The breaking points in the “green corridors” due to new Master Plan of Rome

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Introduction

The soil protection has been recognised as important issue in the sustainable development (UNECE, 2000) by few years ago. Despite the fact that a wide range of activities use and contribute to the depletion of soil resources, soil protection has not generally been the subject of specific policy objectives and targets, unlike the water and air. However, soil is a limited and not renewable resource and it is not easily recoverable. On this soil multi-functionality is based the soil paradox (EEA-UNEP, 2000) which leads to an increasing competition between concurrent use of soil and land. These competing demands, if not properly managed, will cause a wide range of impacts (Figure 1); the soil sealing is one of these.

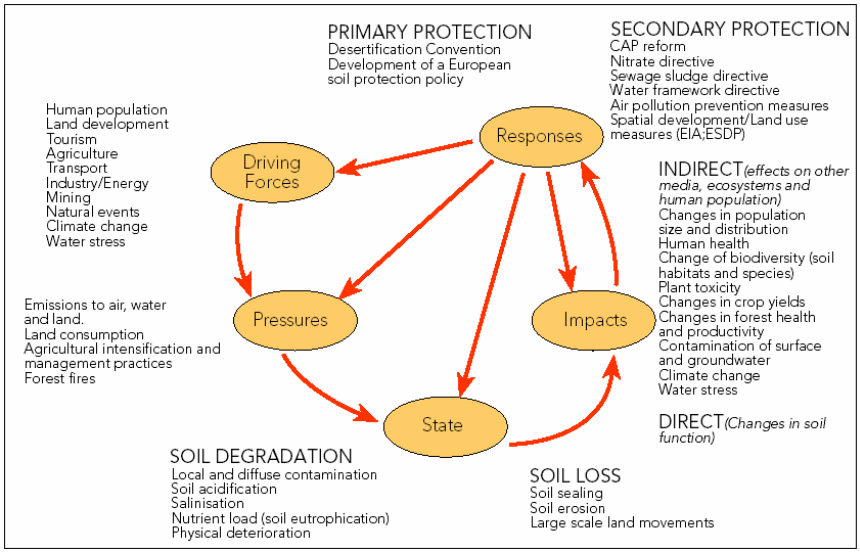

Figure 1 DPSIR framework applied to soil (Source: EEA)

The European Environment Agency (EEA) glossary definition is:
“*Soil sealing is the covering of the soil surface with an impervious material or the changing of its nature so that the soil becomes impermeable*”.
The major impact of the sol sealing is on the water flows due to the chemical (unfiltered runoff water from housing and traffic area) and physical (increased velocity) effects on

the runoff water. It has been observed that floods can be intensified by the human alteration (Katzenmaier et al., 2000).
Even if some projects (e.g. GMES, INSPIRE) have been started to monitoring environmental changes, there is still a lack of information on soil sealing. The built-up area has been used as a proxy indicator for the amount of soil being sealed and for quantifying land-taken by urban expansion. The extent of the built-up area has increased in the European Countries by some 20% (EEA, 2002) while the rate of the population growth in the same period is 6%. Even if the number of households and average residential space per capita is increasing since 1980, a trend that has accelerated since 1990 (EEA, 2001), there is not European regulation about soil protection. In the EU, policy measures related to land-use planning have generally been the responsibilities of Member States; a few countries (Denmark, Germany and the United Kingdom) have adopted specific targets such as reuse of brownfields and derelict areas. In Italy, there is not any regulation about this even if a new generation of plans is ongoing.
Built-up land is lost to other uses such as agriculture, forestry and the ecological functions of soil. Soil sealing can also results in the fragmentation oh habitats and the breaking down of "green corridors" used by wild species.

Methodology
This work aims at evaluating the estimate of soil sealing extent in new master plan of Rome in relationship with the natural state of the urban areas. Such a problem is hard to treat, because it needs to understand in advance the effects of plan's rules functioning, all over a whole town. The problem is emphasized, when the city is Rome (about 1.200 square km. of municipal land) where the new plan is based on a small set of deterministic rules, in order to improve the flexibility of the implementation process.

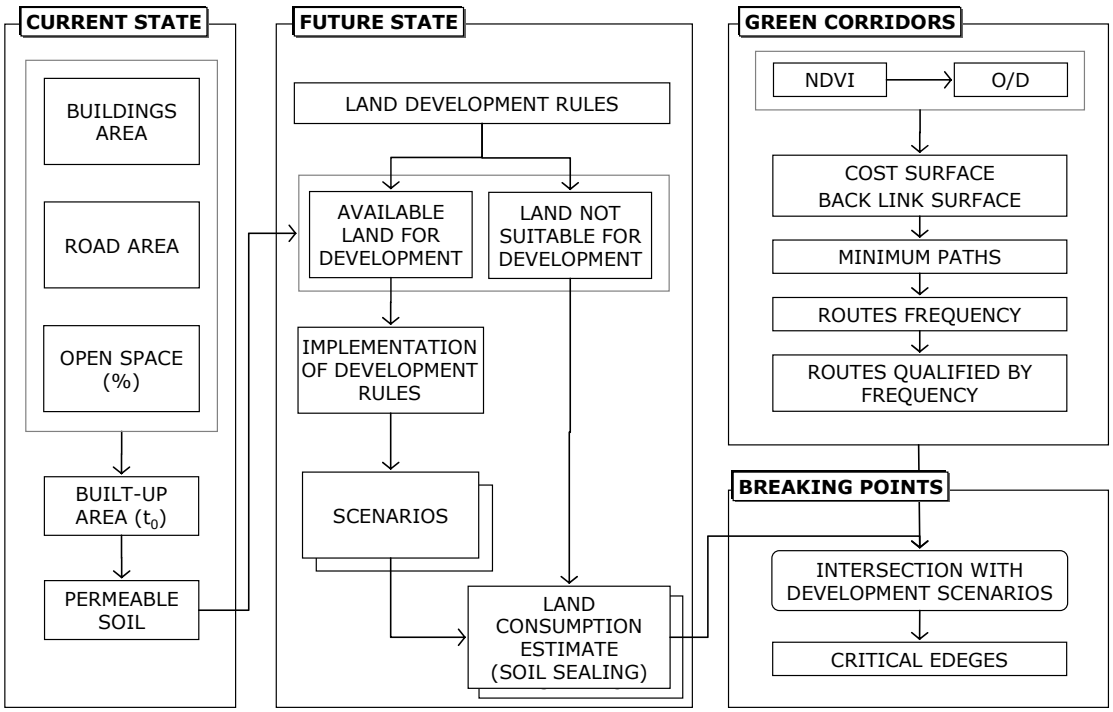

Figure 2 Flow chart describing the research

We must notice that built-up land also includes soils (gardens, parks,..) that are not impermeable; however, the whole impact of soil sealing influences these sites and incorporates them into the impermeable ones.
The research is articulated in four main steps, two of them referred to the current situation and two to the future state (Figure 2). Here, they are briefly described: i) the estimate of the soil sealing at current state; ii) the estimation of the soil sealing in the future state ad resulting by the implementation of the development rules defined in the new Master Plan of Rome; iii) the definition of the green corridors as resulting by the minimum path algorithm running on the Normalized Difference Vegetation Index (NDVI) coverage; iv) the definition of the breaking point of the green corridors.

The estimate of the soil sealing: current and future state

The soil sealing is estimated at the current state and in the future state as provided by the new Master Plan of Rome. Two scenarios (the minimum and the maximum) are developed due to the uncertainty of the socio-economic forces (public or private) to put into effects the plan.
The sealed soil indicator is referred to a regular grid based on a square cell (500 x 500 meters) in order to define the value of the indicator as not depending from the physical dimension of the particular zone.
At present time, the sealed soil is measured with: i) the built-up areas (buildings and road network); ii) a share of "open" spaces evaluated by the means of the Vegetation's Index.
We used an ETM+ 2001 to evaluate the NDVI in Erdas environment.

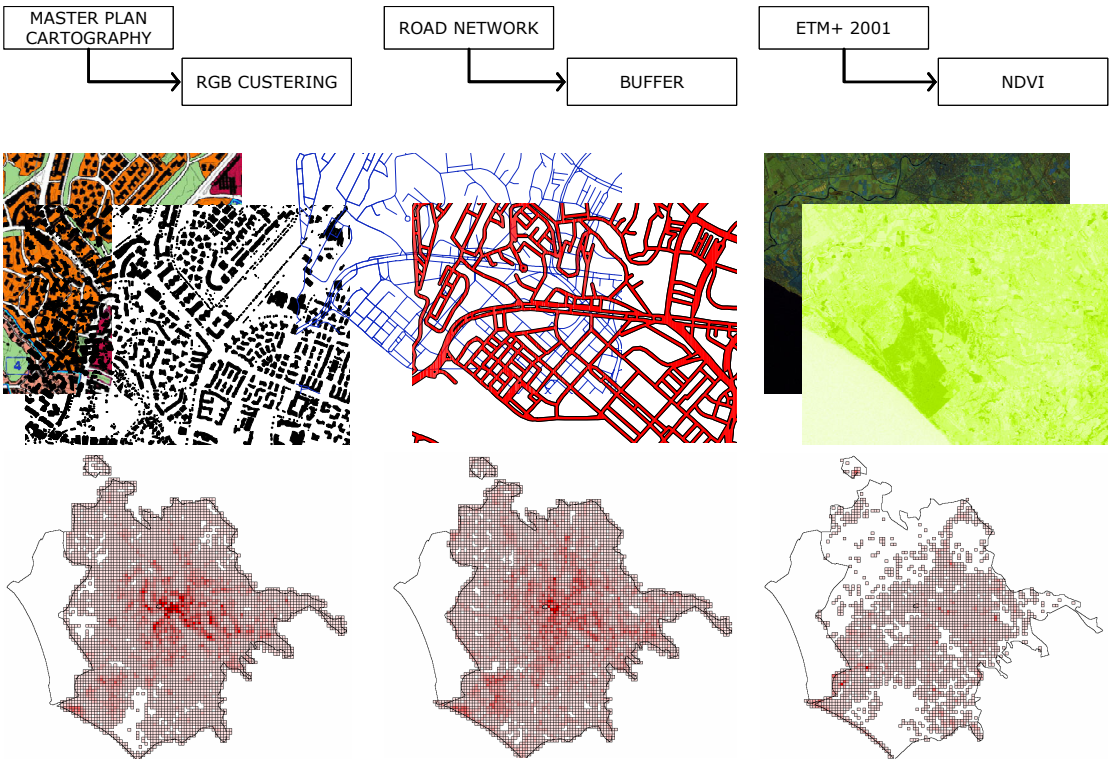

Figure 3 Soil sealing at current state from different type of "source"

To estimate the soil sealing due to the master plan, two different kinds of problem have to be faced both on the normative and on cartographic side. The town planning regulation is analysed to evaluate the total amount of square meters covered by new built-up areas for residential, productive or commercial assignment.
In Italy, the Master plan is substantially based on a zoning system even if some new elements have been introduced to improve the flexibility of the planning system and to address environmental issue.
The Master Plane of Rome (2003) defines three different set of rules: i) the first one is dependent on the existent urban fabric (ten different type of urban fabric have been defined; as a raw description, they define areas that are not allowed to any changes, which ones are only limited modifiable and the expansion area); ii) the second ones is referring to specific area subject to valorisation (area subjected to degradation) and the last defines green area that have to be maintained and strengthened.
The first set of rule could be overlapping with the others depending on the particular situation of a specific zone; the result is a combinatorial set of development rules.
For each of them, a different quantity of new dwellings is allowed; this number is not fixed but depends on the construction density driven by the socio-economic forces. It results in a different rate of soil sealing, so two scenarios have been defined: minimum and maximum.
On the other side, the cartographical base (a raster image) has to be processed to measure the area of each regulated zone; this task results in a complex of processing's steps because of the master plan is not available in vector format. The cartography of the master plan has been managed as satellite image; a supervised classification has been performed where the colour of each zone refers to the regulation of this zone. The soil sealing extent is presented in Figure 4.

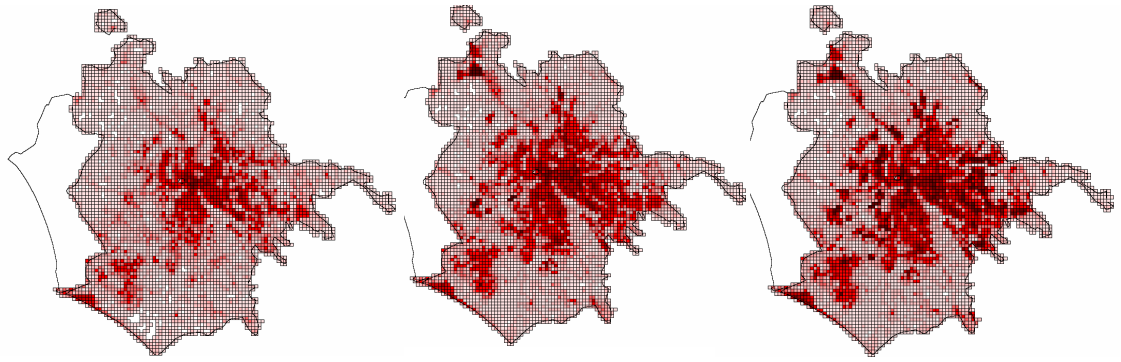

Figure 4 Soil sealing: a) current state ;b) minimum scenario; c) maximum scenario

The green corridors

The current "green" corridors are determined by analyzing the vegetation index on the urban area. The identification of the green corridors involves two different kind of problem: i) the identification of the core-areas (with an high degree of natural value); ii) the definition of the cost surface.
The core-areas has been defined by the classification of the NDVI index in high, medium and low value and taking into account high value areas with a spatial extension prominent at urban scale In this way, they have been identified 66 core-areas; they represent the

origin and destination points of the green corridors
The green corridors are links connecting the high green quality areas. The connection is also represented by high degree of green areas; in other words, they are the minimum path calculated of the NDVI coverage. To perform this step, it was necessary to test different spatial resolution of the NDVI grid to draw out a natural green network. At the end, the grid has been reclassified to a 250m x 250m spatial resolution. Furthermore, the cost surface has been reclassified in order to constraint the built-up areas; the "quality" of the green areas is directly linked with the NDVI index (the lower values of NDVI correspond to high quality green areas and to a lower level in the cost surface).
For each origin point, it has been evaluated the minimum path to each destination point.

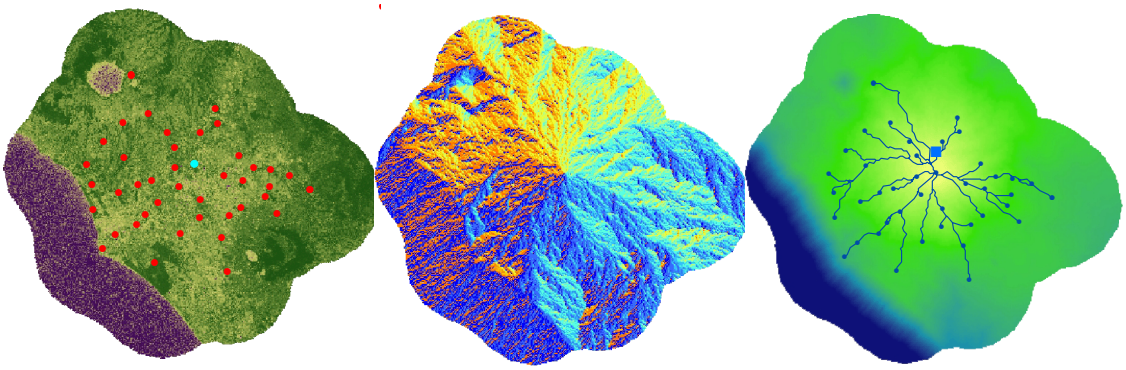

Figure 5 The minimum path on the NDVI grid

Results
The green corridors are finally designed by running the minimum path algorithm on the cost surface. At the end, the resulting minimum paths have been summarised to find the frequency of each of them (Figure 6).

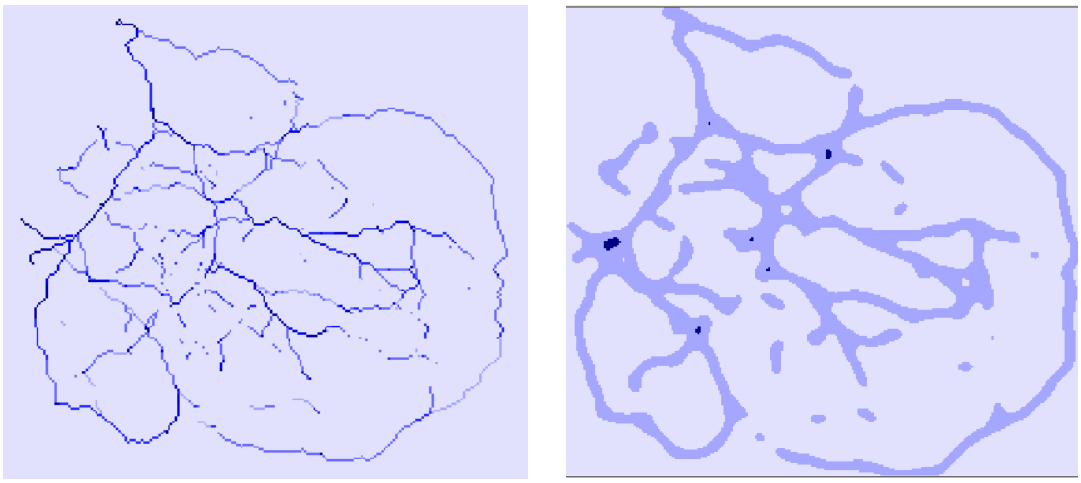

Figure 6 The frequency of the minimum paths

The "green" corridors are compared with the estimated sealed soil to stress the breaking point in the network due to the putting into effects the new Master Plan of Rome (Figure 7).

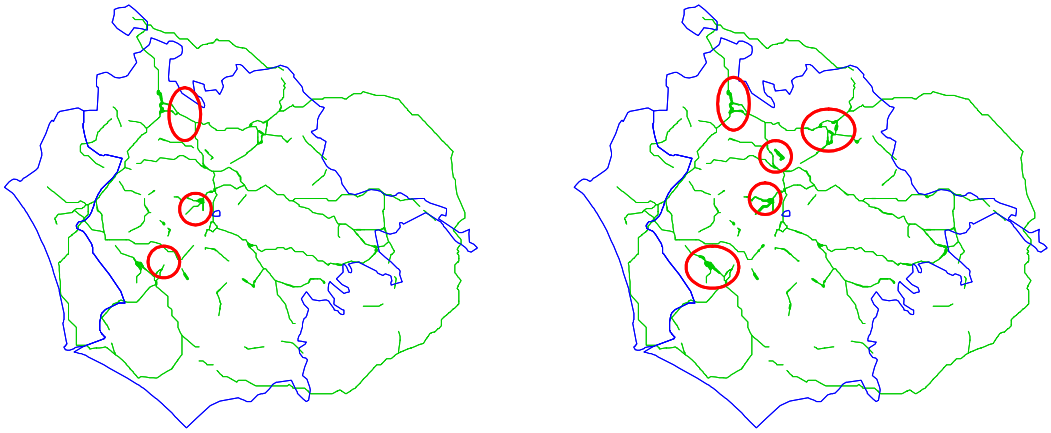

Figure 7 The breaking points in the green corridors: a) minimum; b) maximum

In both case, the breaking points interrupt the north-south path in the centre-west side of the municipality of Rome. This area is along the river Tevere and it is particularly relevant form an environmental point of view. In the maximum scenario, more breaking points have been identified; they are located in the north-east of the municipal territory. This area is one of the most important "node area" ("centralità") in the new Master Plan but it was also a natural area ("campagna romana") of the municipality of Rome.

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