

Soil maps for development

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Abstract

Here we present a preliminary analysis of soil map density in 31 European countries and 44 low and middle income countries linked to GDP per caput and the number of soil scientists. National coverage of exploratory soil maps is generally higher in the poorest countries and decreases with increasing GDP per caput whereas the national coverage of detailed soil maps tends to increase with increasing GDP. GDP is larger in countries with more soil scientists per unit area, likewise, the number of soil scientists increases with increasing GDP. More soil scientists per ha agricultural land may be related to higher crop yields. There are many confounding factors but this analysis illustrates how proxies for soil data density can be used; it is suggested that appropriate indicators are developed for spatial data infrastructures and digital soil maps to demonstrate its effectiveness for society and human welfare.

Introduction

Some countries are poor, some are rich, and there a lot of countries in between. Explaining the differences is not easy and the development of countries is driven by macro-economics but also by, for example, geography and the richness of natural resources: e.g. soils, climate and mineral wealth (Sachs, 2005). Not only the richness of soil resources itself but also the richness of information about those soil resources affects a country's wealth – so we think. So far as we know, little effort has been made to link soil information to developmental indicators or to quantify the effects of soil research on the wealth and welfare of nations. It is hard to unravel the influence of individual developmental factors - many of which are interacting. We know that, globally, about two-third of the countries have been mapped at a 1:1 million scale or larger, but more than two third of the total land area has yet to be mapped even at a 1:1 million (Nachtergaele and Van Ranst, 2003). There are great differences between countries – not only in the status of mapping but also in the status of digitising old information and combining it with other data. This has many reasons (colonial, political, economics, disasters). For this paper it is important there are fairly accurate data on the coverage of soil maps at different scales for most countries. We use soil map density at different scales as a proxy for soil data density which we link to generic indicators like GDP per caput and the number of soil scientists of 31 European countries and 44 low and middle income countries across the globe.

Soil scientists per country

Soil science activity is dependent on the number of soil scientists and their resources. Van Baren et al. (2000) linked the number of IUSS members to total inhabitants and the agricultural land area for different countries. We have updated this information

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with more accurate figures from the national soil science societies (Table 1). The total number of members of a national soil science society is well-correlated (0.7***) with the number of inhabitants in a country. Also, members and the total area under agriculture are fairly well-correlated (0.5**); countries with large areas under agriculture often have more soil scientists.

Table 1. Total members per national soil science society, per land area, and GDP per caput

country	total members	member per million inhabitants	members/ 1000 km ² total area	members/ 1000 km ² agric. land	GDP per caput US\$	R&D as % of GDP	Grain yield Mg ha ⁻¹
Australia	496	24.7	0.1	0.1	32,000	1.70	1.9
Belgium	250	24.1	8.2	3.0	31,900	1.90	8.0
Brazil	200	1.1	<0.1	0.1	8,400	0.98	2.4
Canada	255	7.8	<0.1	0.4	32,900	1.93	2.8
France	413	6.8	0.7	1.4	30,000	2.16	7.2
Germany	2311	28.0	6.5	13.6	29,800	2.49	6.5
India	1846	1.7	0.6	1.0	3,400	0.85	1.9
Mexico	50	0.5	<0.1	<0.1	10,100	0.40	2.7
Netherlands	409	24.9	10.0	21.2	30,600	1.85	8.0
Spain	408	10.1	0.8	1.4	25,200	1.11	3.6
Thailand	300	4.7	0.6	1.6	8,300	0.26	2.0
UK	815	13.5	3.3	4.8	30,900	1.89	7.2
USA	4000	13.5	0.4	1.0	42,000	2.68	5.8

Member data from IUSS (R. Harris) 2004 and 2005; Agricultural land use 2003 from FAO FAOSTAT; population data from 2005 www.census.gov; GDP data from 2003-2004 www.cia.gov; Research and Development data from World Bank and UNESCO 2001-2004; Grain yield equivalent data from 2000, FAOSTAT, FAO

Soil maps – Europe

The first generation soil maps of Europe produced in the 1920s and 1930s had a strong agro-geological focus and based on limited soil survey work. These soil maps stimulated soil surveys in most European countries. Hundreds of detailed and semi-detailed soil maps are available. We linked the availability of maps to the size of the country and it seems that smaller countries have better coverage of both exploratory and detailed soil maps (Fig. 1).

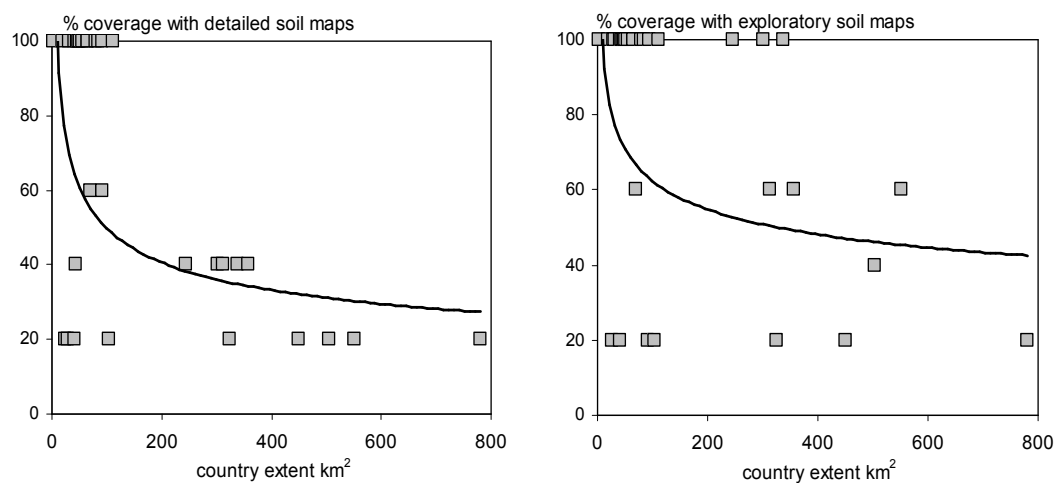


Fig. 2. Relation between size of 31 EU countries and the coverage with detailed soil maps (<1:50,000) and exploratory soil maps (>1:250,000)

Correlation between a country's population density and the availability of soil maps is fairly strong and highly significant (Table 2). Small, highly-populated countries in Europe have the best soil information; large, less densely populated countries like France, UK and Germany generally have less detailed soil maps.

Table 2. Correlation between coverage of soil maps at 1:50,000 or 1:250,000 and the size of the country, total population and population density of 31 European countries. Data extracted from: European Soil Bureau Network of the European Commission (2005)

	Size of the country	Total population	Population density
1:50,00 soil maps	0.364*	0.358*	0.743***
1:250,000 soil maps	0.472**	0.492**	0.795***

*, **, *** indicates significance at $P < 0.05$, $P < 0.01$ and $P < 0.001$, resp.

Correlation between number of soil scientists in 1998 or 2005 and the availability of soil maps in 2005 is poor. However, the availability of soil maps in 2005 is related to the number of soil scientists in 1974 (Fig. 3). The higher the number of soil scientists per unit area of agricultural land in 1974, the greater the coverage of soil maps, particularly exploratory soil maps in 2005.

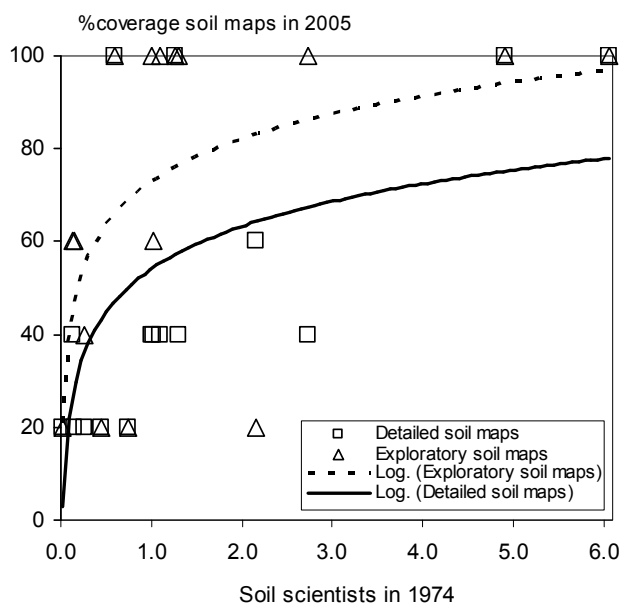


Fig. 3. The number of soil scientists per 1000 km² agricultural land in 1974 and the coverage with detailed soil maps (<1:50,000) and exploratory soil maps (>1:250,000) for 16 European countries in 2005

Soil maps and GDP

Gross Domestic Product (GDP) per caput is often used as an indicator for the measure of a country's welfare. GDP is defined as the market value of all goods and services produced within a country in a given period of time; all other things being equal - standard of living tends to increase when GDP per caput increases. Economic data from UNDP was combined with data on the status of soil mapping in different tropical countries (Nachtergaele and Van Ranst, 2003; Zinck, 1995). National coverage of soil maps is linked to GDP per caput (2001 data) for 44 countries in tropical regions (Fig. 4). Although the data are scattered, regression suggests that national coverage of exploratory soil maps is generally higher in the poorest countries and decreases with increasing GDP per caput; the national coverage of detailed soil maps tends to increase with increasing GDP. However, total coverage is very low in

most of these countries (<20%). GDP is larger in countries with increasing soil scientists (Fig. 5) – of course, the other way around is reasonable as well: the number of soil scientists increases with increasing GDP.

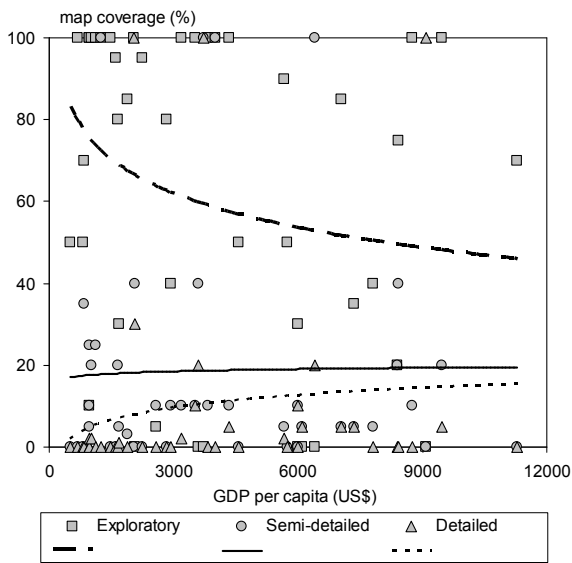


Fig. 4. Relation between GDP per caput (2001 data) and national coverage of exploratory soil maps ($\approx 1:100,000 - 1:500,000$), semi-detailed soil maps ($\approx 1:100,000 - 1:50,000$) and detailed soil maps ($\approx 1:25,000$) of 44 low and middle income countries (<US\$12,000 GDP per caput in 2001 – UNDP data)

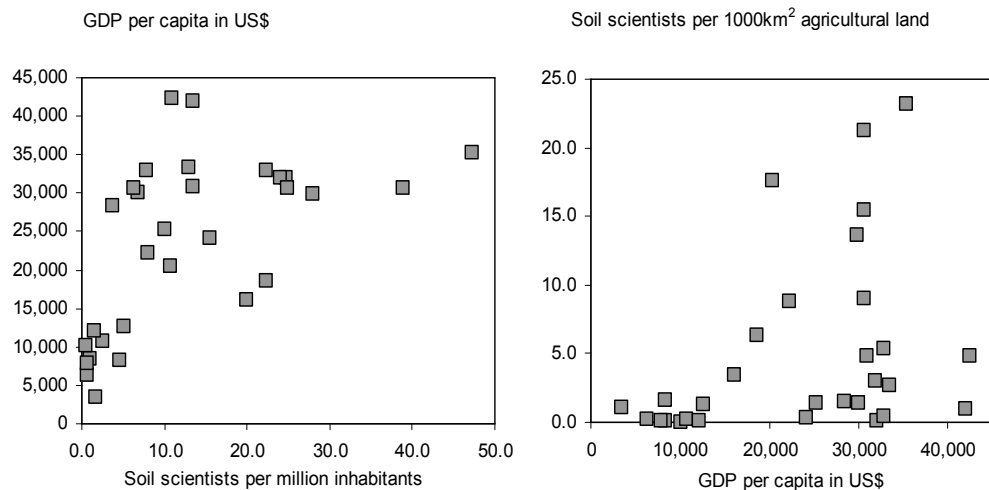


Fig. 5. Relationship between soil scientists per million inhabitants and GDP per caput; and between GDP per caput and the number of soil scientists per 1000 km² agricultural land

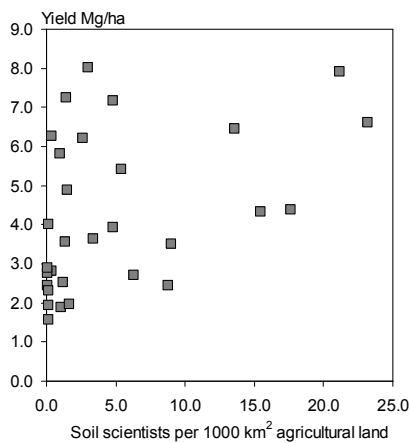


Fig. 6. Relation between soil scientists per 1000 km² agricultural land and average grain yields (FAOSTAT data)

More soil scientists per ha agricultural land often lead to higher yields (Fig. 6). Correlation between soil map density and grain yield equivalents was very low.

Discussion and conclusions

The soil science community has not clearly demonstrated the benefits of soil science for society (Greenland, 1991; IUSS, 2006). If everyone were convinced that soil science is essential for human welfare perhaps this demonstration would not be needed, but we fear that is not the case. There is a link between soil science information (maps) and GDP and some other variables. Although there are many confounding factors, these relations warrant further investigation. In fact, an analysis whereby soil information (or a range of proxies) is related to soil richness (natural, manmade) and successively linked to a range of socio-economic indicators would be informative. It would provide useful information for both development economists and decision makers.

Soil science has distinctly different foci in the developed compared to developing countries (Hartemink, 2002) This paper has shown that there are large differences in these regions in terms of soil data density of other parameters. Some very poor countries have very good data and maps; some very rich countries are poor in data. For both such groups it is imperative that the usefulness of soil information for development is illustrated. The development of digital soil maps takes places in both regions (Lagacherie et al., 2006) and it is important that appropriate indicators are sought to illustrate the effectiveness of digital soil maps.

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