Poor soils make poor people and poor people make the soil worse

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Abstract

Throughout the world there is a strong evidence to support the link between poverty and soil conditions. In subsistence agriculture the wealth of people on low fertility sandy soils is much lower than those living on rich volcanic soils. But there are great differences between regions in the world and this talk focuses on historical developments in soil research in tropical and temperate regions. One-third of the soils of the world are situated in the tropics and as such support more than three-quarters of the world population, yet more is known about the soil resources of the temperate regions than these important soils of the topics. Since the Second World War, soil research has immensely contributed to crop production increases in the temperate regions and the discipline has greatly benefited from new instrumentation and developments in other sciences. Soil research in tropical regions started later and its scope has not changed much: the feeding of the growing population, land degradation and nutrient management remain important research themes. The amount of research in environmental protection, soil contamination and ecosystem health is relatively limited. Mineral surpluses are a major concern in many temperate soils under agriculture whereas the increase of soil fertility is an important research topic in many tropical regions. The impact of soil research on poverty alleviation, crop production or rural livelihoods will be discussed.

Introduction

Soil science is a relatively young science that emerged some 150 years ago. It developed in Europe, North America and the Russian Empire (Kellogg, 1974). Soil surveys started in sparsely populated areas where there was ample land for farm extension and thus a clear need for soil inventories (e.g. Russian Empire and the USA). In more densely populated Western Europe where land was relatively scarce research efforts were devoted to maintain and improve soil conditions, and in most European countries soil survey organizations were only established after the Second World War. Soil science has always had a strong focus on increasing agricultural production needed for an increasing human population (van Baren et al., 2000). One could argue that the focus of attention of soil research was related to the availability of land driven by human population pressures.

The increase in human population has been phenomenal with dramatic increases over the 100 years and has resulted in a continuous debate on man's role and impact on the earth. Much of the debate is related to food production, poverty and the environmental effects of increased land use pressure due to a growing population. Different views on the effects of a growing human population have been published and in this paper some of the arguments are discussed including an overview of facts and figures. The aim of this paper is to provide a brief historical overview of studies on the relation between soil science, population growth and food production. Much has been written about these subjects and this paper is not aiming to review all available literature, but to summarize some of the major outcomes from such studies in order to sketch the main trends and developments. It starts at the end of the 18th century – which is some decades before soil science emerged.

Human population growth

Global population hardly changed up to 1000 BC and slightly decreased in medieval times (Figure 1). The real increase started from 1650 onwards when global population passed through the "J-bend" of the exponential growth curve. Population growth remained below 0.5% up to 1800 and was about 0.6% in the 19th century. In the first half of the 20th century growth was 1%, but the largest rate occurred in the second half of the 20th century when the world population grew over 2% in a few years.

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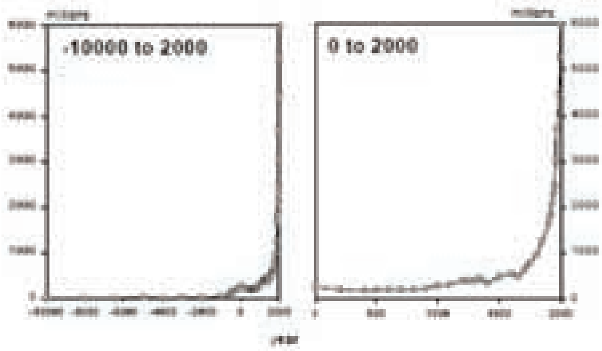

Figure 1. World population estimates for the years –10,000 BC to 2000 and the years 0 to 2000. Based on reconciliation of published data

The main reason for the exponential increase in human population since the 1600s is science and technology – in particular medical, industrial and agricultural sciences. The conquest of infectious diseases in infancy and childhood and other medical inventions are the main contributors to the exponential growth of the human population. Another factor is the decline in traditional breastfeeding practices by urbanisation and by the premature introduction of animal milk or infant milk (Short, 1998). Also the increase in food production in Europe in the 17th and 18th century due to advanced cultural techniques (ploughing, liming) and more stable societies resulted in an increase in human population. Important inventions like the acidulation of bones by J.B. Lawes and technological marvels like the Haber-Bosch process that allowed the industrial production of urea indirectly caused a large increase in the European population.

Since 1950, the world population has grown almost linearly. Official statistics have shown that the annual increase in human population was 85 million in the late 1980s and had decreased to 80 million per year in 1995 (Smil, 1999). Currently the world population is growing by 1.3% per year, which is significantly less than the 2.0% growth rate of the late 1960s. Population growth has been different in different regions. More than 80% of the population lives in developing regions, and Asia accounts for 61% of the world total. Two out of five people in the world live either in China or India. According to the population division of the United Nations, Africa's population is now larger than that of Europe but in 1960 Africa had less than half Europe's population.

There are great differences in the age distribution of different countries. This is illustrated in Figure 2 where the age distribution of the population of New Zealand (top) and Uganda (bottom) is shown. Such uneven distributions may be further aggrevated by Aids and other infectious diseases that dramatically affect national population pyramids.

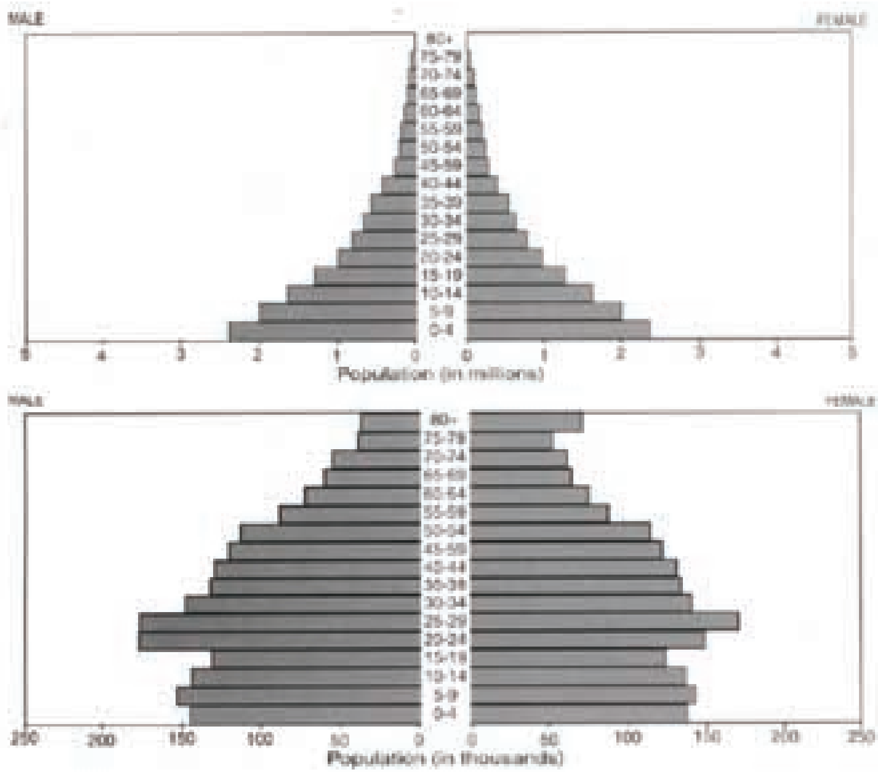

Figure 2. Population age distribution of Uganda (top) and New Zealand (bottom)

It has been estimated that the world population would be 9.4 billion by 2050. Fischer and Heilig (1997) estimated that the average population increase between now and 2015 is 80 million per year which will decrease to around 50 million per year in 2050. Doubling of the human population by 2050 is therefore unlikely and the UN Department of Social and Economic Affairs has also lowered its forecast to 8.9 billion in 2050 as global population growth is slowing down (Lutz et al., 1997; Smil, 1999). About one-third of this drop is due to the unexpectedly dire ravages of AIDS in sub-Saharan Africa and parts of the Indian subcontinent.

Population growth is also slowing down due to a change of attitude in the developing world, which accounts for over 95% of the population growth. In 1969, people in the developing world had an average of six children compared to three today. The population keeps on growing, however, because more babies survive and old people live longer and in Africa each women has on average five children. By 2050, there will be three times as many people in Africa than in Europe.

A new focus of attention is developing in demographic studies and in Western Europe and the USA the focus of the public, political and scientific debate has shifted from global population growth to population ageing (Lutz et al., 1997). Two hundred years after Malthus' essay that is quite a shift of focus – at least for those parts of the world where food is ample. The fear exists that the issue of ageing will detract the much-needed attention from those areas in the world where populations keep on increasing, hunger is widespread and a higher food production is needed to nourish current and future generations. That combination is mostly found in developing countries in tropical regions.

Food production and soil science

More food needs to be produced when the population grows if starvation is to be avoided. In the absence of massive food relocation, the extra food needs to come from either the available land through intensification, better crop husbandry practises and new high yielding varieties (yield increases) or through taking more land into production (area increases). Both production increase and area increase depend on a thorough knowledge of the soil and technological applications of this knowledge. Soil science, being essentially an interdisciplinary and applied science, has a long tradition of considering increased food production for the growth of the human population.

Soil erosion emerged in the first half of the 20th century as an obvious factor affecting food production in relation to the expanding human population. In the USA the question whether sufficient food could be produced for a growing population followed the "dustbowls" in the 1930s caused by severe erosion by wind. One of the first global overviews of soil erosion was prepared by Jacks and Whyte (1939) titled "The rape of the earth – A world survey of soil erosion". They concluded: the world food production was seriously affected if erosion would remain unchecked.

After the Second World War when international organisations such as the FAO were established and many countries were aiming at independence, the feeding of the growing population became an important area of research. Increasing food production was a concern in Western Europe because of the devastation after the war and the baby boom. Fortunately, science came out of the war with high status and was overall respected (Tinker, 1985). There was great optimism and positivism in the 1950s and agricultural research rapidly expanded. Most, if not all, agricultural research was directed towards agricultural production, which increased dramatically thanks to technological developments and major investments in agricultural infrastructure. Even though the term "green revolution" is mostly being reserved for agricultural production in developing countries, it could apply as well to post-war agriculture in Western Europe (Bouma and Hartemink, 2002). There is no doubt that soil science played an important role in the increase of agricultural productivity, and Malthus would have been correct predicting that population growth would outstrip food supplies but for the discoveries of soil scientists (Greenland, 1991).

Various books and journal articles have reviewed the history and developments in soil science (Greenwood, 1993; Hartemink, 2002; Russell and Williams, 1977; van Baren et al., 2000; Yaalon and Berkowicz, 1997). In addition, detailed reviews on developments in soil chemistry (Sparks, 2001), soil physics (Raats, 2001), soil microbiology (Insam, 2001), soil variation (Heuvelink and Webster, 2001) were recently published. These reviews all show the enormous progress that has been made in our understanding of the fundamentals of soil properties and processes. At the same time the reviews show in which areas (e.g. agriculture or the environment) soil science has made major contributions.

Lal (Lal, 2001) summarized the cause of increased food demand in the 19th and 20th century and a number of causes were related to the soil and its management: ploughing, terracing, soil erosion control, irrigation and soil fertility management through manure and inorganic fertilizers. Mermut and Eswaran, 2001 reviewed the developments in soil survey and mapping, soil technology, soil microscopy, pedology and classification of soils, and the mineral and organic components of soils. Several technologies have emerged from these developments including agroforestry, conservation tillage and precision agriculture. Major progress has been made in environmental soil science, and soil science has also been instrumental in studies on land degradation and sustainable use of natural resources and in studies on carbon cycling and sequestration (Mermut and Eswaran, 2001).

Future outlook for food production

The world produces more than enough food at present to feed everyone, but nevertheless many people still starve or are undernourished (Latham, 2000). In absolute terms the world already produces enough food to feed ten billion people but the problem is that most of it is fed to animals. It is poverty and not a physical shortage of food that is the primary cause of hunger in the world (Buringh, 1982; Latham, 2000; Pinstrup-Andersen, 1998). Additional problems are inequitable distribution of food supplies, spoilage and other losses between production and consumption, politics (Ross, 1999) and war and trading policies. Many international aid programmes aim to alleviate poverty for it is the main cause for hunger and environmental degradation (McCalla, 1999). So total global food production is not a good indicator, or as Dudal stated: It is not enough for the world as a whole to have the capability of feeding itself, it is necessary to produce more food where it is needed (Dudal, 1982).

Between 1960 and 2000 the world population doubled. But the green revolution during that period brought about substantial increase in food production and quality, these increases resulted from better varieties, improved irrigation and drainage, increased fertiliser use, improved pest and weed control, advances in food storage and transport, increased area under agriculture (Ross, 1999). The impact of land degradation on food productivity is largely unknown. In addition there is the loss of land to non-agricultural use which is high (Buringh, 1982). There is also limited extra land to bring into production (Eswaran et al., 1999; Young, 1999) which is contrary to predictions made in earlier studies (e.g. Buringh et al., 1975; Meadows et al., 1972).

Prospects for increasing food production depend on improved technologies, a biotechnological revolution, widening of food sources (e.g. sea weed), more land in production (Ross, 1999). Doubling yields in complex and intensive farming systems without damaging the environment is a significant challenge (McCalla, 1999). Progress towards a ‘greener agriculture’ will come from continued improvements in modern high-yield crop production methods combined with sophisticated use of both inorganic and organic nutrient sources, water, crop germplasm, pest management and beneficial organisms (Sinclair and Cassman, 1999).

An important consideration when discussing food production and population growth is under-nourishment, which is referred to by FAO as the status of persons whose food intake does not provide enough calories to meet their basic energy requirements (FAO, 2000). In 1999, FAO estimated the incidence of under-nourishment in the developing countries at some 800 million persons or 18% of the population. It was 960 million in the late 1960s, or 37% of the population (FAO, 2000). Projections indicate that it will decrease to 576 million by 2015, and to 401 million by 2030. So both absolutely and relatively the number of undernourished people is on the decline and projections for the future show improvement although hundreds of millions people remain undernourished in the future. Much depends on political resolutions and will-power but if all resources are harnessed, and adequate measures taken to minimise soil degradation, sufficient food to feed the population in 2020 can be produced, and probably sufficient for a few billion more (Greenland et al., 1997).

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