Digital soil mapping and soil resource management

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Abstract

The growth in world population since 1950 exceeds that during the preceding 4 million years. This, plus the six fold expanded world economy during the same period, has led to an abnormal overuse of the planet's natural capacities (Brown, 2005). It is not difficult to notice that vegetation cover is shrinking in surface area (due to deforestation, deteriorating grasslands), soils are eroding, and/or salt- affected, water table is falling, ….., all affecting food production.

Two measures are thought of to tackle the problem of food shortage: i) increasing the surface area under cultivation and ii) intensification by means of using chemicals, high yield seed varieties, and machineries; the assumption in both cases is that the required water is available!

While water tables are steadily falling, suitable soils become scarce too. Of even more concern, soil degradation is increasing, for a great part, due to the misuse of pumped groundwater, often leading to salinization and/or compaction, and the use of marginally suitable sloping areas, which results in more flooding and erosion.

Fortunately we now have the technologies to do things that can help to better manage and consequently conserve resources. In 'natural resource management' data availability is the issue. To manage anything one has to properly know the object to be managed; here the soil resources.

Soil properties are crucial inputs for models of carbon balance, nitrogen fluxes, hydrological cycle, land suitability for irrigation projects, crop forecasting, landslide risk, and infrastructure construction, which are required in various fields of disaster management, food security and environmental sustainability (Farshad and Rossiter, 2008).

Conventional soil survey becomes time demanding and expensive. Besides, techniques for mapping dynamic soil properties, mainly remotely-sensed and/or model-based (Ben-Dor, 2002; Bui, 2004), have been developing. Thanks to the advances in the broad field of geographic information system (GIS), a new trend, often called digital soil mapping, is emerging which will have a positive impact on the soil survey.

The introduction of space-technology advances in Information and Communication Technology (ICT), coupled with the derived facilities in automation, urged many scientific fields to go for adaptation. It is remarkable to witness that the pioneer Jenny's equation (Jenny, 1941) receives more and more attention (McBratney et al., 2003, Moonjun et al., 2008). Soil Survey Manual was revised and issued in 1993, after almost half a century. Soil Taxonomy (USDA, 1975) was regularly revised; with its tenth edition issued in 2006. At the same time adapted concepts were used to introduce a more applicable soil classification system, the World Reference Base for soil resources (as World Soil Resources Reports No. 103-- FAO 2006).

Shortcoming of the Boolean logic in soil mapping is a known fact. Soil surveyors were always trained about the fuzziness of soil boundaries, map unit composition, transitional map unit between soil bodies and the issue of soil variability. Depending on scale, the transitional units were either cartographically shown on the map, or by a different series name, or were described under the flag of "range of characteristics", in the soil survey reports.
With the introduction of some new techniques and tools, for instance, geostatistics, more advanced computers, and the increasing GIS facilities, to make use of interpolation became a common practice in soil survey.
Above all, the introduction of the digital terrain surface modeling was a revolutionary step (Hengl et al., 2009). A digital terrain model is a mathematical (or digital) model of the terrain surface (Li et al, 2005). The mathematics takes care of the interpolation process, which has progressively developed with increasingly efficient and cheap computation power and storage, availability of digital contour, stream, and ortho-photographic data (www.ffp.csiro.au/nfm/mdp/softdem.htm), not to forget the LIDAR (Light Detection and Ranging). This is an optical remote sensing technology that helps measure differential height leading to register the terrain surface topography (www.csc.noaa.gov/products/sccoasts/html/tutlid.htm). To stay with less sophisticated technology, the required data for the digital terrain modeling may come either from field survey (e.g., use of conventional surveying instrument or GPS), from stereo pairs of aerial (or space) images using photogrammetric techniques, or from digitization of the existing topographic maps. The latter source is the most commonly used technique, although more and more use is made of the freely available DEM's, down loadable from SRTM (Shuttle Radar Topography Mission) at http://srtm.usgs.gov/. This product (with 90m resolution, except for the USA, with 30m resolution) won't satisfy those who need higher resolution data.
Almost all well known GIS packages are equipped with a sub module for generating DTM. ARCINFO, for instance, is equipped with ANUDEM (http://fennerschool.anu.edu.au/), a program developed in the Australian National University in Canberra, which supports production of grid-based DEMs using contour line map. Or in ENVI software, the sub module "topography" supports generating DTM using ASTER images. GRASS GIS software and a few freely available packages, such as TARDEM and TauDEM (of Utah Water Research Laboratory) can also be named here.

Thinking of some of the definitions and concepts (van Wambeke and Forbs, 1986) concerning 'what is a soil?", "what is the content of a soil map unit?", "soils are 3-D natural bodies", and "soils of unmapped areas can be mapped using soil data from the neighboring areas" may lead to rise the questions on what is the 'digital soil mapping'?, and to what extent the shortcomings of the conventional approach can be recovered using the new trend?, does the new trend suggest changes in definitions and concepts (re-thinking soil survey)? Whatsoever the answers, digital soil mapping, also known as predictive soil mapping, must receive more attention in the steadily growing world of today. And at the same time, it must be said that it would be a great mistake if the emphasis is put on the term "digital", no! The emphasis must be put on "soil mapping" and that can only be done by experienced soil surveyors, as for mapping soils thorough understanding of soil spatial composition and the soil-landforms relations are absolutely 'a must'.

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