TeMA

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This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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SMART CITY

PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

Special Issue, June 2014

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TeMA

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Land Use, Mobility and
Environment

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TeMA
Journal of
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This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.

TeMA Journal of Land Use, Mobility and Environment

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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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BIO-ENERGY CONNECTIVITY AND ECOSYSTEM SERVICES

AN ASSESSMENT BY PANDORA 3.0 MODEL FOR LAND USE DECISION MAKING

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ABSTRACT

Landscape connectivity is one of the major issues related to biodiversity conservation and to the delivery of Ecosystem Services (ES). Several models were developed to assess landscape connectivity but lack of data and mismatching scale of analysis often represent insurmountable constraints for the correct evaluation and integration of ecological connectivity into plans and assessment procedures. In this paper a procedure for ES assessment related with Habitat and Bio-Energy Landscape Connectivity (BELC) is proposed. The method is based on the connectivity measure furnished by the last version of PANDORA model and uses a modified formulation of current ES evaluation. The implementation of the model in a real case has highlighted its potential multi-scale workability. The spatial approach of the model aims at furnishing a further tool for the spread of ES and landscape ecology concepts into procedures of assessment (e.g. EIA, SEA) and land use planning at different administrative scales.

KEYWORDS

Landscape connectivity, Urban planning , Environmental Assessment, Environmental modeling

1 INTRODUCTION

As reported in the Charter of European Planning (ECPT- CEU 2013), a sustainable development requires the maintainance, enhancement and creation of natural resources that are within towns and cities or that provide services for them including the protection of cities from pollution and degradation, high levels of efficiency in energy production and the wise use of resources (e.g. water, air, soil).

Indeed, every land use change can induce either negative consequences or positive repercussions. Man, more than other living species, plays a fundamental role in the global health of the environment as his ability to strongly modify the landscape structure, and consequently its functionality, to reach his objectives. Examples of this capacity are the huge land cover and land use changes realized, above all in these last centuries (Foley et al., 2005; Pelorosso, Leone, & Boccia, 2009) thanks to the technology advances and the use of stoked carbon fossil sources of energy, to acquire even more goods and services from ecosystems and landscapes, generally named Ecosystem Services (ES) (Hermann, Schleifer, & Wrbka, 2011; Termorshuizen & Opdam, 2009). Among these ESs we can find provisioning services such as food, wood and water, as well as energy used by citizen and urban systems, or cultural services such as social, recreational, and touristic benefits. However, the exploitation of natural resources affects the delivery of other ESs as regulating services, such as flood and CO2 control, or supporting services, such as oxygen production, that maintain the conditions for life on Earth (MEA, 2003). In particular, urbanized areas seal soils determining several environmental consequences, e.g.: increasing of water runoff and relative pollutants transport, deterioration of ecosystems functionality, rising of green house gases, fragmentation of habitats and biodiversity reduction. These impacts and consequences can be assessed in the ES framework since it can provide “a new way to approach environmental management and to connect nature and society in research and appraisals” (Karjalainen, Marttunen, Sarkki, & Rytkönen, 2013). Indeed, policies and plans are gradually directed to supply and reinforce desired ecosystem/landscape services (Gulickx, Verburg, Stoorvogel, Kok, & Veldkamp, 2013).

Ecological landscape connectivity is an important issue often erroneously considered only in extra urban or/and protected areas planning context (Pelorosso, Gobattoni, Lauro, Monaco, & Leone, 2012). Landscape connectivity can be defined as the ability of landscape to facilitate or impede movement among habitat patches, support fluxes of energy, organisms and materials (e.g seeds, biomass, pollen, nutrients, sediments) and long-term persistence of biodiversity (Foltête, Clauzel, & Vuidel, 2012; Ng, Xie, & Yu, 2013; Saura & Pascual-Hortal, 2007). Landscape connectivity is therefore one of the major issues related to animal dispersal, population persistence and ecological functions maintenance. In particular, biodiversity represents a fundamental ecosystem property: estimations reports that a 1% change in biodiversity results in a 0.5% change in the value of all ecosystem services (Bastian, 2013).

In this view, landscape connectivity covers an important role in the definition of ecosystem services value of a single patch of the landscape mosaic; indeed, habitat patches, with the same size and characteristics at different locations, may provide different ecosystem services due to their different connectivity within the landscape. Moreover, a well connected landscape increases the resilience of the social ecological systems allowing them to overcome sudden changes (e.g climate changes, wildfires) by persistence, adaptation and transformation processes (Zurlini et al., 2014). Indeed, several methods, indices, approaches and models have been developed regarding landscape connectivity and fragmentation issues (e.g. Luque, Saura, & Fortin, 2012; Saura & Pascual-Hortal, 2007). Moreover, recent papers have focused on the importance of the integration of landscape connectivity measures into the Ecosystem Services (ES) assessment (Ng et al., 2013), Urban Planning (Ahern, 2012; Tannier, Foltête, & Girardet, 2012), and into Environmental Impact

Assessment (EIA) and Strategic Environmental Assessment (SEA) (Girardet, Foltête, & Clauzel, 2013; Mancebo Quintana, Martín Ramos, Casermeiro Martínez, & Otero Pastor, 2010; Scolozzi & Geneletti, 2012a).

Connectivity assessment in the context of land use decision making processes and landscape and urban planning is still challenging (Scolozzi & Geneletti, 2012b). Lack of data and mismatching scale of analysis can represent insurmountable constraints for the correct evaluation and integration of ecological connectivity into plans and assessment procedures. Moreover, complex models can be hard to manage when scenario comparison is requested or the localization and extension of the area change. Thus, several examples of structural connectivity assessment (not species specific approach) and simplified models were presented to adequately face these issues in the planning and assessment practice at different spatial scales (Mancebo Quintana et al., 2010; Marulli & Mallarach, 2005; Ng et al., 2013). An assessment of structural landscape connectivity in terms of energy, based on landscape graphs approach, was presented in an innovative model named PANDORA (Gobattoni, Lauro, Monaco, & Pelorosso, 2012; Gobattoni, Pelorosso, Lauro, Leone, & Monaco, 2011). The energy considered by the model is linked with vegetation metabolism by BTC index, thus it assesses the biological energetic state of the landscape and bio-energy exchanges among landscape components (Bio-Energy Landscape Connectivity, BELC). The model was developed to meet the needs of planners and practitioners involved in the environmental assessment procedure and it was proposed as operative Decision Support System to assess the impact of different scenarios of land use change. The last version of the model (Gobattoni, Groppi, Monaco, & Pelorosso, 2014) analyzes the contribute of each patch of land mosaic to global BELC and, consequently to functionality and resilience of the whole system.

In the current methods to assess landscape connectivity in terms of ecosystem services, there are two main limitations: 1) connectivity is calculated within the same land use category of habitat patches; 2) the evaluation of ecosystem services mainly relies on patch size without considering other variables, e.g. water, soil and climatic characteristics, that could strongly affect the final ecosystem services value (Ng et al., 2013). A model fully integrating ES into landscape connectivity assessment has not been presented yet.

In this work, to face those limits, we propose the last version of model PANDORA with the new module, presented here for the first time, for the evaluation of the ecological value (Ecosystem Services) of single patches of landscape mosaic in terms of Habitat (e.g. land cover) and BELC. The multi-scale workability and the spatial approach of the model aim at furnishing a further tool for the spread of ecosystem services and landscape ecology concepts into procedures of assessment (e.g. EIA, SEA) and land planning at different administrative scales.

2 METHODOLOGY

The proposed method for bio-energy landscape connectivity (BELC) assessment is here synthetically reported. A deep description is out of the aims of this paper and it can be found in other publications. The ES evaluation is then reported in a specific paragraph.

Numerical integration of the Ordinal Differential Equations (ODEs) system, on which the model PANDORA is founded, can be rather heavy because of the high number of equations, specially to produce a friendly user system. Thus, an approximated solution is proposed in order to substitute the above set of ODEs with an algebraic hierarchy which may be implemented easily (Gobattoni et al., 2014). The Bio-Energy (B) is the state variable related to the metabolism of vegetation characterizing each land cover patch. The parameters regulating the B evolution (e.i. evolution to mature forest with highest biodiversity level) are derived by vegetational, morphological, climatic and soil characteristics of the landscape units. Most important human-made barriers to energy fluxes (e.g. large and high traffic roads) define the borders of each landscape unit

(LU). Other human-made barriers (e.g. minor roads, edified areas, urban sprawl, no photosynthetic surfaces) in each LU are considered as limiting factors to energy fluxes and consequently to the evolution of biotopes energy level inside them. Fluxes of bio-energy among LUs are continuously recalculated with the evolution of the patches and they define the connectivity index of each LU. High connectivity level defined by such an index is considered by the model as a positive factor for the increase of the Bio-Energy of the patch. The solution of the algebraic hierarchy until asymptotic values gives the final values of B^{as} for each patch and the Generalized Biological Energy of the overall system (M^{as}tot).

The ES assessment has been realized by considering both the land cover typology (e.i. habitat) and the importance of the patch for the global landscape connectivity expressed by the asymptotic value of M^{as}tot. The importance of each patch in terms of its contribution to the maintenance of M^{as}tot level has been calculated by comparing the M^{as}tot difference before and after changing the patch into an urban area (e.i. impervious and no photosynthetic surface). Such an index is defined as dMtot. Ecosystem Services Value for Biodiversity protection (ESV_B) for a unit area of different land cover categories (€/ha/year) has been updated and modified to Italian case from Ng, Xie, & Yu (2013). The model has been developed in open source environment and applied in a portion of the municipality of Viterbo (Central Italy) considering the actual land use and urban development.

2.1 ECOSYSTEM SERVICES ASSESSMENT

ES value (ESV) can be evaluated for each patch taking in consideration only the type of habitat (e.g. land Cover) and the area of a patch by the following conventional formula (Ng *et al.* 2013):

$$ESV_{kj} = VC_k \cdot A_{k\_j} \quad (1)$$

where ESV_{kj} is the estimated Ecosystem Services Value of patch *j* of land cover category *k*, VC_k is the value coefficient for landcover category *k*, A_{k_j} is the area of the patch *j* and land cover category *k*. VC_k is the economic value of each macro land cover typology and it was used to evaluate different ESs in China (Ng et al., 2013; Tianhong, Wenkai, and Zhenghan, 2010; Xie, Lu, C. X., Leng, Zhang, and Li, 2003). Based on a seminal work of Costanza et al. (1997) and Xie et al. (2003), Tianhong et al. (2010) report the procedure to obtain the contribute of each land cover class in the delivery of a range of ES starting from equivalent weight factors of ESs for several terrestrial ecosystem (see table 1).

ECOSYSTEM SERVICES	FOREST	GRASSLAND	CROPLAND	WETLAND	WATER BODY	BARREN LAND
Gas regulation	3.5	0.80	0.50	1.80	0	0
Climate regulation	2.70	0.90	0.89	17.10	0.46	0
Water supply	3.20	0.80	0.60	15.50	20.40	0.03
Soil formation and retention	3.90	1.95	1.46	1.71	0.01	0.02
Waste treatment	1.31	1.31	1.64	18.18	18.20	0.01
Biodiversity protection	3.26	1.09	0.71	2.50	2.49	0.34
Food	0.10	0.30	**1.0**	0.30	0.10	0.01
Raw material	2.60	0.05	0.10	0.07	0.01	0
Recreation and culture	1.28	0.04	0.01	5.55	4.34	0.01
Total	21.85	7.24	6.91	62.71	46.01	0.42

Tab. 1 Equivalent weight factor of ESs per hectare of terrestrial ecosystems in China (Tianhong *et al.* 2010)

The economic value of average natural food production of cropland per hectare per year (ANFPC) was assigned to the weight factor one (bold character in table 1). Thus, to obtain the delivered ESs for unit area of different terrestrial ecosystem it is necessary to multiply the economic value of ANFPC for each weight of the table 1. ES value of one unit area of each land use\land cover category can be then assigned based on the nearest equivalent ecosystems. ANFPC can be calculated considering a mean price for hectare of most common crops (e.g. wheat) and that, generally, the natural food production is 1/7 of the actual food production. The weights were estimated for China context so for other Regions possible variations are expected. In this work, for the applicability of the method and the aims of the paper, the proposed weights were unchanged, while, the economic value of ANFPC was recalculated for Italian study case and update to nowadays. Different types of land cover in the study area were finally estimated.

The method proposed by Ng et al. (2013), to calculate biodiversity Ecosystem Services Value (ESV_B) considering ecological connectivity measures, introduces a connectivity index as followings:

$$ESV\_B_{kj} = VC_k \cdot \left(\frac{dPC_{k\_j}}{dPC_{k\_\max}} \right) \cdot A_{k\_\max} \qquad (2)$$

$$dPC_{k\_j} = \left(\frac{PC_{k\_j} - PC'_{k\_j}}{PC_{k\_j}} \right) \cdot 100 \qquad (3)$$

where ESV_B$_{kj}$ is the estimated biodiversity Ecosystem Services Value of patch *j* of land cover category *k*, A_{k_max} refers to the largest area of patches among the land cover category *k*. PC (possibility of connectivity) is a well known area-based functional connectivity index (Saura and Pascual-Hortal 2007). dPC_{k_j} indicates the importance of each patch in terms of its contribution to the maintenance of overall connectivity by comparing the overall connectivity difference before (i.e. PC_{k_j}) and after (i.e. PC'_{k_j}) moving the patch (Saura and Pascual-Hortal, 2007). dPC_{k_j} is the dPC value of patch *j* of land cover category *k*, and dPC_{k_max} indicates the maximum value of dPC among land cover category *k*. The method standardizes values of connectivity within the same land cover category and takes in consideration the largest patch as reference.

The proposed new method to calculate ESV_B$_{kj}$ is a modification of the formula (2) and (3) and it aims to overcome above cited constrictions by introducing a connectivity index linked with bio-energy level of the landscape and the actual patch area:

$$ESV\_B_{kj} = VC_k \cdot \left(1 + \frac{dMtot_{kj}}{dMtot_{j\_\max}} \right) \cdot A_j \qquad (4)$$

$$dMtot_{kj} = \left(\frac{M^{as}tot_j - M^{as}tot'_j}{M^{as}tot_j} \right) \cdot 100 \qquad (5)$$

where ESV_B$_{kj}$ is the estimated biodiversity ecosystem services value of patch *j* of land cover category *k* with bio-energy connectivity evaluation, VC_k is the value coefficient for land cover category *k* updated for Italian study case, A_j refers to the area of the patch *j* without considering land cover type membership. $M^{as}tot_j$ is the Generalized Biological Energy of the overall system; it derives by Pandora 3.0 model e.i. by the solution of the algebraic hierarchy until asymptotic values of all the patches: it is the index of overall BELC and it considers the Bioenergy evolution of all the landscape patches under the actual barriers to energy fluxes, climatic, morphological and soil conditions. $dMtot_{kj}$ indicates the importance of each patch *j* and land cover category *k* in terms of its contribution to the maintenance of overall BELC by comparing the overall connectivity difference before (i.e. $M^{as}tot_j$) and after (i.e. $M^{as}tot'_j$) changing the patch into an urban area. $dMtot_{j\_max}$ indicates the maximum value of dMtot among all the patches *j* of the landscape without considering land cover type difference.

In this work a comparison between ESV_B evaluation without and with BELC assessment is proposed on the basis of formulas (1) and (4) respectively, moreover aggregated ESV_B assessments are pointed out at:

a) Land cover type scale

$$ESV\_B_k = \sum_{j=1}^{z_k} ESV\_B_{kj} \tag{6}$$

Where z_k is the number of patches with land cover category *k*.

b) Landscape Unit scale

$$ESV\_B_i = \sum_{r=1}^{m_i} ESV\_B_{ir} \tag{7}$$

Where m_i is the number of patches inside the landscape unit *i*.

c) Landscape scale

$$ESV\_B_{tot} = \sum_{i=1}^{n} ESV\_B_i \tag{8}$$

Where *n* is the number of landscape units.

3 RESULTS

The commodity exchange of Bologna for 2013 reports a mean price of 200 €/ton for soft wheat and 270 €/ton for durum wheat. Thus, considering a value of 250 €/ton and a mean production of 6 ton/ha per year, the economic value of ANFPC for Italy was estimated as 214 €/ha per year. Table 2 reports the final VC_k for the main land cover typology of the study area for Biodiversity protection.

	FOREST	GRASSLAND	ORCHARD	CROPLAND	WETLAND	WATER BODY	BARREN LAND	BUILD UP
Biodiversity protection	697,64	233,26	189,92	151,94	535,00	532,86	72,76	0,00

Tab. 2 Value Coefficient (VC_k) for land cover category *k* of unit area for Biodiversity protection (€/ha*year). Note that orchards are calculated as 25% more of cropland

The index $dMtot_j$ representation (Fig. 1) allows to highlight the importance of each patch in terms of its contribution to the maintenance of the overall bio-energy level and consequently to BELC. The results show also the capabilities of the model to spatially discriminate the ES value of each patch on land mosaic (Fig. 2), the ES at level of land cover typology (Fig. 3) and at level of LU (Fig. 4). The ES value at landscape scale without and with connectivity measure is therefore 7.134.357,90 €/year and 10.192.959,80 €/year, respectively, with an increase of 42.8% considering the BELC.

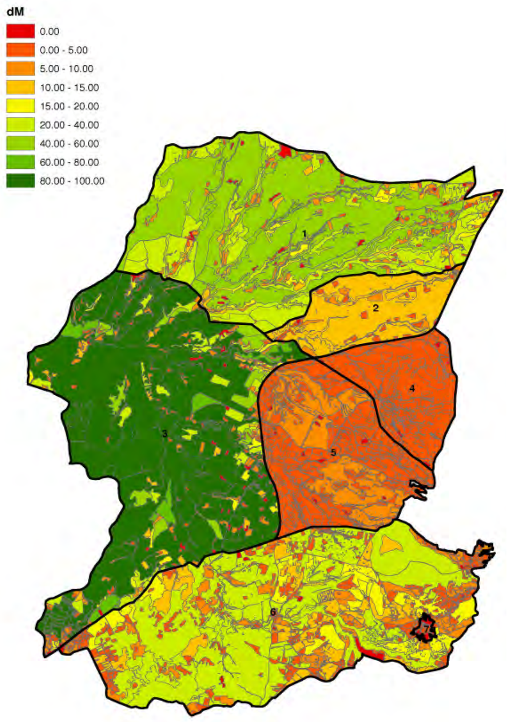


Fig. 1 dMtotkj index representation: the value ranges between 0 and 100 and defines the percentage decrease of overall generalized bio-energy Mastot consequent to the conversion of the patch into an urban area (e.i. impervious and no photosynthetic surface)

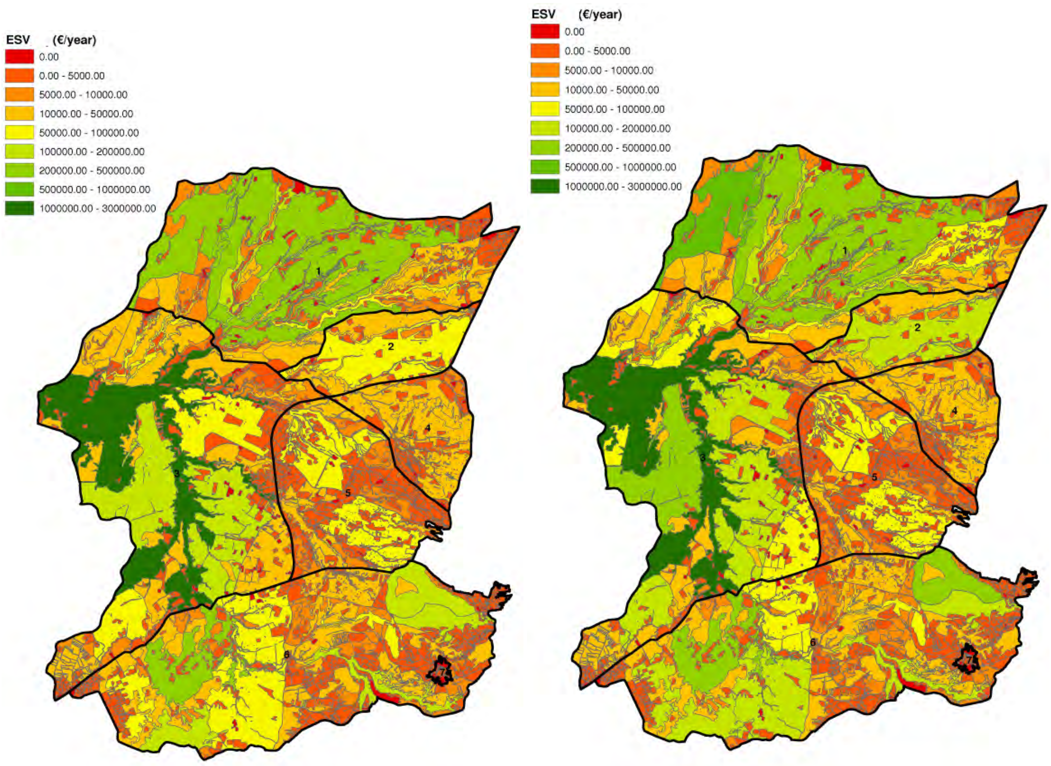
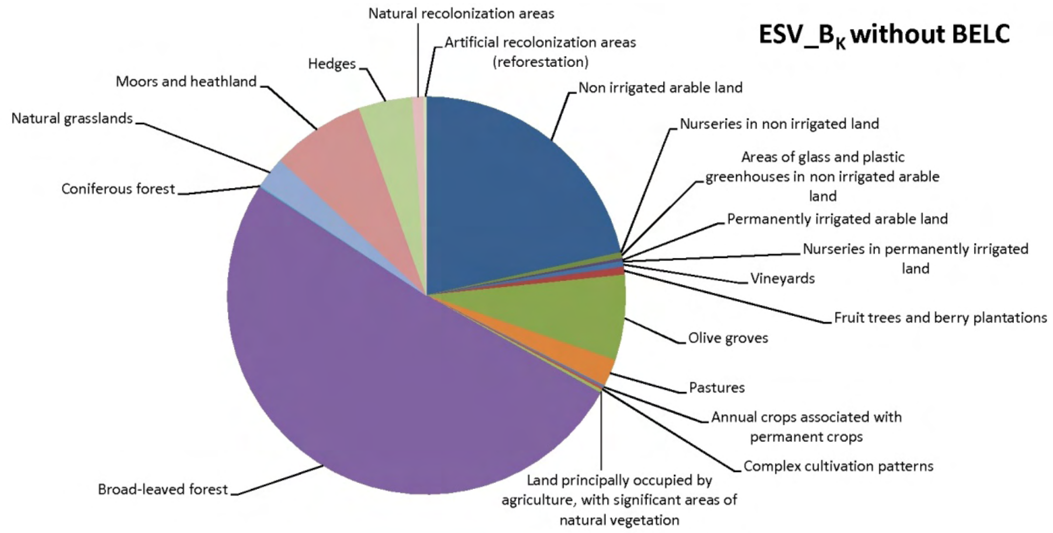


Fig. 2 ESV_B_{kj} for each land cover patch of study area. a) Without considering BELC; b) with BELC



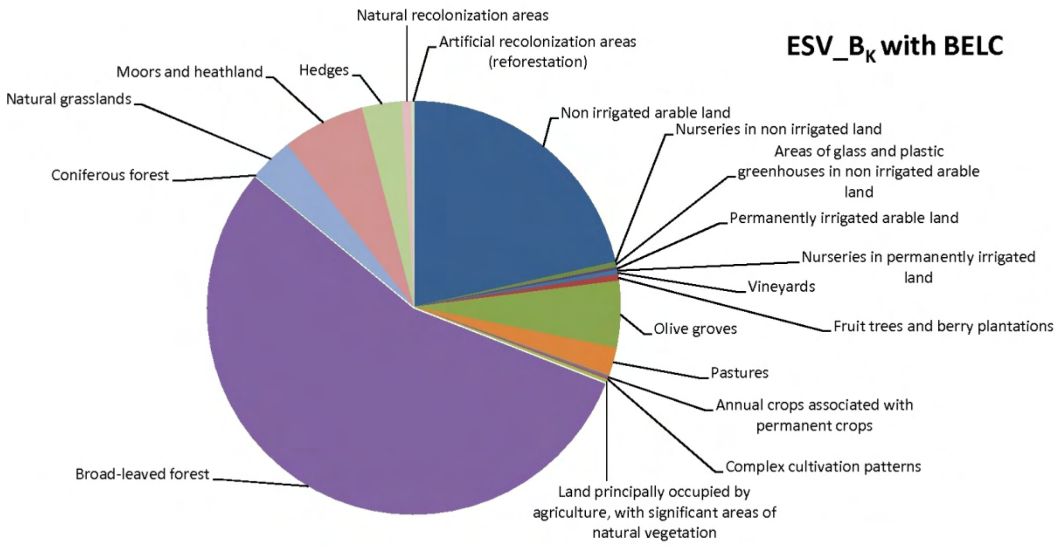


Fig. 3 ES Value for each land cover typology without and with BELC, respectively

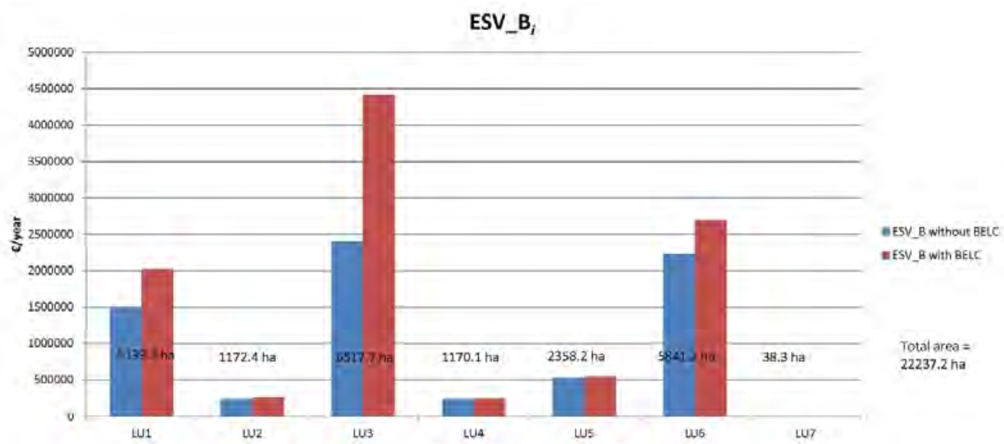


Fig. 4 ES Value for each Landscape Unit of the study area without and with BELC, respectively

4 DISCUSSION

The concept of landscape embraces all the components of human environment: cultural identity, natural resources, economy and society. Landscape is, therefore, an expression of the diversity of shared mutli-cultural and natural heritage (ECTP-CEU, 2013).

Spatial planning science and praxis has to provide cohesion among these different aspects and, consequently, it has to be applied to all the various contexts: residential, commercial and industrial areas; infrastructures; tourist and leisure locations; urban green areas and parks; rural areas. The challenge for effective planning consists in integrating these needs, starting from the protection and management of biodiversity and lndscapes. To pursue this aim, it's necessary to assess the interactions between human settlements, infrastructures and natural areas, i.e. examining landscape connectivity, which is a theme stressed since long time ago by landscape ecology (e.g. Forman, 1995).

Starting from Landscape Ecology assumptions, it's necessary to extrapolate the role for spatial planning. Namely, landscape connectivity was considered in the evaluation of ES only recently (Ng et al., 2013). The current methods to assess landscape connectivity in terms of ES, show two main general limitations: 1) connectivity is calculated within the same land use category of habitat patches; 2) the evaluation of ES mainly relies on patch size without considering other variables, e.g. water, soil and climatic characteristics, that could strongly affect the final ES value. Moreover, a model fully integrating ES into landscape connectivity assessment has not been presented yet.

In this work, we propose an innovative approach to face these limitations. The new index dMtot points out the importance of each patch in terms of its contribution to the maintenance of BELC (Fig. 1). It considers soil, climatic and morphological aspects of the LUs and, moreover, is related to the connectivity of all the patches with respect to a bio-energy measure making the dMtot index no-dependent from habitat typology, indeed all the patches contribute to BELC.

The calculation of ES values of the patch considers a measure of a structural landscape connectivity founded on thermodynamic laws that lie behind all the environmental processes and dynamics of landscape, as well as animal movements and vegetation/ecosystem evolution. Consequently, such a connectivity is strictly linked to the functionality and resilience of the landscape.

Indeed, ES values as well as dMtot index can be used to individuate suitable areas for urban development or conservation measures both at level of patch (Fig. 1, Fig. 2) and at level of LUs (Fig. 4). Such a latter zoning, based on recognizable barriers (e.g. roads) on landscape, may facilitate the integration of connectivity information in different territorial plans e.g. supporting the characterization of urbanized and non-urbanized areas into municipality plans, or of rural areas for provincial or regional plans. Finally, the data required by the model are usually available by land manager making the implementation of the procedure feasible also into contexts of scarce resources and low financial availability.

In this way, it's possible to carry out the usual planning praxis giving it an effective, low cost and scientifically sound analysis. Moreover, it's possible to quickly compare scenarios and make maps and graphics generated by PANDORA model accessible to stakeholders thus supporting, in a more transparent way, both planners' choices and people participation. The proposed approach can therefore allow decision makers, but also communities, to have a clear picture of the ecological impacts of planned order and, as a consequence, to contribute to build healthy landscapes.

5 CONCLUSIONS

The final aim of this research consists in developing methods and tools to include the ES thinking in planning practice since it can allow to assign an objective value to natural resources: biodiversity, air, soil, water and energy.

At the present step, in this paper, the new version of model PANDORA 3.0 is presented: through the application to a real case, it has pointed out its capability to assess the landscape in terms of BELC and ES. The model allows to support the decision making process by the assessment of different land use scenarios. The multi-scale workability and the spatial approach of the model aim at furnishing a further tool for the spread of ES and landscape ecology concepts into procedures of assessment (e.g. EIA, SEA) and land planning at different administrative scales.

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