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EVALUATING LAND CONSUMPTION AND SOIL FUNCTIONS TO INFORM SPATIAL PLANNING

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Abstract

The European Union, in the European Soil Thematic Strategy (EC. 2006a), recognises the need to improve the integration of measures to prevent soil consumption and degradation, in spatial planning and in those sector policies such as transport, tourism, commerce etc. that have a major influence on land use change. Indeed, there is a growing awareness at many territorial levels (Europe, Member States, Regions) of the problem of land consumption and its impact on environmental resources. Furthermore, it is recognised that one of the major drivers of land consumption is urban development, which in some areas of Europe, due to its sprawling nature, has higher impact in terms of energy and soil disturbance, than compact development.
For a sustainable spatial planning, for the purposes of reducing the impact of new urban development, it is essential the knowledge of the many functions that soil performs such as biomass production, filtering, carbon pool, habitat support etc. and their spatial distribution.
There is a need for spatial decision support tools and methods to allow the incorporation of soil information and the spatial knowledge of soil functions as part of planning decisions. In particular, for the purposes of soil conservation and soil management, it is recognised the high potential of spatial planning in order to limit soil loss, both in strategic environmental assessment and in plans.
This paper presents an analytical approach to the problem of land consumption by urban development and its impacts on land resources with particular attention to soil resources.
In the first part of this paper, trends in urban development are analysed for some regions of North Italy and for the provinces of the Friuli Venezia Giulia (FVG) region. Then a land evaluation model developed within a GIS for assessing the performances of selected soil functions in the Pordenone area (FVG region) is presented and is applied to demonstrate its effectiveness/validity for assessing the impact of future urban development on the soil resource.

The evaluation of soil functions

Soil, due to its extremely slow rate of regeneration processes, can be considered as a non-renewable resource of common interest to Europe because of its capability to perform several functions crucial for society and ecosystems. Blum (1993) groups these functions into two categories: ecological functions and economic/cultural functions. The former comprises the production of biomass – which is also the basis for agriculture and forestry - the filtering, buffering and transforming of substances - which allows for the protection of water resources or the disposal of wastes-, the supporting of diverse biological communities. Among the economic/cultural functions there are the provision of a spatial base for human activities, the provision of raw materials such as minerals and water resources and the protection of cultural heritage sites. The proposal for a framework Directive (COM(2006) 232) (EC, 2006b) whose aim is the prevention of soil degradation processes and the protection of soil functions, has recognised all the above cited functions and in addition, the acting of soil as carbon pool.
The perception of the importance of soil functions has changed through time. During Fordism and until the second half of the 20th century, natural resources were evaluated mainly according to criteria of economics or human convenience. For example, in the agricultural sector the properties of soil were evaluated for the purpose

of maximizing farming yields or determining the suitability of an area for growing specific crops (eg. maize, soybean etc.) according to their requirements. In the building sector, soil was evaluated for its capability of providing a safe spatial base and, consequently, for some desirable characteristics such as the absence of underground cavities, of the rising of groundwater, of shrinkable materials or of contaminated materials (Thompson and Peccol, 1995).
The capacity of soil to perform any of the above cited functions in terms of their number, composition and level of performance, while recognizing the fact that all functions are not equal, has been defined by Tóth et al. (2007) as Soil Functional Ability (SFA). SFA depends on characteristics both intrinsic and external to the soil: the former are defined by physical, biological and chemical parameters (e.g. texture, organic matter content, pH, cation exchange capacity, porosity etc.), the latter by natural (e.g. slope, steepness) and/or anthropogenic (soil-use and management) characteristics. SFA is a fundamental component of soil quality, in integration with Soil Response Properties (SRP) that represents the soil capability of responding both in direction and magnitude to a disturbance or change. Hence, SRP are defined as those "soil characteristics that determine the soil's response to environmental or human influences and thus mark different potentials of SFA" (Tóth, 2007).

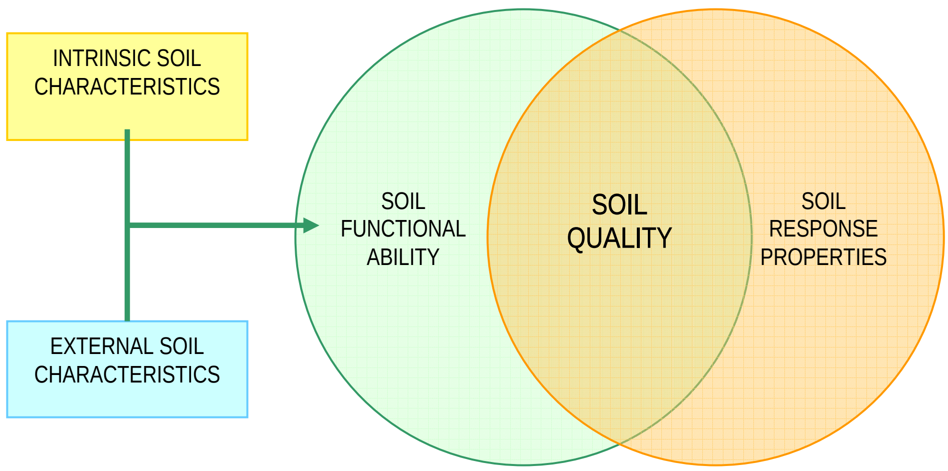

Figure 1: Relationship between Soil Functional Ability and Soil Quality (Tóth et al., 2007).

Soil Quality (figure 1) can be derived by developing a Soil Quality Index (SQI) as from the following expression:

$$\text{Soil Quality Index (SQI)} = \text{SFA} \times \text{SRP}$$

where:
SFA = Soil Functional Ability
SRP = Soil Response Properties

For the purposes of evaluating the Soil Functional Ability (SFA) Tóth et al. (2007) suggest using the following equation :

$$SFA = (F_{i,n} X\ EF_{i,n})/n$$

where:

$F_{i,n}$ are the considered functions from i to n,
E is the efficiency (level) of how functions from i to n are performed individually
n is the number of functions included in the evaluation
The importance or preference of each soil function relative to other functions in the overall assessment can be expressed by a weighting scheme that allows for the consideration of local preferences, potentials and constraints. Some of these functions are exclusive and in competition (Scalenghe and Ajmone Marsan, 2009) and therefore they can be evaluated by assigning them different weights, depending on competing objectives and interests.
Soil functions can be described within the framework of the ecosystem services (ES) defined by the Millennium Ecosystem Assessment (MEA) (Powlson et al. 2011, DEFRA, 2009), as they are recognised to be fundamental or

contributory to virtually all of the "provisioning", "regulating" and "cultural" services identified in the MEA. Indeed in the last decade, there has been a growing awareness of the need to measure the benefits of ecosystems, particularly for the purposes of assessing impact and environmental damage, of planning future patterns of development, of prioritising environmental management practices, of outlining regulatory programs that involve the trading of ecosystems (Boyd and Wainger, 2003). The Millennium Ecosystem Assessment (MA) is an international assessment process that developed a framework to assess the benefits of ecosystems for human well-being (MA, 2005) deployed to understand and quantify how ecosystems provide services, how to value ES, the use of ES in trade-off analysis and decision making and the use of ecosystem services in planning and management.
Thus the ability of soil to provide ecosystem and society services, depends upon soil quality and soil's capacity to perform its functions and respond to external influences. The functional relationship between soil functions and soil services is represented in figure 2.

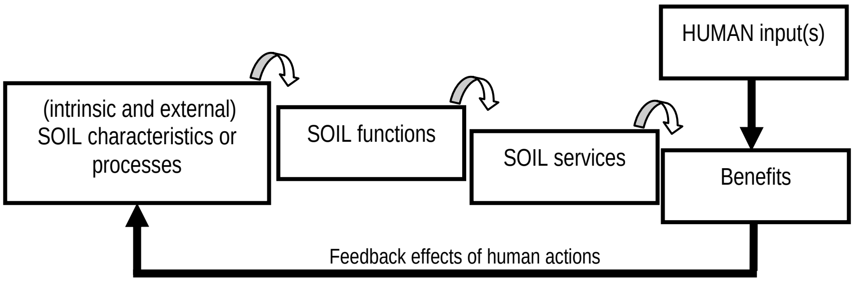

Figure 2: Conceptual scheme from soil characteristics to human benefits (adapted from Lamarque, 2011)

Soil functions, and the soil parameters upon which they depend, are time and spatially dependant. Soil management practices and land use change may enhance or reduce soil function performances. In particular, the increase of soil sealing, which is positively correlated with the increase in artificial land, produces several impacts on soil functions such as, among others, a reduction in soil carbon sequestration and carbon storage, in the protective capacity of water, in the capacity of supporting habitats and species and in a loss in water retention areas with consequent increase of runoff (Prokop et al., 2011).
In Italy, the increase from 1990 to 2006 of artificial areas (coded 1 in the first level of the Corine Land Cover nomenclature), derived from the Corine Land Cover databases by ISPRA, is 1.292 km^2 (APAT 2005; Sambucini et al. 2012) and corresponds to a rate of +10.9%, which is disproportionate to the population one (figure 3).

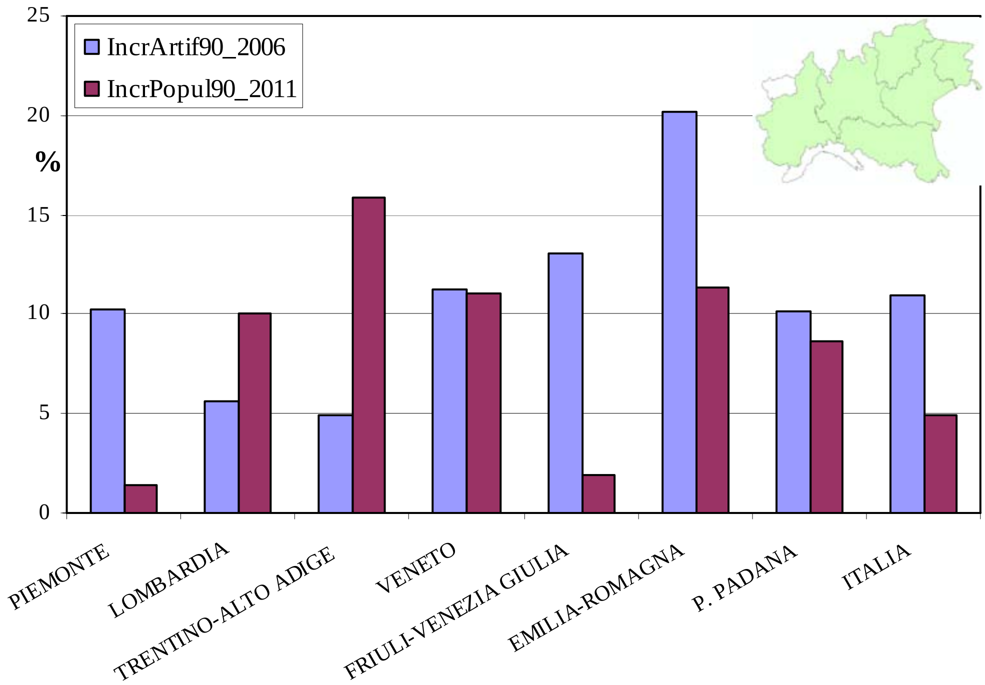

Figure 3: Regional rate of increase of artificial land and population in North Italy

The regions in figure 3 make up about 51% of Italy's total. Emilia Romagna shows the highest rate of increase in artificial land since 1990, yet the highest disproportion between the increase in artificial land and population can be found in the Friuli Venezia Giulia region, in the further North East. Land use change transitions show that artificial development expands mainly over agricultural land, with 95% in Italy (2000-2006) and 94% (1980 – 2000) in the FVG region as proven by national statistics (Sambucini et al. 2010) and by the Moland project (IES, 2002). In the above selected regions the increase of artificial development has occurred mainly along the main transport routes in a west east direction, which connect the main towns of the Padana plain, in the valley bottoms and along the secondary road network (Busi et al. 2011). Moreover, in some areas urban development has taken the form of urban sprawl, as in the triangle between Veneto, Lombardy and Emilia Romagna.

Consequently, one of the priorities of spatial planning should be the containment of land consumption and the prevention of irreversible damage to the soil resource, leading to a management of territorial resources in line with the principles of sustainable development. A sustainable spatial planning should rely on a set of practices aimed at minimizing the impact of human activities on soil through planning regulations aimed at: reducing the loss of greenfields; at promoting compact forms of urban development; at brownfield redevelopment; at prioritising new development on soils of lower environmental quality and at ensuring a more rational use of land to maintain as many soil functions as possible (Vrˇsˇcaj et al. 2008).

Despite the need, stated in the proposal for a Directive "Establishing a Framework for the Protection of Soil" (EC, 2006b), to identify, describe and assess particularly impacting policies on soil such as regional and urban spatial planning, in Italy there is a lack of a national framework to assess the impact of human activities on soil and the evaluation of soil resources is not a widespread procedure in planning processes. Instead, such an approach would be particularly valuable in strategic environmental assessments (SEA), where the relevant public authorities are responsible for the final approval of the assessed impacts on the environment, including soil.

Some authors point out the lack for the whole of Italy of an integrated land use database with a more detailed scale than the Corine Land Cover one and a system of nomenclature more appropriate to monitor urban development and the rate of soil sealing (AAVV, 2010). Of course, for strategic evaluations, suitable soil maps with the soil descriptions and the basic soil parameters should be available and harmonized at regional and local levels, but this is not the case for all regions in Italy.

Land evaluation is recognised to be one of the traditional tools to assess the performance of soil functions (Tóth et al., 2007) and some recent applications have demonstrated its effectiveness for this purpose in the context of spatial planning (Vrˇsˇcaj et al. 2008, Lehmann and Stahr, 2010).

In the first part of this paper, trends in urban development are analysed for some regions of North Italy and for the provinces of the FVG region. Then, a land evaluation model developed for assessing the performances of soil, in terms of selected soil functions is presented and is applied in the Pordenone area to demonstrate its effectiveness/validity for assessing the impact of future urban development on the soil resource.

Methodology

The case study of the Pordenone conurbation

Pordenone is one of the main towns in the FVG region and, together with its conurbation having a population of 84,143 residents (ISTAT Census 2011 provisional data) and an extension of 123.95 km^2, represents an area connecting the neighbouring Veneto region to the further North East of Italy.

This area, since the '50s has undergone a high and constant growth in terms of population, economic and urban development; the latter started along the main road network (eg. the Pontebbana State Road) in a west-east direction and is gradually extending towards the north - west area. Urban development has been partially triggered by the presence of some big industries, including the Zanussi company (now part of the Electrolux Corporation) and by the development of medium and small enterprises, which form an industrial cluster that provides goods and services to these major industries. The residential urban development in the municipalities around the town of Pordenone, analysed for the time frame from 1950 to 2000, is almost 90% low density, which makes this area highly sprawled in its character (EEA, 2006).

An efficiency indicator that divides artificial surface among population (Artificial Surface Per Capita) has been calculated for the Pordenone province and it has been analysed for a time frame within the context of the other provinces of the FVG region and of other regions in North Italy. The data used for the calculation of the indicator were derived from the Population and Housing Census data by the National Institute of Statistics of Italy (ISTAT) and from land cover data. The latter, have been provided for the regional level by the Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) after processing the 1:100.000 Corine Land Cover databases (1990, 2000 and 2006 years), while for the provincial level of FVG, the land cover data were derived by processing the 1:25.000 Moland databases of the FVG region (1950, 1970, 1980 and 2000).

The evaluation of soil functional ability

The performances of soil in terms of Soil Functional Ability depend on intrinsic (eg. cation exchange capacity, texture, organic matter content etc.) and external (slope, anthropic management factors) soil characteristics (Tóth et al., 2007). A land evaluation model has been developed in a raster GIS environment (spatial resolution of 10 m) with the purpose of assessing the performances of soil in terms of selected soil functions (Soil Functional Ability), relevant for the Pordenone conurbation area. The evaluation was carried out in a framework of soil protection, without assessing the performances of soil functions with respect to specific land use options. Besides, this application is focused on the evaluation of soil for its intrinsic characteristics and should be integrated, in its further development, by indicators representative of external soil characteristics (slope, irrigation etc.).

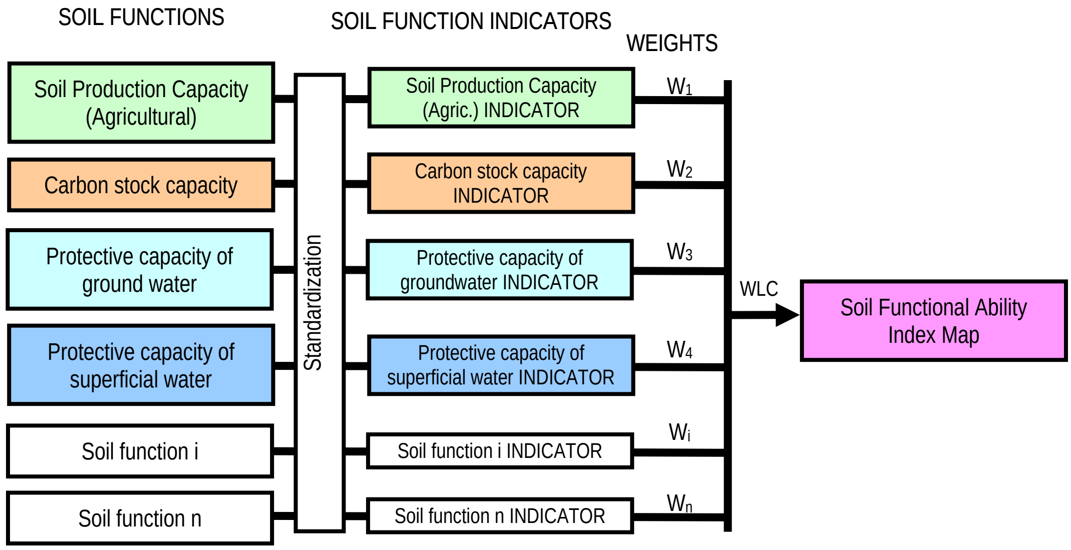

Figure 3 Scheme of the method followed to produce the Map of the Soil Functional Ability

The work flow for the evaluation of Soil Functional Ability has developed through the following phases:
1. soil data collection (map and related parameters)
2. processing the layers of the selected soil functions (fig. 3) from the soil map and soil parameters
3. calculation of the indicator layers
4. integration of the indicator layers into a Soil Functional Ability Index layer.

1 Soil data collection

The FVG soil map has been recently produced on a provincial basis by the Soil Bureau ERSA (the Regional Agency for Rural Development) from soil surveys with a methodology compatible with national and European standards. Soil mapping has followed the concept of substrate-systematic mapping, which means that every soil map unit contains information about the soil type and its parent material. For the Pordenone province, ERSA releases a 1:100.000 digital soil map (AA VV, 2003) representative of soil map units. These are the result of the aggregation of several soil types, with different soil properties, into one single complex soil map unit taking into account the scale of the map and the heterogeneity of soils across the landscape (Häring et al. 2012). A soil map unit is the smallest unit represented on the map and is a clearly defined entity in the map legend that shows the percentage of different soil types belonging to each soil map unit. This is a limit for land evaluation purposes, since it does not allow tracing the correct boundaries of each soil within each soil map unit. Since the soil map records the soil parameters for each soil type, while it represents soil map units (soil types combined in one complex map unit), a database table was prepared, which contained the soil parameters for each soil type, the percentage of each soil type for each soil map unit and the soil map unit codes.

2 Processing the layers of the soil functions

Map of the agricultural soil production capacity: soil properties from soil survey information have a significant and direct effect on crop production and different crops have specific requirements in terms of soil characteristics. In this context, by following a method set up by Danuso et al. (1998), a map of the General Soil Production Capacity was calculated. This method, as the best known "Land Capability method" by USDA (Klingebiel and Montgomery, 1961), is aimed at classifying the land in areas with different degrees of limitation to cultivations, on the basis of an assessment of soil parameters, but is calibrated onto the cultivations and the environmental condition of the FVG region.

Map of the soil carbon stock: soil is the largest pool of organic carbon in the terrestrial biosphere and, as such, has the capacity to accumulate or release carbon into the atmosphere; hence, changes in soil organic carbon storage can impact atmospheric carbon dioxide concentrations (Xu et al. 2011). Some soils have the potential to store a considerable amount of carbon and they may have a role as a sink for carbon (Scalenghe and Ajmone Marsan, 2009). Urbanization may have significant secondary ripple effects in terms of soil carbon loss for the removal of the topsoil, which is the richest horizon in organic carbon, for the reduced C sequestration capacity and for the decreased content in organic carbon in soils beneath impervious surfaces (Pouyat et al., 2006). Therefore, a map of carbon stock is an attempt to represent areas with the highest concentration of organic carbon, where potential urban development would be more impacting on the soil carbon pool. The carbon pool in soils is mainly due to the soil organic matter which includes organic carbon in mineral soils to a defined depth and may include live fine roots to a defined depth.

The estimate of the SOC stock was the product of SOC concentration, bulk density (BD) and soil depth, limited to the A horizon.

Maps of the soil protective capacity of superficial and groundwater: the soil protective capacity (SPC) of groundwater is the capability of soil of acting as natural filter for certain pollutants (eg. fertilizers or pesticides) by transforming them, absorbing soluble pollutants by clay minerals and organic matter and accumulating their toxicity (ARPAV, 2005). The SPC for superficial water, represents the capability of controlling the transport of pollutants by surface waters and therefore, the soil parameters considered are related with the risk of soil erosion and runoff. These important functions of soil, reduce the risk of water contamination and of crop contaminants uptake and deserve special protection, particularly in soils with high filtering and buffering capacity, for their contribution in supplying the population with clean drinking water.

In this study the data on the soil protective capacity of superficial and groundwater have been released by the Soil Bureau ERSA (AA.VV., 2003), together with the published soil map.

3 Calculation of the Soil Functional Ability Index

The four soil functions assessed in this study are represented by the:

- map of agricultural soil production capacity (ASPC)
- map of soil carbon stock (SCS)
- map of soil protective capacity of superficial water (SPCSW)
- map of soil protective capacity of groundwater (SPCGW).

The map of the Soil Functional Ability Index (SFAI) was obtained by integrating the above maps, transformed in indicator layers, with a weighted linear combination method. This is one of the most often used techniques to support spatial decision making problems since, being a hybrid, model offers the advantage of combining qualitative and quantitative evaluation methods (Gorsevski et al., 2006).

Prior to their integration, the soil function layers have been transformed into indicator layers of performance by applying membership functions, which are considered as tools to transform objective information (measurements) into a utility value for the evaluation goal. This is accomplished by a function that, through the selection of proper parameters based on expert judgement, assigns a utility value to the measurement. As a result, pixel values in each soil function layer were recast by using an evaluation scale, in this case ranging from 0 to 255, where higher values represent better performances for each soil function (eg. highest agricultural soil production capacity has values near or equal 255). For soil functions represented by quantitative attributes (soil production capacity and soil carbon stock) the approach was based on the application of fuzzy membership functions – in this case linear ascending - while for those represented by qualitative attributes the value was assigned on the basis of expert knowledge by compiling a table of reference values.

Once the soil function indicator maps - representative of soil functional performance with standardized values from 0 to 255 - were completed, a weight that reflects the importance of each soil function in the evaluation was assigned. In this specific case, equal weights were chosen, but the weights can be different according to the relative importance attached to each soil function. Then, the soil function indicator maps were combined with the weighted linear combination method as in Eq 1:

$$SFAI_j = I_{use} * (W_{ASPC} * I_{ASPC} + W_{SCS} * I_{SCS} + W_{SPCSW} * I_{SPCSW} + W_{SPCGW} * I_{SPCGW}) \quad \text{Eq. 1}$$

where: $SFAI_j$ represents the Soil Functional Ability Index for $pixel_j$, Wi are the weights – in this case equal - respectively assigned to each indicator layer and I_i are the soil function indicator layers. Since the sum of the set of weights for the evaluation is one, the resulting $SFAI_j$ map has the same range of values (0-255) as the indicator maps that were used. This result was then multiplied by the boolean layer $I_{use,}$ to mask out existing artificial areas. This layer was derived from the 1:25.000 regional Moland land use database, after recoding the cells of artificial areas (code 1 of the Corine Land Cover nomenclature) with value 0 and all the other land covers with value 1.

Results

Trends in urban development

The indicator "Artificial surface per capita" represents levels of efficiency in the use of soil by the population: high values point out low efficiency while low values, vice versa, result when there are high population densities in association with compact development. This indicator, calculated for selected regions of North Italy (figure 4) shows that for the most recent year, given the available data (2006), all the regions are above the national value of 250 m² with peaks of almost the double for FVG., which is the only region above the EU_{37} figure of 389 m² (Prokop et al., 2011).

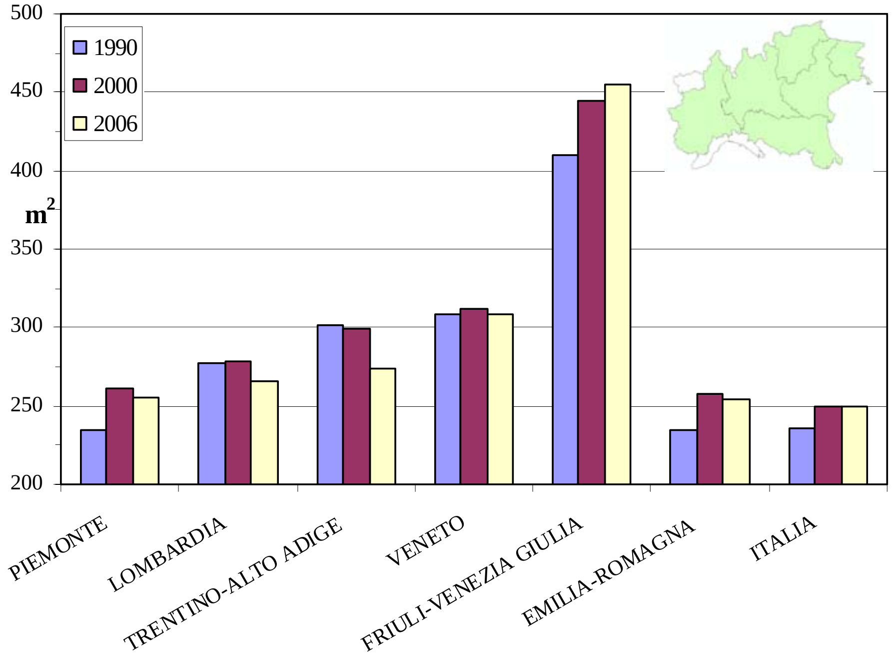

Figure 4 Artificial surface per capita (m²): trends in the regions of North Italy

The trend shows that while from 1990 to 2000 there has been an increase in the indicator value with a consequent decrease of efficiency in all regions, in the period 2000-2006, in Italy and in all the analysed regions with the exception of FVG, there has been a decrease in the artificial surface per capita, due to a rate of increase in the population greater than in artificial areas.

When considering the same indicator for the four provinces of the FVG region (figure 5) - for the lack of recent 1:25.000 land use maps, 2000 is the most recent year - the two provinces of Udine and Pordenone reveal exceptionally high values when compared with the 250 m² of Italy for the same year. Such a high value partly depends, at least for Pordenone, on the presence, since the '50s, of a relevant extent of military areas that in the map are classified as artificial areas, although they are not yet sealed. However, the recalculation of the indicator by using only "residential areas" (part of the artificial areas) for 2000, remains remarkably high for Pordenone (565 m²) and Udine (492 m²) showing a trend of these two provinces towards a sprawled urban development.

It is worth highlighting the difference between the FVG "Artificial surfaces per capita" for the year 2000 in figure 4 and 5, which is 171,5 km² higher in figure 5. This depends on the scale difference between the two land cover databases used to derive these statistics, which are respectively, the 1:100.000 Corine LC one in figure 4 and the 1:25.000 FVG Moland land cover one in figure 5.

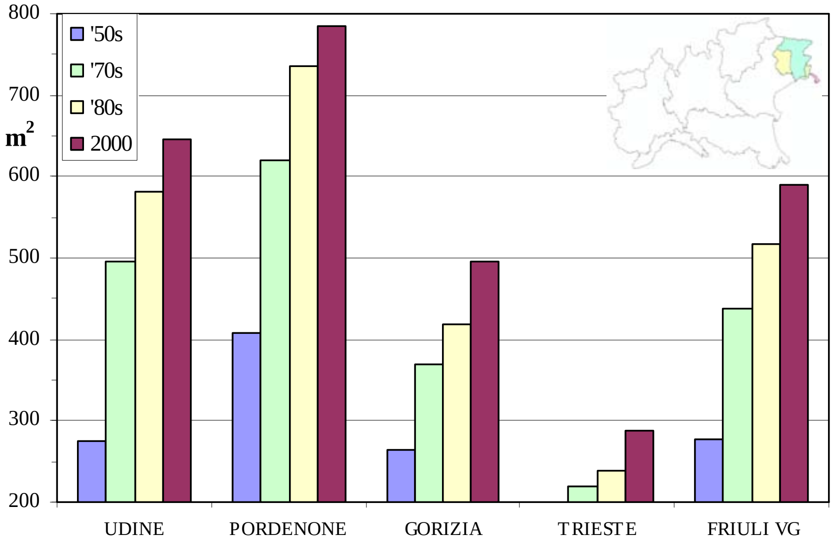

Figure 5 Artificial surfaces per capita (m^2): trends in the provinces of Friuli - VG

It is possible to draw the conclusion that the Corine LC database, for its small scale, tends to underestimate artificial development in FVG for quite a large amount of around 25%. This is in line with the resulting "artificial land per capita" indicator for the FVG provinces, which detects a trend towards a sprawled development, whose nature is mainly of dispersed small urban centres not recorded on the map.

Furthermore, due to loose planning regulations and the lack of established soil evaluation procedures within the frame of local urban plans, almost 92 % of residential development for these provinces in the time frame 50-2000, has expanded on agricultural land. Being the trends from 2000 to 2006 of an increase in artificial development in the region, we can assume that as a consequence, in these two provinces there has been an increase too. This more recent trend, disproportionate when compared with the population trend, may partially depend on a fiscal/taxation system existing in Italy, where the municipalities fund part of their current expenditures with planning fees.

These results are integrated in the next section, with the results deriving from the evaluation of the soil functional ability for the area of Pordenone that has produced the maps of the selected four soil functions in the study area end the final map of the Soil Functional Ability Index (figure 6).

The map (figure 6) represents the Soil Functional Ability Index for the four functions of protective capacity of superficial water, protective capacity of ground water, soil carbon stock and agricultural soil production capacity. Each function has been assigned the same weight and therefore the final result does not reflect preferences for a specific function. In the original map the index is represented by values measured on a scale from 0 to 255, which have been reclassified by using the average and standard deviations calculated for the study area. Therefore since the legend shows grades of functional ability around, above and below the average value, the levels of the index are not represented in absolute terms, but they are relative to the extent and the values distribution of the study area (Pordenone conurbation).

The map represents an overall value of Soil Functional Ability, derived with a weighted linear combination method from the four soil function indicator layers that allows for compensation between soil function indicators. This means that a raster cell with a low score on one soil function indicator can be compensated by a high score on a cell of another, leading to a trade-off or substitutability between soil functions. In this sense, the cells coded as "High" on the map, do not necessarily represent high performances for all the four soil functions.

The map of the Soil Functional Ability Index shows the highest values in the south east area of the Pordenone conurbation, adjacent to the boundary of the most compact urban development. In this area the highest values for all soil function indicators can be found, except for the protective capacity of superficial water that is higher in the north and north-west area of town. The north east part of the study area is characterised by a "Low" SFA index value, where three out of four soil function indicators show low performances: one of these, is the indicator of the agricultural soil production capacity, despite the fact that this is mainly an agricultural area with scarce urban development.

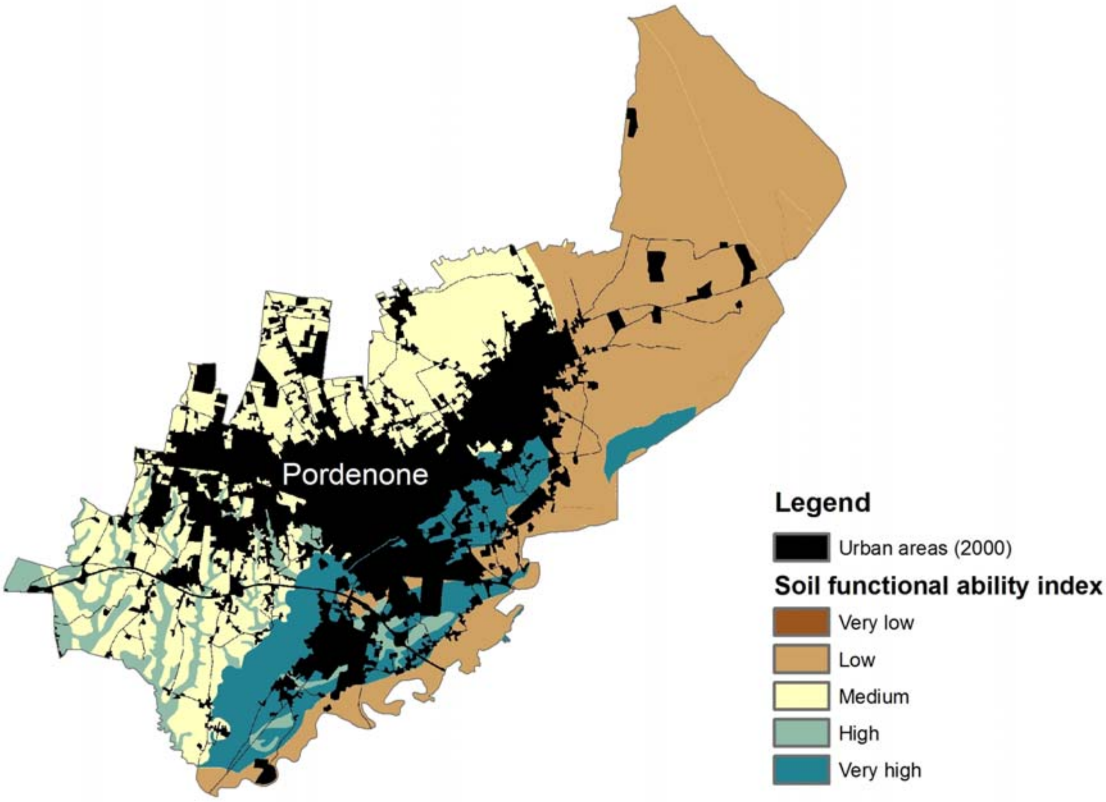

Figure 6: Map of the Soil Functional Ability Index for the Pordenone conurbation

SFA Index	Area (ha)	Area (%)
Very low	5,65	0,05
Low	4750,03	38,33
Medium	4956,93	40,00
High	802,89	6,48
Very high	1876,36	15,14
Total	12391,86	100

Table 1: Area by class of soil functional ability

The areas with high and very high soil functional ability cover almost 27 % of the study area (table 1), while 40 % is represented by the class with the medium values, which surrounds for a larger part the main town.

Discussion and conclusion

The efficiency in the use of the land expressed by the indicator "Artificial surface per capita", for Italy has not changed between 2000 and 2006 and it is decreasing for the regions of the North, with the exception of FVG. In this region the province of Pordenone has exceptionally high values of this indicator, which remain high, even when the calculation is based only on residential areas, proving a trend towards a sprawled development. This indicator is remarkably higher when it is calculated from the map at larger scale (Moland 1:25.000), by maintaining the other variables unchanged (year, geographic coverage etc.), which leads to the conclusion that it would probably increase further, by using larger scale land cover maps (1:10.000 or 1:5.000), presently not available for this region, as for many others in Italy. These results recall the need to monitor urban development and soil sealing in the FVG region with maps that are both larger in scale and more up-to-date than those presently available.
The protection of soil functions should become a key objective in spatial and urban planning and should be a fundamental component, particularly along strategic environment assessments. Presently land evaluation in a

framework of the protection of soil functions is not a commonly applied approach in Italy and there is a need for spatial decision support systems applicable for this purpose in different stages of the planning process.
The method for the evaluation of soil functional ability proposed in this study, is an attempt to demonstrate the potentials of combining spatial decision support systems and GIS for the purpose of mapping soil functional ability in a single spatially explicit index and requires further refinement for its application in an operational environment.
The selection of the soil functions in this study has been made using as reference the list of the key soil functions proposed by the Soil Thematic Strategy and taking into consideration their relevance for the study area, yet it is not comprehensive of all soil functions of the study area. Furthermore it could be integrated with the selection of indicators representative of external factors of soil functional ability such as slope or human management factors.
The evaluation has been performed with the purpose of mapping soil functional ability in a framework of soil protection, without assessing their relevance with respect to specific land use options. In this latter case the functions selected and the assessment of their performance would change, in order to satisfy the requirements deriving from the selected land use.
The method proposed can benefit from processes of consultation with local experts, who should give a contribution to the selection of the soil function indicators, of the weights and of the parameters used in the membership functions used to standardize the indicators. Indeed, this latter is recognised to be a problematic aspect since "the significance of a certain parameter for certain soil functions is unknown" (Lehmann and Stahr, 2010). The method proposed is flexible, in the sense that it can accomodate, as map layers, instances related to soil other than the environmental ones such as the social ones; therefore maps representing social values of the land or community identity maps (of intangible cultural resources such as traditions, stories or local knowledge), when available, may become part of the model. Finally, this method can be repeated in other areas, although in Italy the availability of suitable soil data remains one of the limiting conditions.

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