
International conference on Life Cycle Assessment
as reference methodology for assessing supply chains
and supporting global sustainability challenges

**LCA FOR “FEEDING THE PLANET
AND ENERGY FOR LIFE”**

Stresa, 6-7th October 2015
Milano, Expo 2015, 8th October 2015

Edited by Simona Scalbi, Arianna Dominici Loprieno, Paola Sposato



MILANO 2015



Italian National Agency for New Technologies,
Energy and Sustainable Economic Development



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Environmental and social impact indicators of soil consumption

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1. Abstract

This research is aimed to evaluating the impacts associated to the change of land use from agricultural and forest soils to artificial soils and estimating the losses of soil functions within the Lombardy region. Due to the available data sources, 5 years representative of different historical periods (1926, 1955, 1980, 1999 e 2007) have been examined, but due to the different scopes of the sources only the territory of Bergamo, Brescia and Cremona provinces where chosen for the completeness of data. As it is evident, each increase of the artificial soil reduces the agricultural soil, and it produces negative effects on the functionality of the soil. The effects considered in the paper are crops production losses and anthropic emissions increase; they are expressed by means of a set of indicators like CO₂ sequestration losses, potential agricultural production depletion, evapotranspired water decrease and emission of energy/heat in the atmosphere.

2. Introduction

The scope of the paper is to analyse the environmental and social consequences of the land consumption. The paper is based on the analysis of the available data of the land (or soil) functions and distributions over the time; the data were examined with the target to identify the agricultural, forest and artificial soils evolution. Due to the available data sources, the soil analysis was applied to an historical period of about 80 years (1926[1], 1955[2], 1980[3], 1999[4] e 2007[5]). Of course, due to the different origins and scopes of the books, not all the data are comparable and only the territory having the full set of required data were used, as it is the case for Bergamo, Brescia and Cremona provinces of the Lombardy Region. The data evolution could be summarized as an urbanization trend of growth and a rapid decrease of natural areas, which, in some way, could be extended to other provinces of the Lombardy and also to other Regions. In this research, the soil consumption has been connected to a growing environmental inefficiency, which may be represented by means of the following impacts: crops production losses and anthropic emissions increase, that could be represented by means of a set of indicators that express the agricultural production losses and the climatic regulation capacity losses with the consequent increase of the atmospheric temperature.

3. Analysis of soil cover data of Lombardy and environmental assessment

The values of the surface (hectares = ha) of the three categories of land use (agricultural soil, forest soil and artificial soil) in the provinces of Bergamo, Brescia and Cremona in the period 1926-1955 show the prevalence of agricultural and forest areas; the urban areas are minority and limited to specific areas. The land data of 1926 [1] are complete only for the agricultural soil, but they are not sufficient for identifying the forest and artificial soils; the reason is the propaganda of the fascist period concerning the campaign of Italian wheat production. The successive timeframes show the growth of the urbanization processes, with the increase of the artificial surface (28,4% of Bergamo land area and 35% of Brescia land area) [6]. At the same time there is an important decrease of the agricultural land, more than 50% of the total land area.

As opposed to agricultural areas, the surface of the forest land and semi-natural areas, show an increase: +80,000 ha (from 504,000 in 1955 to 584,000 ha in 2007, according to DUSAF [4] data), against +195,000 ha of new urbanized areas (increased from 91,000 to 286,000 ha). This trend stems from the abandonment of the agricultural activity in the foothills area (with a shift of the land from agricultural to forest).

3.1 Indicators and environmental assessment

The land use change is an irreversible landscape transformation and its increase led to permanent agro-ecological losses. In order to estimate the environmental damage caused by the process of consumption and transformation of soils, several environmental and productive indicators [7] can be associated to the surfaces of the category of land use change:

- emission of CO₂ stocked in the soils: 20 kg CO₂eq stock/m²;
- loss of the annual capacity of the soil to accumulate CO₂: 5 kg CO₂eq/y*m²
- loss of evapotranspiration due to the waterproofing of natural soils 600 l/y*m²;
- agricultural production depletion potential, wheat production losses 500g/y*m²;
- manpower requirements in agricultural soils: 0,06 person/ha y [8]

increase of emission into the atmosphere of energy/heat: 17,50 kWh/y*m². The adopted indicators are known literature values used to measure and monitor soils functionality change.

In the following tables and diagrams are reported the results of the indicators application to the soil consumptions.

		Agricultural soils				
		1926-27	1955	1980	1999	2005-2007
Bergamo	ha	173.485	115.360	106.681	82.429	77.976
Brescia	ha	292.548	220.984	209.187	180.206	167.315
Cremona	ha	155.257	161.429	164.989	153.768	151.370
Amount	ha	621.290	497.773	561.857	416.403	396.661

Table 1: Agricultural Soil comparing in five historical periods.

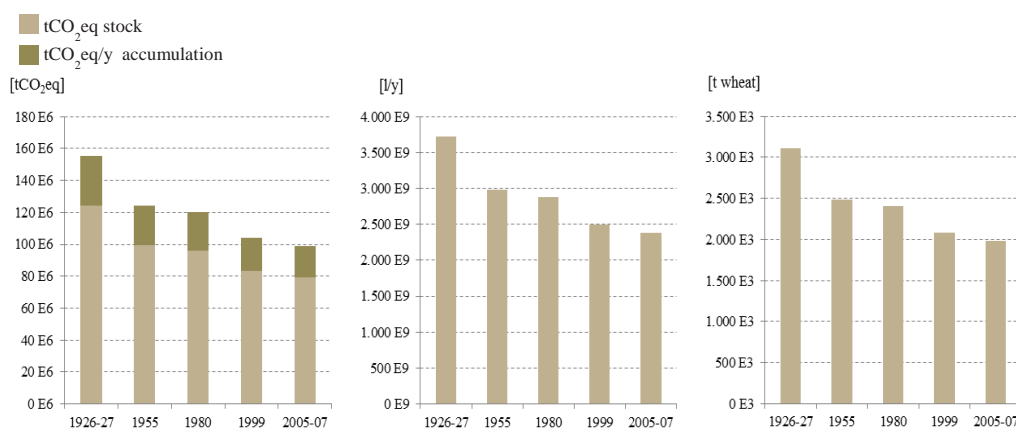


Figure 1: Environmental and productive indicators trend of Agricultural Soils

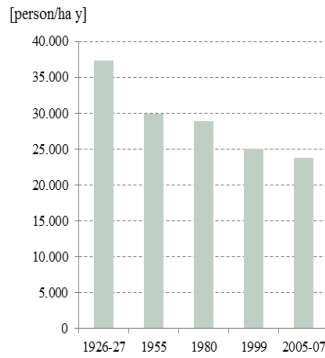


Figure 2: Manpower requirements in Agricultural Soils

		Forest soils			
		1955	1980	1999	2005-2007
Bergamo	ha	147.423	143.620	154.563	154.569
Brescia	ha	219.333	216.460	224.910	230.929
Cremona	ha	6.071	1.192	4.328	4.723
Amount	ha	372.827	361.272	383.801	390.221

Table 2: Comparison between surface area of Forest soils in four historical periods

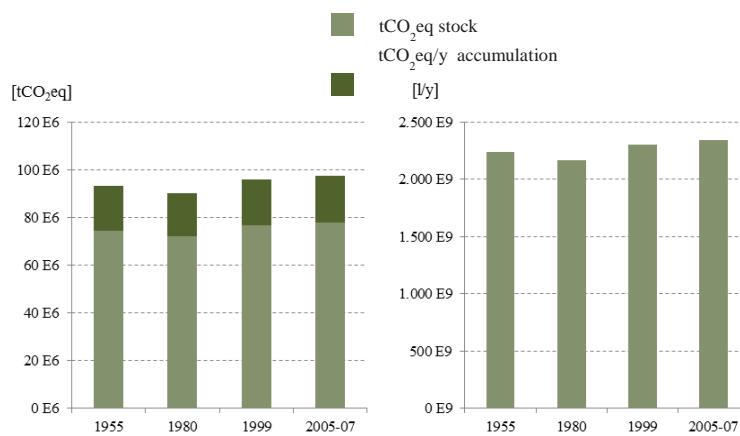


Figure 2: Environmental indicators trend of Forest Soils

		Artificial soils			
		1955	1980	1999	2005-2007
Bergamo	ha	8.297	21.268	33.887	38.274
Brescia	ha	12.850	28.074	47.273	53.996
Cremona	ha	6.894	9.163	16.524	18.694
Amount	ha	28.041	58.505	97.683	110.964

Table 3: Comparison between surface area of Artificial soils in four historical periods

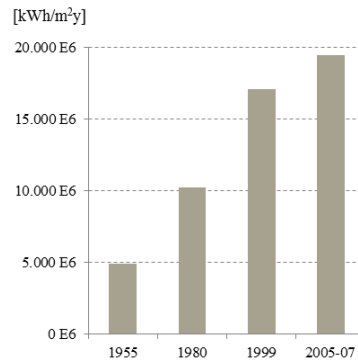


Figure 3: Environmental indicator trend of Artificial soils

The comparison between results obtained by the association of indicators to land use categories, shows as the cropland's progressive reduction leads to a loss of productive value, evapotranspiration ability and a loss of CO₂ soil storage. The loss of agricultural soil is higher in Bergamo and Brescia provinces, due to the highest industrialization. They are foothills territories and the availability of croplands is less if compared to Cremona province, that is situated in Po valley and bounded to agricultural activities. Forest areas increase, between 1980 and 2007, thanks to environmental policies development that incentivize the reforestation, the growth of trees for wood production (Reg. 2080/92) and the colonization of abandoned agricultural lands. With the increase of forest and natural areas, there is an increase of carbon soil stock, potential CO₂ storage ability and evapotraspiration of soils. In the timeframes analyzed the growing demand of settlement soil is feed by transformation processes in productive and service sectors, due to the location of logistic and commercial services. Added to this there is the demand of higher urban life quality, that promote urban sprawl and its pressure on the environment, with a consequent and permanent loss of agricultural resources (between 1955 and 1999). Artificial areas see an increase of atmospheric temperature (urban heat island) due to the growth of energy consumption and the lack of urban green areas. These problems are responsible of energy increase for cooling, of surface water temperature increase and of suspension into the atmosphere of greenhouse gas emissions (harmful to human health). We can confirm that the loss of croplands depends by the increase of other soil use categories: his value is the same to the sum of the increase of artificial areas and forest areas.

4. Conclusion and discussion

The results show some trends of worsening of environmental and living conditions linked to soils artificialization. In some nations the issue of zero land consumption has become regulation, in order to promote the riqualification of brownfield sites. In Germany, since 15 years policies to control soil consumption are active in order to achieving the threshold of 30 ha/day within 2020 (from 129 ha/day and the new goal of zero soil consumption within 2050). In Italy it is estimated a daily soil use of 668 ha/day, that is not justified by the demographic growth value. Land consumption cause a reduction of the biocapacity available for every citizen and all population. In Italy, using the Global Footprint Network data (revised in 2008) [9], the ecological footprint is equal to 4,8 ha/pro capite againts a biocapacity of 1,2 ha/procapite. Therefore cropland reduction of some Lombardy provinces can be applied to the whole Italy and it identifies a soil reduction of 33%, from 1,05 to 0,7 ha/pro capite, in timeframes considered.

This situation does not concern only Italy but the whole western world and shows an additional problem: how to maintain or increase food production through intensification of land use with fertilizers or with the use of marginal soils. However they require a higher environmental burden and a higher economic commitment for equal production results [10]. Soil consumption has negative effects also on society: the share of people employed in agricultural sector, between 2000 and 2012, shows a decrease about 51% (from 2,26% to 1,36%). This value seems to be proportional to regional croplands reduction [11]. However, the increase of awareness about the effects of soil protection and market recovery have led to occupation growth of 1% in 2012, breaking the sharp contraction trend of agriculture employment. The low land preservation cause phenomena that incentivize natural and cultural heritage depletion. Landscape fragmentation is caused by urban sprawl expansion and soil sealing, that exercise a heavy pressure on water resources, ecosystem and biodiversity with an irreversible alteration of green spaces quality, a deterioration of life quality and a landscape degradation. This causes a damage to historical and cultural land value that has also a great economy importance (e.g. as source of tourism).

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