

ID 1368 | RESILIENCE THROUGH A METHODOLOGY TO PLAN GREEN INFRASTRUCTURES

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OVERVIEW: The increasing use in recent years of the word resilience when considering sustainable development, linking relief to development, adaptation to climate change and the need to give greater priority to addressing vulnerability has been much discussed. It has proved attractive because it appears to offer a way to bring different disciplines and perspectives under a single conceptual umbrella. The impacts of urban sprawl on peri-urban landscapes include, among other things: loss of natural habitats for species; lack of natural water retention areas; negative impacts on water quality; negative impacts on human health, mental/physical wellbeing, recreation, social interaction; impacts in terms of climate adaptation. The climate crisis is hitting a territory in which the hydrogeological instability has made the mountain slopes unstable and fragile and where the lowland areas improperly exploited, particularly in the vicinity of rivers, have become spaces of devastation due to floods and landslides. The territory has suffered profound and disfiguring changes in terms of structure, function and, consequently, of resilience capacity to these extreme events (Fasolino, 2017). Green Infrastructures (GI) can mitigate the effects of climate change and extreme events that they pose, managing, for example, the devastating power of floods or landslides, re-establishing spaces and functions (Austin, 2014; Benedict and McMahon, 2006; Laforteza et al., 2013). The main elements of GI include parks, private gardens, agricultural fields, hedges, trees, woodland, green roofs, green walls, rivers and ponds. The theme of GI is closely related to Ecosystem Services (ES), which are fundamental to maintaining the resilience of a territory. We propose a methodology for the effective planning of a GI network that will help achieve numerous benefits, including: reducing risks to people and property, improving psychological health & well-being, boosting local economic regeneration and providing a habitat for wildlife. There are currently any tools available and many more emerging. The challenge is to ensure that well planned GI, providing functions which will meet numerous planning objectives, can go beyond the purely scientific and environmental framework and become an integral part of public policies; but this requires thorough planning, design and management. This paper shows how to develop a GI network using existing European data. Most input data for the Geographic Information System (GIS) was taken from published and reclassified sources for analysis purposes. The choices made during the data processing and analysis are based on expert opinions and are open to public control. In conclusion, to achieve the resilience of a territory, it is very important to promote the mainstreaming of risk assessments into land-use policy development and implementation, including into urban planning.

1 FIELD OF INTEREST AND ANALYSIS ABOUT THAT

1.1 EUROPEAN POLICIES ABOUT GREEN INFRASTRUCTURE AND ECOSYSTEM SERVICES

Human-induced climate change, combined with other man-made pressures such as the conversion of soil uses, has altered the functions of ecological systems and has consequently altered the flow of ES in terms of scale, timing and position. Future climate change will probably aggravate these effects.

The European Union (EU) strategy for adapting to climate change aims to make Europe more resilient to climate change by ensuring ecosystem-based approaches. The importance of GI is identified by the European policies in the following documents:

Exploring Nature-based Solution of European Environment Agency (EEA) - EU, which shows the need for GI to mitigate vulnerability to atmospheric agents, climate change and, in particular, landslide risk.

The Seventh Environment Action Programme - 7EAP (Decision No 1386/2013/EU) proposes to increase ecological and climatic resilience, so that the restoration of ecosystems and GI can have important socio-economic benefits, including public health.

The EU Biodiversity Strategy (COM/2011/244 final) requires the restoration of at least 15% of the degraded ecosystems in Europe and aims to expand the use of GI.

The 2013 European Commission Strategy on Green Infrastructure (COM/2013/0249 final) stresses that GI can make a significant contribution to the effective implementation of all policies where some or all of the desired goals can be achieved at least in part through natural solutions.

The Regional Policy 2014-2020 continues to support nature and GI through financial instruments such as the European Regional Development Fund and the Cohesion Fund, which contribute to providing multiple benefits, in particular economic development.

The Water Frame Directive (2000/60/CE), Nitrates Directive (91/676/EEC) and the Floods Directive (COM(2006)15) offer GI related opportunities; for example, supporting actions to improve soil conservation through GI.

The aim of this study is to develop a methodology that allows, from a multi-scalar point of view, to detail the procedure outlined in the European document by highlighting its limits and translating them into actions onto a more detailed scale in the territorial and urban planning.

1.2 LANDSLIDES

Landslides are harmful events that seem to be repeated more frequently and, after earthquakes, are the events that cause the greatest number of victims and damage to inhabited towns, infrastructures, environmental and cultural assets. Eroding soil erosion can cause significant losses in agricultural and forest productivity. Soil erosion depends mainly on precipitation as well as more superficial properties of the soils (Crozier, 2010). Plant cover plays an important role in soil conservation and in the prevention of landslides (Stokes et al., 2013).

According to a study prepared by the EEA, there are many tests that determine how rising landslides are due to climate change. In particular forests, along with other vegetation, are able to reduce the presence of surface landslides. Their global increase is due to the excessive use of natural resources and deforestation, as well as increasing urbanization and uncontrolled land use.

In a recent analysis, we recognize the importance of different types of vegetation to mitigate the risk of landslides. Although a large part of European literature has recognized the link between plant cover and slope stability, the ability of GI to mitigate the risk of landslides is poorly evaluated locally. The potential methods to be applied include the evaluation of the replacement or avoided costs.

Studies show the ability of ecosystems to mitigate the risk of landslides based on the presence of protective forests and the potential danger of landslides. The integration of both maps involves delineating a potential GI network to mitigate vulnerability from landslides.

The regions with good coverage of potential GI elements are areas with dense forests. Overlaying the GI network with settlements and road infrastructure, we can know the application for the GI protection function. The result shows that most settlements and high mountain roads have effective protection from landslides, while the risk increases moderately in hilly areas with a lower percentage of forest protection.

The potential landslide hazard is based on the European Landslide Susceptibility Map (ELSUS1000) by European Soil Data Centre (ESDAC).

1.3 GREEN INFRASTRUCTURE AND ECOSYSTEM SERVICES

Green Infrastructure (GI) consist of a network of natural and semi-natural areas strategically planned with other environmental features, designed and administered to provide a wide range of ES. The importance is

given to the ES provided as well as the use and management of the soil, with the aim of delivering a set of environmental benefits while maintaining and improving the ecological functions (Lennon and Scott, 2014).

Eco-systemic functions are defined as: the ability of processes and natural components to provide goods and services that directly or indirectly meet the needs of man and guarantee the life of all species.

In order to prevent the impacts of uncontrolled urban development and fragmentation, connections are made in ecological networks and green spaces are promoted in the urban context. Potential GI are identified by the combination of an existing hazard in a given region and the presence of ecosystems with ES that mitigate the impact of the hazard.

Ecosystem Services (ES). The ecosystems of a territory, through chemical-physical, biological and more generally ecological processes, provide irreplaceable support to the quality of life of its inhabitants and are the basic factors for sustainable economic development. These processes are recognized as ES, that is, a set of functions naturally provided by ecosystems (Costanza et al., 1997; Burkhard, B. et al., 2010).

Territories able to preserve or restore their natural capital will have greater opportunities for lasting prosperity. If ecosystems are healthy or functional, they will be, for example, more resilient and less vulnerable to extreme natural events (e.g. heavy rains, heat waves) that can absorb atmospheric pollutants (air quality), to self-purify water (water quality), to replenish the foothills and to regulate the hydrological cycle (water availability), to offer recreational spaces and the possibility of psychological well-being.

The Millennium Ecosystem Assessment (MEA) (2005), the widest and in-depth systematization of the knowledge acquired so far on the status of ecosystems in the world has provided a useful classification by dividing ecosystem functions into four main categories:

- Ecological Integrity (EI) (or Supporting): these functions collect all the services needed to produce all other ESs and contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes.
- Regulating (SR): In addition to maintaining the health and functioning of ecosystems, regulatory functions collect many other services that have direct and indirect human benefits (such as climate stabilization, waste recycling), which are usually unrecognized until they are lost or degraded;
- Provisioning (SA): These functions collect all those resources supplying services that natural and semi-natural ecosystems produce (oxygen, water, food, etc.).
- Cultural (SC): Natural ecosystems provide an essential consultation function and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreational and aesthetic experiences.

The regulation falls under the protection from the hydrogeological disasters: ecosystems contribute to containing the hydrogeological disaster due to rains and wind. This allows, among other things, to maintain agricultural productivity by reducing the loss of fertile soil.

It has been estimated that over the last 50 years, 60% of ES on the planet have been compromised. Therefore, it has become crucial to integrate the concept of functions and ES into land management and planning decisions so that local administrators can control the pressures that threaten the ecosystem and their functionality, improve their effectiveness and build a model of Governance that is based on tools such as payments for ES.

1.4 EVALUATION OF ECOSYSTEM SERVICES

Since ES have never been fully quantified in monetary terms, they have always had little or no weight in policy decisions.

The potential assessment of the soils to provide ES is considered as an important tool to address the current difficulty of systematically considering ES in land planning.

Several tables found in current literature (Müller et al. 2011; Fisher and Turner, 2008) containing ES, defined by MEA, values for each soil class of Corine Land Cover (CLC) have been compared.

To evaluate the capabilities of the different types of land cover to provide ES, a matrix has been created. The assigned values are based on expert evaluations, both conceptual and derived from different case studies. These values can be seen as research hypotheses that need to be tested in further applications.

The matrix shows the high capacity to provide a wide range of ES for different soil coverings (forests, peat bogs, marshes and moors). The types of soil cover deeply modified by humans, such as urban fabric, industrial or commercial areas, mining and landfill extraction, have a very low capacity.

The different values found in literature for each ES, relative to the four macro-classes, according to the type of soil cover were homogenized by performing an arithmetic average operation. In a single table that follows the same type of assessment of the previous approaches based on the ability of the different types of soil cover to provide individual service: 0 = no capacity, 1 = low capacity, 2 = relevant capacity, 3 = average Capacity, 4 = high capacity, 5 = very high capacity.

1.5 EVALUATION OF HYDROGEOLOGICAL DISRUPTION

Agro-forestry activities, through sustainable management practices, may have a positive impact on the countryside's defences and prevention of disaster, given that much of the countryside is still rural.

The Guidelines for the Evaluation of Hydrogeological Disruption written by Higher Institute for Environmental Protection and Research (ISPRA) propose guidelines and methodologies that, based on the integration of territorial databases of the environment and agriculture sectors, enable the identification of priority areas of intervention throughout the national territory and the most appropriate mitigation measures, both in active and abandoned agri-forest areas.

Agro-silvo-forest interventions are included in the maintenance of the territory.

These interventions can only be used effectively for some types of disruption, such as accelerated erosion and surface landslides, while deafening phenomenon with deeper sliding surface can only be stabilized with traditional engineering interventions such as tunnels and drainage wells, supporting walls, etc.

2 METHODOLOGICAL PROPOSAL AND APPLICATION

2.1 METHODOLOGICAL PROPOSAL

The proposed methodology is based on a spatial analysis implemented in the GIS environment (Foresman, 1998) and consists of three macro-phases: 1) Identification of soil uses that maximize the ecosystemic erosion control (Sr6) service at high and very high danger areas; 2) Construction of networks that maximize ecological integrity and multifunctionality of GI; 3) Identifying strategic priorities.

The macro-phase 1) consists of the following steps:

- assigning value scores associated with each land use according to the CLC classification;
- Identifying the combination of levels of danger with the patches that maximize the Sr6 service.

The macro-phase 2) involves the construction of networks by using cost-distance, using as the resistance values the corresponding scores for soil utilization related to the ES defined ecological integrity (IE), the combination of the latter with SR6 and the combination of Sr6 with the other ES values.

The macro-phase 3), in turn, is articulated in:

- network measurement using network analysis through appropriate indices;
- comparison between the different networks in order to define their maximization;
- definition of strategic priorities.

2.2 TECHNIQUES AND INSTRUMENTS TO SUPPORT THE MODEL

The analysis implemented in the GIS environment, upon which the methodology is based, refer in detail to the following techniques: cost distance, network analysis and map algebra.

Cost-distance analyses were carried out using algorithms (Eastman, 1989) and implemented in the Idrisi 32 (Clark Labs, Clark University) software. Two different algorithms were used for the analyses: for *Sitta europaea*, connectivity was evaluated using an isotropic model (Eastman 1989); In the case of *Triturus carnifex*, an anisotropic model was applied (Eastman 1999).

The network analysis is based on the theory of graphs. Local metrics are important for the Node degree (measures the importance of a node in the network based on node connections), the Betweenness Centrality Index (measures the frequency with which a node appears on the shortest path between nodes of the network) and Proximity (measures the average distance from a given node to all the other nodes in the network).

The algebra map consists of map processes (spatial data layers) as variables in algebraic equations.

The GIS overlay procedure generates a new layer (output level) depending on two or more input layers, the attribute value assigned to each position (such as raster or polygon) on the output layer is a function of the independent values associated with that position on the input levels. There are two commonly used classes for combining overlays in GIS: Boolean overlay (such as AND and OR); Linear Weighted Combination (WLC).

The Graphab software is dedicated to the modelling of ecological networks based on graph theory. It allows for the creation of connections between the same patch types based on the cost-distance, taking into account the type of patches to be crossed or based on the minimum distance between patches, with it being compatible with GIS through which maps can be modelled to create ecological networks.

Once a graph has been created, several reference metrics can be applied.

2.3 APPLYING THE METHODOLOGY TO THE CASE STUDY

Campania has a high lithological and geological-structural variability that makes the territory susceptible to different types of landslides. It is in second place among the Italian regions for the number of victims due to hydrogeological phenomena: almost all of these were due to the rapid castings of loose pyroclastic covered by the carbonate masses of the Campanian Apennine and the stone sequences present in the volcanic areas of the Vesuvius and the Phlegrean Fields.

The distribution of the danger from landslides, identified by the Hydrogeological Basin Authorities falling within the territory of Campania, is highlighted according to the territorialization and use of the soil expressed as the second level of the CLC legend. There are 135,800 hectares with high danger (P3) and 131,500 hectares with very high danger (P4). Regarding the P3 and P4 hazardous areas, the wooded areas constitute the most significant land use type (126,279 hectares), equal to 20,5% of the total landslide areas.

2.4 GREEN INFRASTRUCTURES AND HYDROGEOLOGICAL RISK IN THE CAMPANIA REGION

The Rural Development Program 2014-2020 (PSR) of the Campania Region depicts the regional territory as a territory affected by worrying symptoms of abandonment, partly caused by the decline in agricultural land and demographic impoverishment, with three quarters of it being characterized by mountainous and hilly areas where soil conservation policies with relevant erosive dynamics. Current climate change increases the danger and risk of landslides and floods, the potential risk of erosion and more generally degradation of the soil.

Hydraulic, agricultural and hydraulic-forestry interventions, as well as the persistence of agricultural and forestry activities, particularly in mountainous and/or disadvantaged areas, can significantly prevent and

reduce the issues highlighted. It is therefore necessary to ensure the permanence of agricultural and forestry activities in such areas, by compensating for the disadvantages, encouraging the active management of the forest, promoting, also through training and information actions, farming methods that ensure the maintenance of a protective cover and the recovery of traditional techniques.

Agricultural and forestry interventions cover the maintenance of the territory and contribute to the regional strategy in continuity with the PSR 2007-2013, extending the range of actions to improve soil quality, aimed at reducing soil loss from erosion and hydrogeological disruption in particular in the most at risk and hazardous areas through: the persistence of agricultural and forestry activities in disadvantaged and mountainous areas; hydraulic-agricultural and hydraulic-forestry facilities including maintenance/restoration of agricultural terraces; maintenance/restoration of the surface drainage network in agriculture; crop management systems that mitigate risk (e.g. no and minimum tillage, cover crop); forestation and active management of the forest; protection from forest fires.

It is worth noting the measure 8.2.4.3.9. 4.4.2 Creation and/or restoration and/or expansion of green infrastructure and agri-rural landscape elements and sub-tenure 4.4 - Support for non-productive investments related to the fulfillment of agro-environmental objectives. This measure aims to achieve the sustainable development objective of Campania agro-food business, foreseeing it necessary to improve the environmental conditions of the territory from an agro-climate point of view, pursuing a satisfactory state of conservation of the biodiversity. It should also be pointed out that an environment with a low degree of biological diversity, i.e. less ecologically less diversified, and therefore disorganized, reacts less actively to sudden atmospheric and climatic changes.

Consequently, a specific type of intervention should be provided for the support, restoration and conservation of natural and semi-natural habitats, flora and fauna of EU interest, as well as specific elements of the agrarian landscape through the realization of interventions for the creation and/or restoration and/or expansion of green infrastructures and specific landscape elements in degraded and/or cultivated areas.

Eligible interventions to subsidy are identified in the restoration and/or creation and/or extension of: a) terraces and brickwork; b) buffer bands; c) hedges, rows, groves.

For this purpose, the type of intervention is addressed, in particular, in terms of public utility to areas of the Natura 2000 Network or other areas of great natural value defined by the PSR.

Moreover, the abandonment of agricultural activities also favours the spontaneous dynamics of ecological mosaic evolution, with the loss of ecosystems due to the progressive advancement of the forest of neo-formation. Therefore, the role of farms as a defence has positive effects both on the territory for the economic and productive implications it entails, on the environment in terms of soil protection as well as the protection of complex ecosystems.

In the PSR, the principles guiding the definition of selection criteria include, inter alia, the following rewards: location of the intervention: a) sites of the Natura 2000 Network; b) areas of great natural value defined by the PSR 2014-2020; c) Regional Parks and Regional Nature Reserves; d) vulnerable agricultural zones to nitrates; e) high or very high altitude hazardous areas for terracing and burial operations.

2.5 APPLICATION

With reference to macro-phase 1), we identify the soil uses that maximize the ES erosion control (Sr6) in correspondence of high and very high hazardous areas, the geodatabase is made up of information from the Agricultural Utilization Soil Map (CUAS) of Campania Region, dated 2009.

From the quantification, it has been found that the incidences of the different eco-systemic values in terms of surface are differently distributed. Reference was made to the PSAI for the Central Campania Authority, which has been in force since 2015. From the intersection, the patches that maximize the Sr6 service in combination with the P3 and P4 areas have been identified. Thus, the distribution of land uses in high and very high hazard areas has been reported.

With reference to macro-phase 2), the networks were built to maximize ecological integrity and multifunctionality, and the Graphab software was used to design the networks.

The network that maximizes ES IE was built for the entire regional territory, with it being the one that relates the combination of all ESs, i.e. IE-SA-SC-Sr6 and finally IE-Sr6. (figure 1)

With reference to macro-phase 3), the software was used to generate the graph and calculate the different metrics at local and global levels. The calculation was made in relation to the insistent area encompassing the territory of the Central Campania Authority.

Then, a comparison was carried out between the different networks in order to define their maximization as well as define the mitigation strategy. (figure 2)

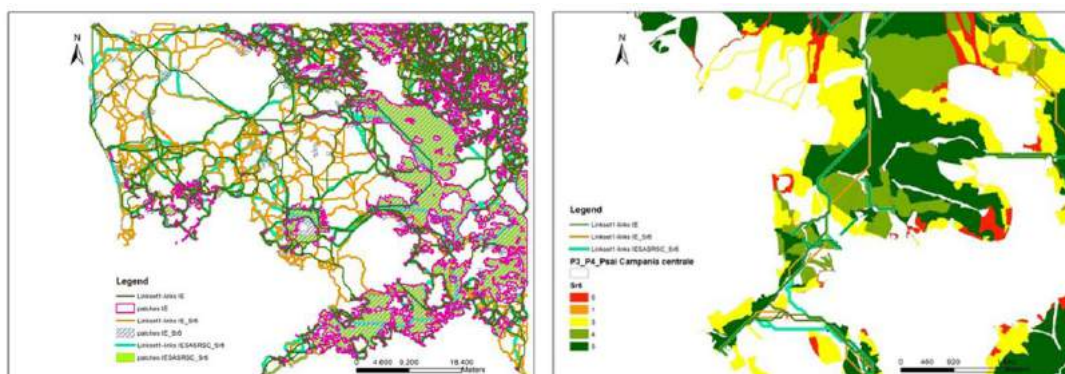


Figure 1 - Overlay network map | Figure 2 - Multifunctional network

3 DISCUSSIONS AND CONCLUSIONS

The application of the methodology to the case of the Campania region, and in particular to the territory included within the Hydrogeological Structure Excerpt Plan (PSAI) of Central Campania Authority, has highlighted how it is possible to identify the contact points between the protection of ecological integrity and the mitigation of landslide risk, in line with EU strategies, thus highlighting the boundaries of the study that should be carefully taken care of.

From the overlay map reading of the Sr6 distribution factor map and the mapping map of the landslide hazard distribution, the concomitant use of high-value Sr6 soil uses with P3 and P4 hazard levels emerges. This information indicates that, on the one hand, the use of the soil performs a protective action, while on the other it alone does not contribute to the resolution of the problem due mainly to geological and geotechnical conditions.

Therefore, the primary consideration is that, as defined in the EU document, the choice of the construction of the ecological network will have to prioritize both strategies in an order of priority: firstly it must be given to the axes that maximize the Sr6 network in order to build ecological network that intersects the high and very high hazard areas; secondarily those in which the IE-Sr6 network is maximized intersecting the P3 and P4 areas. finally, consider the P3 and P4 areas intersecting the IE network.

In these areas, it is possible to implement the actions proposed by the ISPRA Guidelines in order to contribute to the maintenance and hydrogeological protection of the area.

The areas selected in the previously seen order must be subject to appropriate detail analysis in order to determine the use of the soil which maximizes the protective action, possibly subject to the prevision of structural mitigation against landslide hazard.

The present work, however, could be used to provide for pricing mechanisms for areas with high risk of land-sliding and erosion, given the great importance of the resources allocated to the environmental issue.

The methodology therefore provides a new way of drawing the GI, which is generally based on the specific ability to favour biotic and abiotic flows. In this case, we try to optimize this pattern by also maintaining and raising other ES, starting from the regulation of the soil disruption.

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ID 1409 | LIVING THE CLIMATE RESILIENT CITY—HANGZHOU’S ‘FIVE WATER CO-LEAD’ STRATEGY

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1 INTRODUCTION

Climate awareness in urban planning has increased from 2011 due to more frequent occurrences of extreme-weather disturbances in Chinese cities. To deal with climate-related disturbances, the notions of urban resilience and resilient planning have gained increasing attention and interest over recent years in the field of water management and urban planning. A simple definition of resilience is the ability of a city to