Land Use Policy 39 (2014) 350–357

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Soil is brown gold in the Emilia-Romagna region, Italy

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ARTICLE INFO

Article history:
Received 3 July 2013
Received in revised form 26 January 2014
Accepted 28 January 2014

Keywords:
Land take
Land consumption
Carbon sequestration
Soil sealing
Land use
Food security

ABSTRACT

Soil is a natural resource essential to human welfare by virtue of its numerous crucial functions. In the past, soil has been taken for granted because of its widespread, albeit finite, availability. However, now that world's population is projected to exceed ten billion before the end of this century, soil is increasingly perceived as a precious commodity. Consequently, soil is increasingly under pressure by rich private investors and governments within the poorest countries to satisfy appetites for food production and biofuel. A case study is used to explore the plausibility of soil being considered as 'brown gold'. Based on the comparison of land use maps, we estimated the value in terms of resource from raw material, carbon sink and virtual calories of the productive soil lost during the period 2003–2008 in the Emilia-Romagna Plain, one of the most productive areas of Italy. More than fifteen thousand hectares of cropland underwent land use change – in particular urbanization – over the 6-year period with an implied loss of crop production potential equivalent to the daily calorific requirement of more than 440,000 people. Taking into account that Italy is no longer self-sufficient in food production, such a loss appears to be strategically significant. Perhaps more importantly, urbanization and soil sealing has had negative ramifications on environmental sustainability, on both local and broad scales, with increased consumption of public funds. A logical framework of the socio-economic impact of land use change has been compiled and is presented as a possible example of a policy relevant approach to managing productive soils as a finite resource.

Introduction

At the end of 20th century, the deterioration of the natural environment was perceived as a serious problem and our confidence in an unlimited technological development declined. Environmental protection is considered now as a priority and many natural commodities, previously taken for granted, deserve more attention, especially because they are finite. This is the case for soil, which underpins almost all food production, and is becoming more and more precious to Nation States as a consequence of increasing human pressure. The productive function of soil is not the only crucial role that soil provides to the benefit of society: soil absorbs and filters rainwater, allows the safe decomposition of waste, provides raw materials such as clay, sand, and gravel, sustains infrastructures, conserves archaeological and other cultural remains and, last but not least, is one of the most important reserves of biodiversity on the planet. In recent years, soil has received additional interest by virtue of being a major sink for atmospheric CO_2 and hence having a significant potential in climate change issues (Renforth et al., 2009; Davidson et al., 2013). Since the industrial revolution soil has been progressively neglected although overused as an indispensable natural resource. In the meantime, world population has increased exponentially and is expected to rise to 9.5 ± 1.5 billion by 2050 (United Nations Population Division, 2012). In an over-populated Earth, fertile soils are a strategic resource and land (or soil) take, consumption, loss, degradation, grabbing refer to the aggressive demands that humans are putting on the global terrain (Table 1). An elegant way to perceive the unprecedented danger the soil resource is experiencing is to count how many times these words have been used in the Literature year by year (Fig. 1). Land grabbing is one of the last terms come into common use and indicates the acquisition of land or the long lasting rights to use it by public and private investors in some of the world's poorest countries to satisfy appetites for food and non-agricultural commodities (von Braun and Meinzen-Dick, 2009; Cotula et al., 2009). Additional cultivable land is scarce, while in some regions virtually missing (Young, 1999). Land exploitation can lead to soil erosion, drought, decline of biodiversity, and climate change. The ongoing

Abbreviations: ERR, Emilia-Romagna Region; ERP, Emilia-Romagna plain; gha, standardized global hectares; GMP, gross marketable production; UAA, usable agricultural area; SOC, soil organic carbon; EUROSTAT, Statistical Office of the European Union; ISTAT, Italian Institute of Statistics.

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http://dx.doi.org/10.1016/j.landusepol.2014.01.019

Table 1
Google and Google Scholar (in italic and in brackets) score in millions pages and definitions of some of the most used terms dealing with current insane land exploitation.

Terminology	Score[a]	Definitions	References
Land take	2030 (*2.99*)	Appropriation of land to devote to infrastructures and related facilities Previously undeveloped soil taken in to the built housing, utilities, transport, industry and commercial activities, recreation	EEA[b] Huber et al. (2008)
Soil consumption	32 (*1.14*)	Geophagy ≈Land take	Var. authors Nuissl et al. (2009)
Soil loss	17 (*1.51*)	Soil material loss by erosion	USDA[c]
Soil degradation	5 (*1.76*)	Mismanagement of arable areas by farmers and grazing areas by livestock owners. Result of natural hazards (steep slopes, floods, tornadoes, high wind, heavy rains, strong leaching, and drought) or due to unsuitable management practices (deforestation, over-cutting, shifting cultivation, overgrazing, unbalanced fertilizer use, over-pumping of ground water)	FAO[d]
Land grabbing	5 (*0.06*)	Large-scale (>10 kha) land acquisitions whereby powerful foreign public or private investors create agreements with domestic states, which implies possession of and/or control	FAO[d]
Brownfield	7 (*0.04*)	Abandoned or underused (industrial/commercial) facilities available for re-use Sites affected by the former uses, derelict or underused that have real or perceived contamination problems and are mainly in developed urban areas not currently fully in use	Wikipedia Encyclopedia of Earth

[a] For instance, the words 'air', 'water', and 'soil' score 2860 (*5*), 2270 (*6*), and 160 (*3*) millions pages, respectively on 2013, July.
[b] European Environment Agency.
[c] United States Department of Agriculture.
[d] Food and Agriculture Organization of the United Nations.

explosion in urban population is leading to enormous, uncontrolled expansion of many cities all over the world (Seto et al., 2011), which in most cases leads to significant loss of highly productive soils (Morello et al., 2000; Pan and Zhao, 2007; Scalenghe and Ajmone-Marsan, 2009) and for the future imposes adopting some planetary stewardship, possibly based on a global system of cities that develop sustainable processes and policies in concert with its non-urban areas (Seitzinger et al., 2012). The loss of cropland in connection with the increased demand for housing, industry and infrastructure, is especially acute in the developing countries, where population growth is rapid (Chen, 2007; Jiang et al., 2013). Although at lower rates, land take – soil taken in to the built environment by human settlements and related infrastructure – is also occurring in developed countries (Huber et al., 2008). In the coming three decades, global soil loss is expected to amount to 30–60 Mha (Döös, 2002), which is 3–6% of the land currently in use. As a consequence, to ensure a constant per capita food production, some 100 Mha of additional cultivable land is required. Urbanization, especially when implying the soil sealing, drastically depresses the main functions of soil but also those more strictly bound to the preservation of total environment (Grimm et al., 2008). For example, due to urbanization in China over the last 20 years, runoff coefficients have increased by 13.4% while the maximum flood discharge increased by 12.9% on average (Shi et al., 2007).

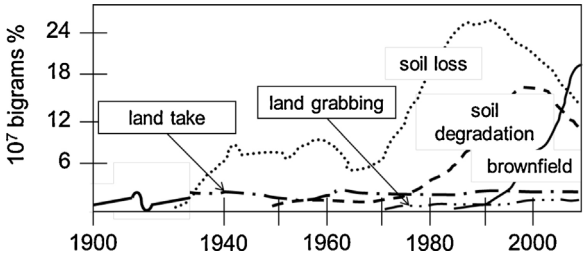

Fig. 1. Anthropogenic land exploitation jargon through the last century. This graph displays how some bigrams based on the terminology in Table 1 have occurred in a corpus of books in English published worldwide over the period 1900–2012 (Michel et al., 2012).

In this paper, we have collated data at regional level from the Emilia-Romagna Plain, one of the most productive areas of Italy, to quantify the ongoing decline of soil functions on a monetary basis. Emphasis is placed on the productive function but not ignoring the ecological aspects, although rendering them on monetary basis is difficult.

Materials and methods

The Emilia-Romagna Plain (hereafter called ERP) is a triangular-shaped area in Northern Italy with almost no relief. It is 1.2 million ha wide and delimitated by the River Po, the Apennines and the Adriatic Sea (Fig. 2), lying roughly between latitudes 43°54′N and 45°06′N and longitudes 9°20′E and 12°45′E, and between −3 and 150 m above sea level. The ERP is inhabited by 3 million people and hosts large industrial and agricultural activities, so much that its Gross Domestic Product (GDP) represents 75% of the GDP of the entire Emilia-Romagna region (ERR), which about double of ERP in terms of surface. In particular, ERP contributes to one third of the Italian production of wheat. Its soils are not subject to any specific threats according to European Soil Data Centre (Panagos et al., 2012), but since the 1950s had began to be pressured by the expansion of urban and industrial areas (Di Gennaro et al., 2010). To assess the rate of loss of productive soils in the ERP in recent years, an analysis of land use transformation was performed on the land use maps produced in the last two surveys of ERR, which date back to 2003 and 2008 (Regione Emilia Romagna, 2011a, b). These land use maps are based on photo aerial interpretation with a minimum resolution of 1.6 ha. For the purpose of this work, the Corine Land Cover legend was grouped into four classes: (i) urban and industrial areas; (ii) wood, grassland, and natural areas; (iii) agricultural areas; and (iv) wetlands and rivers (Table 2).

The economical value of soil was calculated relative to three major functions according to the Thematic Strategy for Soil Protection (European Commission, 2002) – "*Source of Raw Materials*", "*Carbon Sink*", and "*Food and other biomass production*" – as described below. The impact of land use change in ERP on the soil function "*Storing, Filtering and Transformation*" of water and