtained through crop-cutting experiments conducted by the Department of Agriculture, Government of Andhra Pradesh. NDVI was negatively influenced by increased pH and boron content. It was found that interpolation techniques could be applied to soil attributes derived from SHCs, though the soils were not sampled at equally spaced grids. It was also evident that these digital soil maps along with satellite data products can be used in geospatial analysis of crop performance coupled with crop production conditions. Certain agencies prepare need-based high-resolution soil maps by specific grid survey at a cost, but SHCs provide enormous information for free and this kind of application is extendable to any scale.

1. Rao D. V. K. N., *Andhra Agric. J.*, 2018, **65**, 286–292.
2. Burrough, P., *Soils Fertil.*, 1993, **56**, 529–562.
3. Hengl, T., Rossiter, D. G. and Stein, A., *Aust. J. Soil Res.*, 2004, **41**(8), 1403–1422.
4. Liu, L., Wang, H., Dai, W., Lei, X., Yang, X. and Li, X., *J. For. Res.*, 2014, **25**(4), 867–876.
5. Rao, D. V. K. N., In XIV Agricultural Science Congress – Innovation for Agricultural Transformation, Abstr., NAAS, New Delhi, 20–23 February 2019, pp. 177–178.
6. Rao, D. V. K. N. and Mridha, N., In AFITA/WCCA 2018, Indian Institute of Technology-Bombay, Mumbai, 24–26 October 2018.

D. V. K. Nageswara Rao is in the ICAR-Indian Institute of Rice Research, Hyderabad 500 030, India.
e-mail: DVKN.Rao@icar.gov.in