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# Sessione speciale Challenges, resistances and opportunities for the inclusion of ecosystem services in urban and regional planning

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## Introduzione

Current research highlights the lack of appropriate instruments for the inclusion of Ecosystem Services (ES) in urban and regional planning. Spatial plans have the capacity to induce positive or negative changes in the quality or quantity of ES, by determining changes in land use and providing rules and norms for its use. Although many approaches are available for integrating the ES concept in planning, many issues remain unresolved to ultimately mainstreaming the role of ES to clearly inform sustainable planning decisions. Among these issues, one of the most important is represented by the lack of precise or mandatory indications in planning laws or norms to use information coming from ES assessment in the land-use planning process. To date, only in some strategic environmental assessments of spatial plans, references to ES can be found. This implies that planners often consider ES assessments as add-ons that can somehow burden the entire planning process.

The session welcomes contributes (theoretical and applied, successful or critic) to highlight resistances and opportunities for the inclusion of Ecosystem Services in spatial planning processes for Italian and international cases. A common perspective essay to be submitted to an international peer review journal is prospected to be jointly developed by session participants.

# Servizi Ecosistemici e Contesto Locale

Stefano Aragona

**Abstract**

Il paper intende confrontarsi con la questione basilare dei Servizi Ecosistemici ovvero della loro natura "integrata", olistica. Tale caratteristica richiede una pianificazione che sia interscalare e connessa sotto il profilo disciplinare. Ciò in assoluta coerenza con la Carta di Lipsia (2007) laddove sono richieste strategie pianificatrici integrate tra aree rurali e non, quindi con le città piccole, medie, grandi e le aree metropolitane. Argomenti che richiedono azioni a ciascun livello istituzionale. Quindi ognuno di essi – Regione, Provincia, Area Vasta, Comuni ed Aree Metropolitane – deve svolgere uno o più compiti ed ha varie responsabilità.

Sono tali "componenti" realizzate, attuate, negli oltre quattrocento Comuni, per lo più piccoli o piccolissimi, della Calabria? Il contributo proposto tenta di riportare elementi relativamente ai temi citati, suggerendo possibili scenari.

## Indispensabile una visione integrata del territorio

La prospettiva da cui si scrive è quella del considerare il territorio come spazio integrato. Cioè esito delle tante componenti che partecipano alla sua formazione. Riferendosi ai Servizi Ecosistemici l'ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale), rifacendosi alla UE (http://biodiversity.europa.eu/topics/ecosystem-services) riporta le seguenti caratteristiche e definizioni:

*Gli ecosistemi forniscono all'umanità numerosi vantaggi definiti «beni e servizi ecosistemici». I beni prodotti dagli ecosistemi comprendono, ad esempio, il cibo, l'acqua, i carburanti e il legname; i servizi, invece, comprendono l'approvvigionamento idrico e la purificazione dell'aria, il riciclo naturale dei rifiuti, la formazione del suolo, l'impollinazione e molti altri meccanismi regolatori naturali.*

*Il Millennium Ecosystem Assessment (MA, Valutazione del Millennio degli Ecosistemi) ha definito i servizi ecosistemici (ecosystem services) come quei "benefici multipli forniti dagli ecosistemi al genere umano".*

*Secondo tale lavoro, negli ultimi 50 anni l'uomo ha cambiato gli ecosistemi con una velocità e una forza che non si erano mai osservate in periodi precedenti; le cause principali sono state la crescente necessità di cibo, acqua dolce, legname, fibre e fonti energetiche. Questo impatto sta provocando una perdita irreversibile di biodiversità in tutto il pianeta e, in particolare, è stato valutato che il 60% dei servizi ecosistemici del pianeta siano stati compromessi.*

*Il Millennium Ecosystem Assessment distingue quattro categorie di servizi ecosistemici:*

- i servizi di fornitura o approvvigionamento: forniscono i beni veri e propri, quali cibo, acqua, legname, fibre, combustibile e altre materie prime, ma anche materiali genetici e specie ornamentali
- i servizi di regolazione: regolano il clima, la qualità dell'aria e le acque, la formazione del suolo, l'impollinazione, l'assimilazione dei rifiuti, e mitigano i rischi naturali quali erosione, infestanti ecc.
- i servizi culturali: includono benefici non materiali quali l'eredità e l'identità culturale, l'arricchimento spirituale e intellettuale e i valori estetici e ricreativi
- infine, i servizi di supporto: comprendono la creazione di habitat e la conservazione della biodiversità genetica.

*Poiché i beni e i servizi ecosistemici sono sempre stati disponibili, fuori da ogni mercato e gratuiti, il loro valore reale non viene considerato dalla società. L'economista statunitense Robert Costanza afferma che "poichè i servizi ecosistemici non vengono catturati dai mercati e non vengono quantificati in termini comparabili ai servizi economici e ai prodotti industriali, molto spesso non vengono neanche considerati nelle decisioni politiche".* (http://www.isprambiente.gov.it/it/temi/biodiversita/argomenti/benefici/servizi-ecosistemici).

Molte delle caratteristiche dei servizi ecosistemici rimandano a quello che erano gli "usi civici". Essi si riferivano agli elementi essenziali che servivano per vivere agli abitanti di un territorio. Infatti il soggetto fruitore di tali usi era colui che apparteneva alla Comunità locale quindi non un soggetto privato o pubblico ma un soggetto che poteva godere, nella misura delle sue necessità di un bene comune. Con l'evolversi delle modalità di antropizzazione e l'incalzare di innovazioni sempre più radicali anche le necessità di vita si modificano e le definizioni/requisiti sopra riportate ne sono chiara testimonianza.

I servizi ecosistemici divengono basilari poiché il ricorso alle risorse finite e quindi non rinnovabili è sempre più evidente, come già anticipava oltre 40 anni addietro *I limiti dello sviluppo* (1972). Inoltre in modo crescente stanno emergendo utilizzazioni ambientalmente nocive. Nocività che da anni organizzazioni ambientaliste, come Legambiente, stanno denunciando. Ponendo anche grande attenzione al rapporto con le tematiche della legalità[1]. Questo non solo o principalmente per motivi etici – certamente rilevanti – ma soprattutto per ragioni di utilità e sicurezza pubblica: basti ricordare la frase di un'intercettazione telefonica in cui veniva detto *"... va bhè ma che importa se si inquina la falda, tanto noi beviamo l'acqua in bottigliata"*.

Enzo Scadurra in "L'Ambiente dell'uomo" già dal 1995 evidenzia l'incongruenza – ormai divenuta enorme – tra il modello di società e spazio formatisi dalla prima rivoluzione industriale e le esigenze della natura. L'autore partecipa alla linea di pensiero dei cosiddetti "territorialisti"[2] per i quali occorre una visione integrata di pianificazione territoriale che valorizzi lo sviluppo locale.

Una delle tematiche rilevanti dei Servizi Ecosistemici, come sopra visto, è relativo al tema idrico. La scarsità di precipitazioni piovose o nevose che sta sempre più avvenendo pone in evidenza una questione già nota da qualche decennio: il conflitto di interessi sull'uso delle risorse, sia irriproducibili e che riproducibili, come l'acqua. La vicenda del Lago di Bracciano, riserva idrica principale della Capitale, è emblematica di tale situazione[3]. Mai, a memoria d'uomo, tale scarsità è stata così rilevante (fig.1).

Il fenomeno sta quindi facendo emergere la necessità fondamentale di una pianificazione strategia, territorialmente integrata, per il mantenimento sia della presenza di acqua a Roma e sia per la sopravvivenza del lago. Non a caso l'ing. Idraulico Masullo, docente universitario, ipotizza un intervento di potabilizzazione del Tevere per avere una seconda riserva idrica per la città (Mochi, 2017).

Accanto all'aumento esponenziale dell'uso delle risorse naturali, stanno avvenendo mutamenti climatologici, come ben illustrato da Einaudi[4] nella Lectio Magistalis *Cambiamenti climatici. Questioni scientifiche e pratiche.* Esse dovute anche, in modo significativo, all'azione dell'uomo. Nel breve servono azioni per fronteggiare le emergenze, ma soprat-

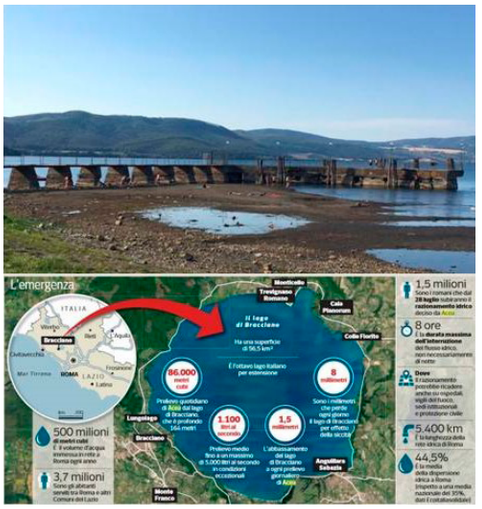


Figura 1 – Il Lago di Bracciano (RM): il periodo di secca di luglio 2017 (sopra)
ed il tributo idrico con Roma
(Fonti: sopra Longo, sotto Corriere della Sera, 2017)

tutto occorre una visione strategica – olistica il più possibile – delle componenti naturali e del loro uso al fine di pianificare scelte per il medio e lungo scenario. Nel caso citato di Bracciano, con la riduzione così significativa del livello idrico, non solo si stravolge il biosistema ma anche le attività lacustri, di ristoro e soggiorno, etc. rischiano di scomparire. Qui si evidenzia come accanto a provvedimenti utili al ripristino, nel breve, delle originarie caratteristiche è indispensabile una programmazione e pianificazione di area vasta e con riferimento temporale per il futuro prossimo e lontano.

Tutto ciò necessita di un nuovo modo di leggere la Terra. Essa è una vasta rete di comunità fluide integrate in un sistema unico, dinamico, di relazioni interdisciplinari. Occorre una rivoluzione copernicana basata su un radicale ripensamento del diritto dell'idea di proprietà delle parti, fino ad oggi viste singolarmente, separate, per lo più private. Queste le tesi proposte nel recente (2017) testo *Ecologia del diritto. Scienza, politica, beni comuni* scritto dal giurista U. Mattei[5] assieme al fisico F. Capra[6]. Le tematiche sono alla base della Carta di Lipsia del 2007 che richiede *"strategie politiche integrate tra aree rurali e non, e aree urbane piccole, medie, grandi, metropolitane"*. Tale visione utile al territorio già nel 1993, e poi nel 1997, veniva proposta dall'economista Mercedes Bresso quando parlava di *economia ecologica*. Nello stesso periodo l'economista Camagni sottolineava la necessità di uno *Sviluppo sostenibile urbano* (1996). Più recentemente, nel 2016, Fusco Girard[7] nel Simposio Internazionale New Metropolitan Prespectives 2016 richiamava l'urgenza di una *economia ecologica* nella logica più ampia di *chiusura dei cicli* riguardo le attività produttive. I richiami ora fatti sono indispensabili a comprendere come siamo dinnanzi ad un periodo che può portare ad una possibile svolta radicale nel considerare il rapporto uomo – natura. Parte essenziale, integrante, di ciò è anche l'economia che però deve essere ripensata in modo profondo, parte integrante di ciò. E quindi, così altrettanto, necessitano una revisione profonda anche gli aspetti di diritto che sono ad essa legata e/o la indirizzano. Istituzionalmente occorre una volontà capace di far prevalere la visione integrata che caratterizzano le componenti naturali di base poiché esse non hanno confini amministrativi. Quindi in primo luogo serve una cooperazione interistituzionale tra Scala vasta e scala locale: cooperazione reale e non fittizia, burocratica. Argomenti centrali nell'*Enciclica Laudato Sii* di Papa Francesco ove il termine "ecologico" è presente in molti passaggi. Anzi si può dire che esso caratterizza l'intero documento[8].

Certamente questo tipo di attività/funzioni non si possono imporre. Occorre coinvolgere la popolazione, gli abitanti, dell'utilità di tutto ciò. Occorre che vi sia una situazione di riconoscimento dell'ambiente come bene pubblico, se non comune, come sopra detto. Ed è indispensabile che la legalità venga riconosciuto come requisito indispensabile per avere i servizi eco sistemici.

Occorre un mutamento di radicale di prospettiva. Occorre quello che da più tempo si sta proponendo (Aragona, 2011) con il titolo di "Approccio integrato ecologico". Linea di ricerca che ha un'ancor più organica strutturazione nella Sessione Organizzata "Pianificazione e progettazione integrata per il territorio e la città ecologici" presente, con declinazioni ogni anno diverse, alle Conferenze Scientifiche Annuali dell'Associazione Italiana di Scienze Regionali (AISRe) ed avviata in quella svoltasi a Torino nel 2011[9]. Temi ripresi a livello internazionale nella Sessione "Metropolis, nature and anthropization: between the earth's resources and those of culture", parte del 2nd International Symposium *NEW METROPOLITAN PERSPECTIVES – Strategic planning, spatial planning, economic programs and decision support tools, through the implementation of Horizon/Europe2020*. ISTH2020, Reggio Calabria, 18 – 20 Maggio 2016 e proposti per 2018 in quella "The integrated ecological approach as a guide and planning opportunity for territories and cities between transformation and environmental and social risks" alla terza edizione del Simposio internazionale *New Metropolitan Perspectives. Local Knowledge and innovation dynamics towards territory attractiveness through the implementation of Horizon/E2020*.

La logica di base di tale ricerca è transdisciplinare ed ha come finalità quella di proporre scenari nel medio, lungo periodo senza però trascurare le azioni che sono necessarie e possibili nel breve. La chiave di volta è il ribaltamento della filosofia che ha guidato il formarsi la città industriale. Che considerava il contesto locale non un luogo – con le sue risorse naturali, paesaggistiche, etc. – ma solo un'area per attività edilizie o produttive. Così distruggendo il patrimonio ecologico, ovvero le preesistenti condizioni naturali ed umane, ed impoverendo le componenti di quelli che oggi sono definiti i servizi escosistemici.

Tutto questo inoltre aumentando le condizioni di rischio – da quello idrogeologico, a quello industriale, sismico, etc. – che sono funzione, oltre che della pericolosità, anche della vulnerabilità ed esposizione.

Il tema è particolarmente rilevante poiché il capitale fisso realizzato dalla industrializzazione edilizia, cioè da circa 80 anni, necessita sempre più di manutenzione, eventualmente demolizione e ricostruzione. Ovviamente con grandi differenze tra gli edifici di epoca storica da quelli delle tante periferie urbane e che rappresentano spesso la gran parte, i 4/5 dell'edificato.

Ed altrettanta manutenzione necessita il patrimonio di verde realizzata, più o meno in modo esteso, nei centri urbani. La giusta presenza richiesta dalla normativa e la crescente domanda di verde non ha neanche minimamente un'adeguata dotazione finanziaria. Ciò sia riguardo l'aspetto quantitativo che gestionale. Dopo il DI 1444/68 vennero emanate leggi riguardo il Piano del verde che prevedevano, Progetti e Gestione, ma ad oggi solo 8 Comuni sono dotati di ciò che era richiesto. I fondi provenienti dalla dotazione nazionale sono molto esigui ed i Comuni hanno scarsissimo personale sotto la voce "giardinieri" o similari. Le conseguenze di

Figura 2 – La diga sul Menta (RC)
(Fonte: Incarnato, 2017)

tutto ciò sono gravi: alberi posti accanto strade non hanno sufficiente spazio per far crescere i loro impianti radicali se non a scapito delle sedi stradali, talvolta a seguito di lavori per reti infrastrutturali le radici vengono tagliate e l'albero cade con danni anche rilevanti. Indagini e quindi la manutenzione di essi è difficile a causa della ricordata scarsità di personale e risorse[10].

Occorre sottolineare come tutto ciò trova difficilmente punti d'incontro con le strategie europee, in primo luogo Agenda Urbana. Finalizzata a far crescere la competitività delle città, creando così alcuni poli privilegiati a scapito sia del territorio che degli altri centri (Aragona, 2014) e considerando la dimensione economica come quella prevalente sopra tutte le altre compresa quella ambientale cioè quella a cui appartengono i Servizi Ecosistemici.

## Le difficoltà del territorio

In Calabria l'estrema polverizzazione dei Comuni, per lo più piccolissimi e dispersi in un territorio morfologicamente caratterizzato da alte montagne spesso a picco sul mare, ha difficoltà ad affermarsi l'idea, prima detta, di ambiente come bene comune[11].

Così anche nella più popolosa città della Regione, Reggio Calabria che conta 183.000 abitanti, vi è una sorta di acquiescenza al fatto che vi sia un contingentamento dell'acqua fornita dall'acquedotto pubblico: da molti decenni nelle periferie e da poco anche nel centro (Naso, 2017). Ciò nonostante la città sia una delle aree metropolitane di recente istituzione. Quindi è difficile pensare a categorie di servizi più sofisticati come quelli ecologici.

La cosa sorprendente è che in Calabria l'acqua non è una risorsa scarsa. Ma miopia politica, forse imperizia, od interessi opachi anche di tipo politico bloccano la realizzazione delle strutture necessarie per il suo uso.

La Diga sul Menta (fig.2) è emblematico esempio di tale inefficacia. Il Governatore della Calabria Oliveiro, come ricorda Incarnato nell'agosto 2017, dichiarava nel 2016: «A distanza di quasi sei anni, quelli che intercorrono dal 2000 ad oggi – spiegava – ripartono i lavori e si riaprono i cantieri per l'ultimazione della Diga sul Menta. Un'opera per la quale sono state investite notevoli risorse pubbliche e che sembrava non dovesse più essere completata. Non a caso essa è stata indicata come l'esempio dell'inefficienza, dell'incapacità e della propensione allo spreco di cui la Calabria ed i calabresi sono stati a lungo considerati protagonisti. Ora il nostro obiettivo è quello di rovesciare questo giudizio e di far diventare la Diga sul Menta da metafora dell'inefficienza a simbolo della Calabria positiva». *Potesse tornare indietro, forse il governatore userebbe altre e più avvedute parole".* L'articolo infatti evidenzia come l'inaugurazione slitta ancora di un anno e cioè al 2018.

Ancor più sorprendente è che in questa Regione esistono già alcune leggi molto avanzate anche in relazione alle questioni ambientali. E' stata la prima Regione meridionale a normare i "Contratti di fiume".

Nel marzo 2017 è stato firmato un accordo per l'attuazione dei Contratti di fiume con Assogal, l'Associazione che raggruppa i Gal (Gruppi di azione locale) della Calabria: "... Il protocollo assume una funzione strategica e decisiva nella misura in cui si tiene conto del fatto che i Gal calabresi, nell'ambito dell'approccio Leader (collegamento tra azioni volte allo sviluppo delle economie rurali), hanno maturato specifiche competenze per quanto riguarda lo sviluppo locale di tipo partecipativo che costituisce il metodo alla base del processo che potrà condurre alla sottoscrizione di un Contratto di fiume. Prevede, tra l'altro, che la Regione e i Gruppi di azione locale calabresi collaborino per favorire la diffusione, la promozione, l'attuazione e la sottoscrizione dei Contratti di fiume, di lago e di costa sul territorio regionale" (Giunta regionale Calabria, 2017).

La particolare morfologia della Regione caratterizzata da un susseguirsi di profonde gole con aste idriche chiamate "fiumare" e la presenza di tanti piccoli e piccolissimi centri sparsi, il vastissimo fronte costiero che contorna quasi tutto il territorio regionale rendono tale strumento ed accordo una potenziale, importante, occasione di programmazione e pianificazione. Indispensabile sotto molti aspetti alla realizzazione dei Servizi Ecosistemici.

Rispetto a questi la Regione, da un paio d'anni, ha iniziato a dotarsi di personale "ad hoc". Nel 2015, è stata emessa dal Dipartimento Ambiente e Territorio (assieme al Dipartimento Organizzazione, Risorse Umane e Controlli), di una Manifestazione di interesse" ai dipendenti della pianta organica per "Esperto servizi Ecosistemici" e di "Esperto per stima valore servizi eco sistemici" *"vista l'indisponibilità all'interno della propria struttura di persone ad adibire a (tali) funzioni"* (DGR n. 491/27.11.2015). L'auspicio è che questi esperti facciano parte di gruppi di lavoro formati da figure provenienti da Dipartimenti vari, attestando la volontà di un approccio multidisciplinare

## Spunti conclusivi

La sensibilità a quelli che vengono chiamati Servizi Ecosistemici non sembra mancare. Non è ancora ben individuabile e se essi possano e/o debbano avere una specifica normazione. E' più probabile che essi trovino il loro spazio nella varia strumentazione di pianificazione esistente assumendo un ruolo più forte e significativo che hanno le attuali aree/funzioni che li caratterizzano. Anch'essi partecipano alle riflessioni e modificazioni che stanno riguardando i servizi, per i quali le canoniche dotazioni quantitative vengono sempre più affiancate dagli aspetti prestazionali.

Come visto anche la Calabria, pur nella sua grande particolarità insediativa e territoriale, sta cercando di sintonizzarsi con tali nuovi argomenti/esigenze scientifiche, culturali e gestionali. Ma, in queste terre in modo particolare, non si deve mai scordare il tema legalità. La presenza della criminalità organizzata è incompatibile con la conoscenza e gestione delle risorse naturali, anzi essa si basa proprio sul "controllo del territorio". Si ricorda che l'assenza della fornitura d'acqua in Sicilia è risolta con distribuzione privata e gestione più o meno illegale di essa. Ancor più interessi non legali riguardano il ciclo dei rifiuti. Primi tra tutti i luoghi dove questi vengono depositati. Più le popolazioni sono informate e coinvolte nella gestione del terri-

torio, come i Gal od i Contratti di fiume prevedono, e ne capiscono la loro utilità, più si hanno possibilità di realizzare i Servizi Ecosistemici, cioè dare sostanza all'approccio ecologico citato.

Ma la battaglia è veramente dura. Esemplare la vicenda del Referendum che si è svolto nel 2011 sulla gestione pubblica dell'acqua sembrava aver messo un punto definitivo su tale tema. Da notare che purtroppo in Calabria la percentuale dei votanti è stata di poco superiore del 50% a fronte di un dato nazionale di oltre il 57%. L'acqua, risorsa scarsa, doveva essere governata dalla politica ed il suo governo, l'economia che la riguarda, andava ricondotta in tale logica. La Sentenza del Consiglio di Stato n.2481/2017 riguardo le tariffe ha invece ribadito la supremazia degli aspetti economici nella definizione di esse come scrive Marotta, docente di Economia Università degli Studi "Suor Orsola Benincasa.

La battaglia, in cui ed a cui appartengono anche i Servizi Ecosistemici, è quella del considerare le risorse naturali come un pubblico e non privato. Anzi nel vedere loro come "Bene comune" da gestire, come dice lo stesso titolo dell'*Enciclica Laudato Sii* prima ricordata, "per la Cura della Casa Comune". Noi urbanisti e pianificatori del territorio dobbiamo essere molto più coraggiosi ed anteporre sempre e comunque il benessere degli abitanti, dei cittadini, al centro e come obiettivo dei nostri studi e piani. E' in questo scenario complessivo, in questa filosofia, che vanno inseriti e "realizzati" i Servizi Ecosistemici.

1. "Il fenomeno, viene affrontato dal 1997 in modo sistematico nell'annuale "Rapporto Ecomafia" un'opera collettiva, coordinata dall'Osservatorio Ambiente e Legalità di Legambiente e realizzata in collaborazione con tutte le forze dell'ordine (Arma dei Carabinieri, Corpo Forestale dello Stato e delle Regioni a statuto speciale, Capitanerie di porto, Guardia di Finanza, Polizia di Stato, Direzione investigativa antimafia), l'istituto di ricerche Cresme (per quanto riguarda il capitolo relativo all'abusivismo edilizio), magistrati impegnati nella lotta alla criminalità ambientale e avvocati dei Centri di azione giuridica di Legambiente" (Legambiente, 2013).
2. Linea di pensiero che si forma dagli anni '90 e che vede Alberto Magnaghi tra i primi a proporla: molti i colleghi impegnati in varie sedi universitarie impegnati ad elaborarla, tra i tanti si ricordano Dino Borri, Anna Marson, Alberto Budoni, Luciano de Bonis.
3. Per 131 anni, fino al 1993, Reservoir, il grande lago di 131 acri a Central Park, è stata una delle riserve d'acqua di New York (Sam, 1993).
4. Il dott. Franco Einaudi ha diretto l'"Earth Sciences Division" della NASA, Goddard Space Flight Center, presso Greenbelt, in Maryland (USA): una struttura con oltre 1000 scienziati provenienti da ogni parte del mondo.
5. Presso l'Hastings College of Law dell'Università della California ricopre la cattedra A. e H. Fromm di International and Comparative Law ed all'Università di Torino è ordinario di Diritto civile. Autore di saggi e pubblicazioni accademiche e militante nel movimento europeo dei beni comuni.
6. PhD, membro del Consiglio della Carta Internazionale della Terra (Earth Charter International), è direttore e fondatore del Centro per l'Ecolfabetizzazione di Berkeley, California, fellow dello Schumacher College, GB. Tra gli scritti si citano *Il Tao della fisica* e *Vita e natura.*
7. E' a capo dell'International research hub on Urban Regeneration dell'UN-Habitat) e dirige l'Interdepartmental Centre for Urban Research, Alberto Calza Bini.
8. Evidenziando la necessità di una *ecologia integrale* cioè ambientale, economica, sociale e culturale l'Enciclica è molto chiara, rivoluzionaria nei termini usati quindi nei contenuti,. Essa va al di la dell'ecologia umana, pure citata in molti passaggi (pp..5, 115, 118, 119, 120), di cui scrivevano nel 1990 Appold e Kasarda. L'Enciclica richiede testualmente di "Eduacare all'Alleanza tra l'Umanità e l'Ambiente" (pp. 209 – 215), facendo riecheggiare quella che Scadurra, prima ricordato, richiedeva nel 1995.
9. Quest'anno nella Conferenza svoltasi a Cagliari vi sono stati 23 paper, segno che la tematica e la filosofia di essa suscita interesse nel mondo della ricerca.
10. Roma, con i suoi 15 Municipi e ca. 129.000 ha, ha poche decine di dipendenti come giardinieri...anche a causa di questioni legali
11. Forse prima del 1861 la situazione era diversa...

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# The integration of ecological corridors and green infrastructure: a study concerning Sardinia

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## Introduction

An important set of ecosystem services (ESs) delivered by green infrastructure (GI) is based on habitats and species protection and enhancement, that is on maintaining and improving biodiversity. Indeed, the second objective of the EU Biodiversity Strategy recommends that ecosystems and their services are maintained and enhanced by establishing GI and restoring at least a 15% of the ecosystems which show up significant decay. From this perspective, habitat fragmentation can be considered one the most outstanding causes of a decreasing attitude of GI towards the delivery of habitat-based ESs, since it weakens the capacity to deliver such services by undermining the networking potential of habitats.

In this paper, we propose a study concerning Sardinia, one of the two insular regions of Italy. 130 Natura 2000 sites (N2Ss) are located in the region (93 Sites of community interest and 37 Special protection areas), which amount to about 14.5% of the regional land.

We propose a methodological approach to identify ecological corridors (ECs) connecting N2Ss, based on the prioritization of functional land patches related to their suitability to ESs delivery, paying particular attention to biodiversity maintenance and enhancement. The methodology consists of two steps: i. identifying the most suitable patches to be included in ECs on the basis of their accessibility, that is, on their negative attitude towards contributing to landscape fragmentation; ii. assessing, through a discrete-choice-model, the ECs identified through point i in terms of their suitability to be included in a regional GI, starting from the territorial taxonomy based on biodiversity characteristics related to N2Ss, habitat suitability, and recreational and landscape potentials.

## Methodology

Our study is related to Sardinia, an Italian insular region located to the southwestern side of continental Italy, close the Corse Island.

The size of Sardinian is about 24,000 square meters, which makes it the third largest Italian region and the second largest Mediterranean island. Sardinia has low population density since less than 1.7 million residents are presently living in Sardinia according to the figures made available by Comuni-Italiani.it[1]. Population is concentrated near to the seashore, mostly in the t, whereas residential density falls dramatically in the internal zones, characterized by difficult accessibility and rough geomorphologic conditions. As a consequence, profound negative gaps related to employment, income, local development and growth have historically featured the regional inner areas with respect to the coastal settlements. Features related to isolation from the rest of Italy, historical and cultural conditions, and insularity give Sardinia a peculiar regional identity which led the Italian Parliament to grant Sardinia the status of "autonomous region", since the foundation of the Italian Republic in the forties. This status allows the Sardinian regional administration (parliament and government) to issue regional laws and regulations autonomously from national legislation as regards several subjects.

We have selected Sardinia on the basis of the following considerations. Rigid regulations have been established since 1993 through the regional landscape plans which concern allowed transformations of new developments are almost totally prohibited. Moreover, the Sardinian Natura 2000 Network covers approximately 19% of the regional area, which is protected under the provisions of the Habitats (no. 92/43/EEC) and Birds (no. 2009/147/EC) Directives. So, the Sardinian region is characterized as a spatial context: i. whose boundaries are very well identified through the coastal seashore; ii. whose frontier shows a homogenous environmental protection regime featured by strict landscape protection; and, iii. environmental conservation measures spread from the coastline towards the inner areas trough the sites belonging g to the Natura 2000 Network. That being so, Sardinia is a geographically clear-cut area which shows a tradition of environmental protection policies which embed an important and widespread regional Natura 2000 Network. These features make Sardinia suitable to our research study which aims at assessing how,

and to what extent, areas belonging to ECs can be identified as suitable to be included into a regional GI.

Our methodological approach is described in the two following subsections. In the first, we discuss how we identify areal parcels suitable to be considered parts of ECs on the basis of their accessibility, whose size is related to the negative contribution to landscape fragmentation. Secondly, we assess the suitability of ECs areas to be included into a regional GI, identified through a spatial classification based on conservation, natural and recreational values.

## Identification of ecological corridors through an accessibility measure

As per art. 10 of the Habitats Directive, implemented into the Italian legislation by art. 2 of the Presidential Decree n. 1997/357, the Natura 2000 Network has to be ecologically and functionally connected by ECs, that is, areal elements, that connect habitats to support biodiversity conservation and enhancement, and, by doing so, increase in the supply of ESs. Thus, the spatial identification of ECs is an important foundation of protection and long-term conservation of biodiversity functions on the basis of prioritization of spatial elements (Snäll et al. 2016) that show low resistance to species movements. Furthermore, ECs aim at maximizing the availability of ESs while supporting species movements.

Recently, promising research work has been implemented with reference to "Least-cost path" algorithms (LCPs), which are very effective in identifying planning scenarios which entails ECs and in prioritizing patches connecting N2Ss (Adriaensen et al. 2003; Beier et al. 2009; European Environment Agency 2014; Lechner et al. 2017; Liquete et al. 2015; Sawyer et al. 2011; Zeller et al. 2012). For this reason, we use LCPs- and cost weighted distance-based analyses (CWDs).

As Adriaensen et al. (2003) show, LCPs identification needs two inputs: a source layer representing patches for which the model calculates the connectivity, and a friction/resistance layer based on two types of information for each cell of a spatial grid: a resistance value and its spatial position and orientation. The resistance value defines the cost of species movements based on the land cover associated to each patch.

The species movements are influenced by: i. the energy consumption implied by the movement; ii. the mortality risk; and, iii. the negative effect on future reproductive potential. These characteristics are represented by the value of cost-resistance associated to each patch.

Through the LCPs we identify paths featured by the least effort or the lowest cost, in terms of species movement.

We use all the Sardinian N2Ss as a source-layer to be connected and we derive the resistance-layer from the available data, available in the literature, on the basis of the concept of habitat suitability.

Thus, the identification of potential ECs is structured in phases.

First, we draw a habitat suitability map by taking account that the patches located outside the borders of the N2Ss can be regarded as habitats as well as patches located inside. The habitat suitability associated to a habitat represents the probability that a habitat be used by a particular species (Boitani et al. 2002; Wang et al. 2008). Generally, the habitat suitability indexes are defined through expert opinions (Graves et al. 2014; Zeller et al. 2012). In our study, we identify global values of potential habitat suitability on the basis of a report, concerning the environmental status of the N2Ss, commissioned by the Sardinian regional administration to AGRISTUDIO (AGRISTUDIO et al. 2011). A global value of potential habitat suitability regards each land cover class of the Corine Land Cover (CLC)2 identified inside and outside N2Ss of the Sardinian region. This value is the result of the weighted mean of the values of the habitat suitability associated to each CLC class in relation to all species cited in the above-mentioned report (104 species are listed). The CLC classes are related to the linear and areal elements of the land cover map of Sardinia.

Secondly, we draw a resistance map representing the spatial distribution of the cost-resistances concerning the movements of species related to the physical characteristics of the environmental context. Resistance values are computed by inverting the values of habitat suitability (European Environment Agency 2014; Forman 1995; Graves et al. 2014; Lechner et al. 2017). Our resistance map takes account of areal and linear elements. Indeed, after mapping the resistance of the areal elements, we increase the resistance values by summing up the values of the street network, and we decrease them on the basis of the hydrological network.

Thirdly, we scale the values of the resistance map with reference to the [1,100] interval, where 100 represents the highest resistance and 1 the lowest (European Environment Agency 2014). The resulting map shows the spatial taxonomy of cost-resistance to the movements of species in relation to the landscape and environmental contexts due to the land cover types.

Finally, we identify the potential ECs through the GIS tool Linkage Mapper[3]. This tool implements connectivity analysis by using the resistance map and the map of the core areas, namely, the N2Ss, on the basis of identification of the least-cost paths. ECs are identified by means of targeted adjacent core areas and of the network of the least-cost paths based on connectivity analysis implemented through CWDs and LCPs.

## Suitability of ecological corridors to be included into a regional green infrastructure

We implement a dichotomous choice model (DCM) in order to analyze the suitability of parcels belonging to ECs to be included into the green infrastructure identified by Lai and Leone (infra) with reference to the Sardinian region. DCMs assess processes featured by ordinal variables, related to mutually exclusive alternatives. The pioneering studies of McFadden (1978; 1980) are reference points for the theoretical foundations as regards behavioral models regarding the choices of agents. William's work (1977) is generalized by McFadden (1978; 1980; 2000) who implements agent-choice models related to standardized microeconomics by integrating heterogeneous characteristics of agents, which may not necessarily be part of the information available to the modeler; in case they are not, they would be included in the model as random features.

DCMs can be implemented with reference to stylized studies available in the literature (Train 2009; Ortúzar and Willumsen 2001; Ben-Akiva and Lerman 1985) which imply the assumptions of incomplete information and imperfect rationality of the agents (Tversky 1972).

Furthermore, in our model we take as grant-

ed that the random utility functions of the agents are not correlated with each other. This implies that, in our model, explanatory and dependent variables are independent and deterministically identified by the available data. As a consequence, the random element of the utility function is characterized by the following conditions (Cherchi 2009; Cannas and Zoppi 2017): i. $E(\varepsilon|x) = 0$ (the random terms have a conditional mean equal to 0), ii. $Var(\varepsilon) = \sigma^2$ (the variance of the random terms is a constant), and, iii. $E[\varepsilon_i \varepsilon_j | X] = 0$ (no correlation exists between the random terms)[4].

In this essay, we use a Logit DCM (LM) to evaluate the suitability of a land patch, which is located in an EC as per the methodological approach proposed in the previous section, to be included into the regional GI as per Lai and Leone (infra). We implement our LM following Zoppi and Lai's (2013), Nerlove and Press' (1973) and Greene's (1993, p. 666-672).

We use the following variables:

- a binary variable (ECGI), concerning land patches, which is equal to 1 if a patch, located in an EC, is included into the regional GI as per Lai and Leone (infra), or 0 otherwise;
- three explanatory variables (CONS_V, NAT_V, RECR_V) concerning the values of conservation, nature and recreation, that is the features of a land patch which are taken into consideration to decide over its inclusion in the regional GI. Descriptive statistics are shown in Table 1.

| Variable | Mean | St.dev. |
|---|---|---|
| ECGI | 0.541 | 0.498 |
| CONS_V | 0.156 | 0.205 |
| NAT_V | 0.811 | 0.260 |
| RECR_V | 0.006 | 0.032 |

Table 1 – Descriptive statistics

## Results and discussion: identification of ecological corridors

The ECs identification, implemented through Linkage Mapper, generates two outcomes. First, a composite raster map which represents ECs identified by the resistance map and the use of LCPs and CWDs. This raster map contains values ranging in the interval [0, 656,074] kilometers. Secondly, a linear shape file containing the normalized least-cost corridors (170 links are identified). McRae and Kavanagh (2011) suggest using the variable computed by the ratio of CWDs to the Euclidean distances as a qualitative metric of the ECs. This entails that high values correspond to high movement costs along the path of least resistance, and low values indicate high quality in terms of connectivity.

Since the ECs, i.e. the least-cost corridors, are defined as linear elements, we reclass the raster map of normalized corridors in ten equicardinal sets, in order to identify two-dimensional ECs. All the patches whose values are included in the first set are assumed to be part of the ECs. Around 2% of the Sardinian regional area belongs to the first set. The identified ECs are mainly agricultural areas (21.6%) and forest and semi-natural areas (77.6%).

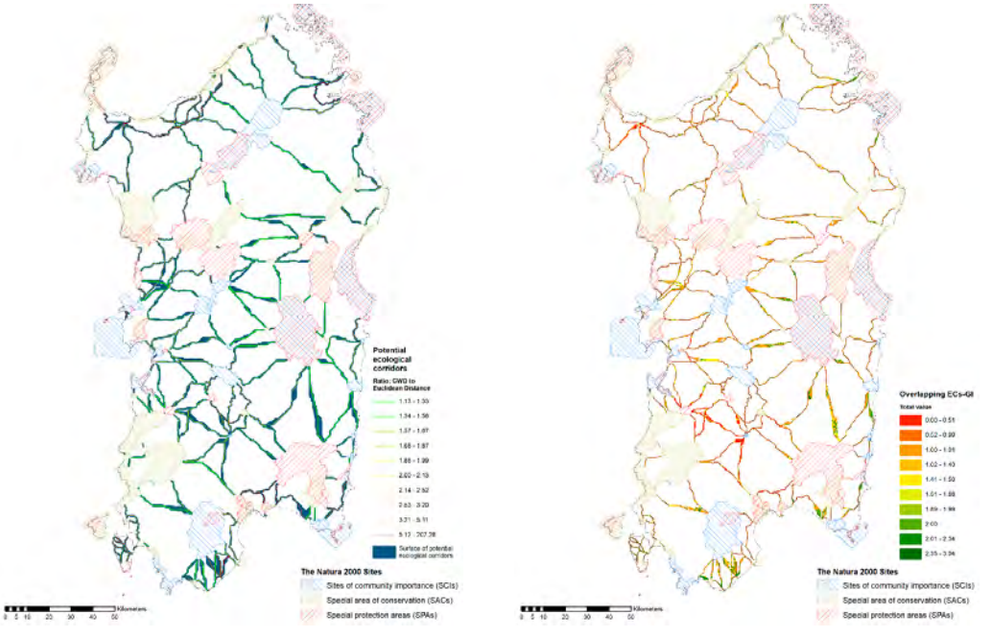


Figure 1 – On the left: potential ECs in Sardinia; on the right: the overlapping map of ECs and the regional GI.

## Results and discussion: suitability of parcels located in ECs to be included into the regional GI

The overlay of the maps of ECs and of the regional GI (Figure 1) returns 9513 land patches. We estimate the probability of each patch to be part of the regional GI, namely, the probability that Y equals 1.

Table 2 reports the marginal effects of independent variables on the probability of a patch to be included in the regional GI entailed by the results of the LM.

As regards the goodness of fit statistics, our outcomes show that the probability values of the Y=1 event are not significantly different from the estimated values, either in terms of the log-likelihood test or with reference to the Hosmer and Lemeshow's (1989) test. Furthermore, the size and sign of the estimated coefficients are consistent with expectations.

The value of conservation (CONS_V in Tables 1 and 2) is related to two determinants, which influence the probability that a patch belongs to the regional GI: i. habitats of Community interest; and, ii. threats, level of knowledge on the habitats status and rarity. As regards the presence of habitats, a ten percent increase of CONS_V at the mean value implies an 2.6% increase in the probability that a patch belongs to the regional GI. Furthermore, if a patch and a priority habitat overlap, this entails that the probability is 54% higher than in the case they do not overlap (see Table 2). With reference to the second factor, higher levels of threats, level of ignorance on the habitats status and rarity are connected to higher levels of probability. The ESs supply provided by biodiversity, which defines the value of nature (NAT_V in Tables 1 and 2) is positively correlated to the probability of a land patch belonging to an EC to be included in the regional GI. This is consistent with expectations since the

| Variable | Marginal effect | z-statistic | Hypothesis test: marginal effect=0 |
|---|---|---|---|
| Marginal effect on Y=1 probability, dProb (Y=1)/dx, Prob (Y=1) = 0.541 | | | |
| CONS_V | 0.258 | 9.814 | 0.0000 |
| NAT_V | 0.181 | 8.817 | 0.0000 |
| RECR_V | 3.351 | 8.062 | 0.0000 |
| Log-likelihood goodness-of-fit test | | | |
| Log-likelihood ratio = 6393.446 – Prob. > chi-square = 0.00000 (3 degrees of freedom) | | | |
| Hosmer and Lemeshow (1989) goodness-of-fit test | | | |
| HL = 646.10767 – Prob. > chi-square = 0.00000 (8 degrees of freedom) | | | |

Table 2 – Marginal effects on the probabilities of Y=1 of the variables related to conservation, natural and recreational values

patches included in ECs are comparatively more adequate to house species protected under the provisions of the Habitats Directive, and to supply biodiversity-related ESs. For instance, our outcomes indicate that if NAT_V increases by 10% at the mean value, the probability that a patch belongs to the regional GI increases by 1.8%.

According to our outcomes, the value of recreation (RECR_V in Tables X and XX), which is based on the users' (local visitors and tourists) revealed interest towards sites, concerning historic and archaeological heritage and natural attractiveness of a given location of the Sardinian region, has the highest marginal impact on the probability of a patch to be included into the regional GI among the three explanatory variables of the DCM LM, since a 10% increase in RECR_V implies a 33.5% increase in the probability that a patch belongs to the regional GI, which is more than ten times the marginal effect of CONS_V and nearly twenty times the marginal effect of NAT_V. Finally, even though the value of recreation is hard to deal with in terms of definition and implementation of planning policies, however our outcomes indicate that the attractiveness of valuable environmental contexts definitely matters in decision-making processes related to environment and protection of nature and natural resources.

## Conclusions

We define and discuss a methodology which aims at identifying ECs which connect Sardinian N2Ss and characteristics of land patches belonging to ECs which make them suitable to be included into the regional GI defined by Lai and Leone (infra). The methodological approach is based on two steps: i. identifying the most suitable land parcels to be included in ECs on the basis of their ecological integrity and accessibility, which consists in their negative attitude towards contributing to landscape fragmentation; ii. assessing, by means of a DCM LM, the ECs identified through point i in terms of their suitability to be included in a multifunctional regional GI, founded on the spatial classification related to biodiversity characteristics concerning N2Ss, that is, on the values of conservation, nature and recreation.

Our study shows (Table XX) that, even though ECs are identified as part of GIs as per the European Commission (2012), nevertheless in the case of Sardinia just a 54% share of the identified ECs belongs to the regional GI, which is a question that needs particular attention.

The nodes of Natura 2000 network consist of special areas of conservation, special protection areas and sites of community importance, whose connections are represented by ECs. The characteristics of parcels included into the ECs are related to habitats of community interest located either outside or inside the N2Ss. In the absence of restrictive rules related to the Birds and Habitats Directives, habitats of community interest can possibly suffer from negative impacts generated by anthropic activities such as new productive and residential developments. Suitable planning measures should be identified in order to protect the local contexts from land-taking processes caused by urbanization policies. These measures should be implemented on the basis of solid scientific and technical foundations and expertise. Indeed, our outcomes show that the Sardinian public administrations (the Region and municipalities) should press the national government and the European Union to extend the conservation approach defined under the provisions of the Birds and Habitats Directives to areas outside N2Ss, in order to spread protection measures as much as possible over the rest of the regional land.

Moreover, our study shows that ESs supplied by biodiversity are very important. This is a fundamental issue in order to promote the integration of ECs into the regional GI. Local, regional and national bodies should improve and support conservation of areas featured by significant ECs supply potentials, by using: i. solid scientific and technical knowledge concerning interdisciplinary fields related to relationships between ESs and land cover typologies; ii. mitigation- and prevention-related measures regarding land take, with reference to on-going and future anthropic developments; and, iii. policies which aim at protecting and enhancing the ESs provision.

Maintaining or enhancing the ESs productive potential is likely to produce negative effects in terms of impacts on other ESs, by weakening the forcefulness of measures stated to grant their conservation. For example, enhancing and catalyzing leisure- and recreation-related ESs (the cultural-service category of the classification of the Millennium Ecosystem Assessment, 2003), or improving agricultural output (the provisioning-service category of the classification of the Millennium Ecosystem Assessment, 2003) is likely to cause negative effects on species and habitats located either in the N2Ss or elsewhere, and, that being so, they are likely to decreased their capacity of producing supporting services (a further category of the Millennium Ecosystem Assessment, 2003).

As a consequence, we believe that a promising future research direction implied by our study is the appraisal and assessment

regarding possible trade-offs between the improvement/worsening of production potentials of different categories of ESs due to the conservation policies implemented to protect N2Ss. Several scholars address this trade-off issue. For example, Kovács et al. (2015), among many, analyze non-monetary trade-offs related to three Hungarian protected sites. Furthermore, our results show an important effect of the value of recreation on the probability of a patch to be part of the regional GI. Actually, its marginal impact exceeds by 130% the value of conservation. It has to be put in evidence that the value of an area in terms of its attractiveness related to leisure is rather volatile and needs more analysis and research than the available studies can provide right now. That being so, future research should also address this issue. Last but not least, our methodology and its implementation can be exported and experimented in other regional contexts of the European Union, where N2Ss are established so as to implement ECs into the nodes of the Natura 2000 network, which are presently disconnected, and, by doing so, to make it consistent with the provisions of the Habitats Directive.


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1. Statistical data available on the Internet at http://www.comuni-italiani.it [accessed November 2017]).
2. Land cover class are classed according to the CORINE Land Cover taxonomy as described in European Environment Agency (1995).
3. Linkage Mapper is a GIS tool that analyzes the habitat connectivity. It is available online at http://www.circuitscape.org/linkagemapper [accessed November 2017].
4. Where: x is the set of independent variables; X is the matrix of observations concerning the independent variables.

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# Ecosystem services in urban plans: What is there, and what is still needed for better decisions[1]

Chiara Cortinovis, Davide Geneletti

## Introduction

Many recent works, from both a research and a policy perspective, advocate the inclusion of ecosystem services (ES) in decision-making to promote sustainable development (Díaz et al., 2015; Guerry et al., 2015). More specifically, integrating concerns for ES in planning processes and tools can lead to a better assessment of the long-term outcomes of planning actions on both biodiversity and human well-being (Haines-Young, Potschin, 2010), thus providing a more comprehensive understanding of the values at stake, and of the trade-offs that may arise (de Groot et al., 2010). However, the integration of ES in planning practices is still limited (Albert et al., 2014; Geneletti, Zardo, 2016)and heightened awareness of their political and socio-economic relevance, mainstream- ing and implementing ES in landscape planning and decision-making are still in their infancy. The objec- tive of this special issue, therefore, is to explore requirements for, approaches to, and potential impacts of, integrating ES in landscape planning and manage- ment. The issue includes three key research themes: (i. In cities, urban ES provide fundamental contributions to the wellbeing of population (Gómez-Baggethun, Barton, 2013), and their benefits are linked to many of the most pressing urban challenges, from climate change adaptation and mitigation (Demuzere et al., 2014)several opportunities exist starting from conscious planning and design of green (and blue, to citizens' health (Tzoulas et al., 2007)and ecosystem and human health. Through an interdisciplinary literature review the concepts of Green Infrastructure, ecosystem health, and human health and well-being are discussed. The possible contributions of urban and peri-urban green space systems, or Green Infrastructure, on both ecosystem and human health are critically reviewed. Finally, based on a synthesis of the literature a conceptual framework is presen-

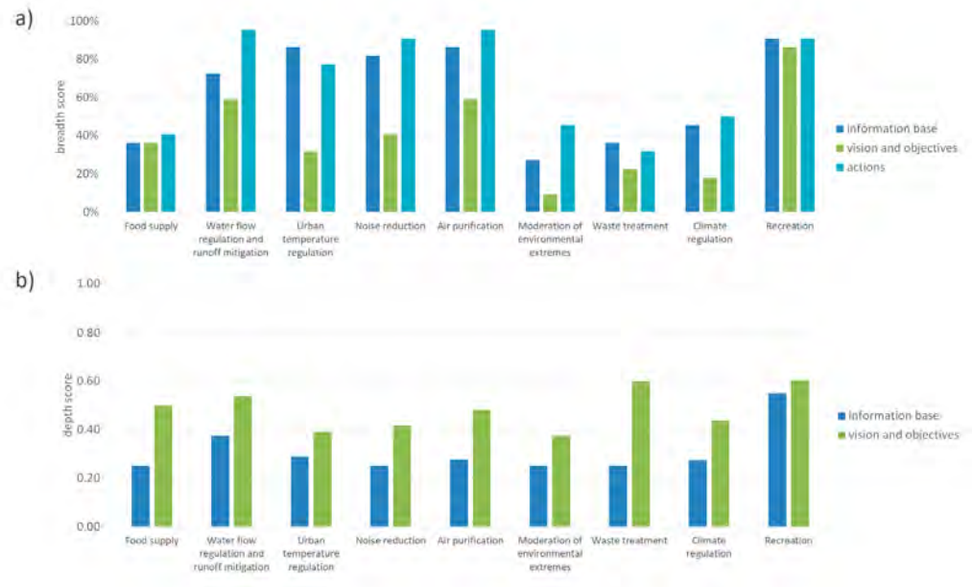


Figure 1 – Breadth and quality of inclusion of urban ES in the sample of urban plans: a) breadth score indicator for the three plan components, b) depth score indicator (i.e., average value excluding scores equal to 0) for the *information* base and the *vision and objectives* components.

ted. The proposed conceptual framework highlights many dynamic factors, and their complex interactions, affecting ecosystem health and human health in urban areas. This framework forms the context into which extant and new research can be placed. In this way it forms the basis for a new interdisciplinary research agenda. (Tzoulas et al., 2007. The provision of urban ES depends on the availability and spatial distribution of green and blue spaces, hence on the strategic decisions on land-use allocations that are made during planning processes. Urban planning also determines the distribution of population and functions within the city, which affects the demand for ES (Baró et al., 2016; Burkhard et al., 2012), as well as other properties of the city physical structure (e.g. accessibility), which play a key role in defining who benefits from ES (Barbosa et al., 2007).

Therefore, the incorporation of ES in urban plans is considered an indicator of their quality (Woodruff, BenDor, 2016) and, ultimately, of their capacity to put in place strategic actions towards more sustainable and resilient cities (Frantzeskaki et al., 2016).

Using Italy as a case study, this article explores how urban plans integrate knowledge on ES to secure or improve ES provision by conserving, restoring, and enhancing urban ecosystems. The ultimate objective is to shed light on what ES information is already included in current urban plans to support planning actions, and what is still needed to improve their content and decisions.

## Materials and methods

The analysis of planning documents is based on a directed qualitative content analysis. This type of analysis interprets a communication based on a pre-defined theoretical framework, which provides the key categories to classify the contents (Hsieh, Shannon, 2005). As key categories, we considered nine urban ES (food supply, water flow regulation and runoff mitigation, urban temperature regulation, noise reduction, air purification, moderation of environmental extremes, waste treatment, climate regulation, and recreation) and three plan components. The *information base* component illustrates the background knowledge that supports planning decisions. The *vision and objectives* component states the long-term vision of the plan and the targets that the plan pursues. The *actions* component illustrates decisions taken by the plan, including strategies and policies that are envisioned to achieve the objectives (Berke, Conroy, 2000; Heidrich et al., 2013)and are typically based on surveys completed by city officials rather than analysis of documented evidence. To gain insight into the status of adaptation and mitigation action across the UK, climate change documents from 30 urban areas (representing ~28 % of the UK\u2019s population.

The analysis followed three steps: i) assessing the breadth of ES inclusion, ii) assessing the quality of ES inclusion, and iii) analysing planning actions. In the first step, we adopted the formulation of the breadth score indicator proposed by Tang et al. (2010), which is defined as the percentage of plans that address the specific ES. The breadth score was calculated both for the whole plans and for each component individually. In the second step, building on the work by Baker et al. (2012), we developed a scoring protocol to assess the quality of ES inclusion in the plans. Regarding the *information base* component, a plan is awarded the highest score when it acknowledges the links between ecosystems and human wellbeing, identifies functions and processes that determine the provision of ES, and applies this knowledge to a quantitative assessment of the local provision that also includes an analysis of demand and beneficiaries. Regarding the *vision and objectives* component, a plan is awarded the highest score when it defines locally-specific principles and quantitative targets for the enhancement of ES provision. To measure the overall quality of inclusion, we calculated the depth score indicator proposed by Tang et al. (2010), defined as the average value of the plans with a non-zero score. The *actions* component was not included in the quality assessment, but further analysed in the following step.

The third step consisted in classifying planning actions according to three properties, namely typology, target area, and implementation tool. The typology describes the type of intervention on urban ecosystems, i.e. conservation, restoration, enhancement, or new ecosystem. The target area describes the scale of the planning action and the spatial distribution of the interventions within the city, i.e. widespread over the whole territory, targeting specific areas, or limited to specific sites. The implementation tool describes the type of legal instruments provided to implement the action, i.e. regulatory tools, design-based tools, incentive-based tools, land acquisition programs, or other tools. Recurrent combinations of the three typologies were identified both in the whole sample of actions and for each urban ES.

We applied the method to a sample of 22 recent urban plans of Italian cities, selected by

| URBAN ES AND RELATED ACTIONS | NUMBER OF PLANS |
|---|---|
| **Food supply** | |
| realization of new allotment gardens | 6 |
| **Water flow regulation and runoff mitigation** | |
| prescription of a minimum share of unsealed surfaces to maintain in new developments | 14 |
| prescription of permeable pavements for parking areas, cycling paths, etc. | 9 |
| realization of green roofs | 6 |
| realization of bio-retention basins or other ecosystem-based approaches to storm-water management | 6 |
| de-paving | 5 |
| **Urban temperature regulation** | |
| provision of trees to shade parking areas | 10 |
| creation of new green areas / enlargement of existing green areas | 7 |
| **Noise reduction** | |
| realization of green barriers/areas for noise shielding from infrastructures | 15 |
| realization of green barriers/areas for noise shielding from factories and plants | 15 |
| **Air purification** | |
| realization of green barriers/areas for air purification from traffic emissions | 15 |
| realization of green barriers/areas for air purification from industrial emissions | 13 |
| creation of woodlands and urban forests | 5 |
| **Moderation of environmental extremes** | |
| enlargement of river areas and conservation/reclamation of floodplains | 8 |
| **Waste treatment** | |
| **Climate regulation** | |
| realization of Kyoto-forests and new woodlands | 8 |
| increase of public green areas | 5 |
| **Recreation** | |
| realization of new public green spaces and urban parks | 16 |
| strengthening walking and cycling accessibility among green areas and with the rest of the city | 16 |
| increasing fruition of green spaces through new walking and cycling paths | 14 |
| restoration of existing green areas aimed at increasing their use | 14 |
| promotion of new functions and uses in the existing green spaces | 12 |
| enlargement of existing green spaces | 8 |
| identification of opportunities for recreation in agricultural areas | 8 |
| realization of peri-urban parks | 7 |
| opening of existing private/unused gardens and green spaces to public use | 6 |

Table 1 – Groups of most recurring actions (found at least in 5 plans) based on the type of intervention proposed.

considering only the plans of the provincial capitals approved, at least in the draft version, since 2012.

## Results

*Breadth of ES inclusion in urban plans*

As shown in Figure 1a) Urban ES are clearly divided into two groups: five urban ES (i.e., recreation, water flow regulation and run-off mitigation, air purification, noise reduction, and urban temperature regulation) are included in almost all plans in the sample; while the other four ES are considered only by around half of the plans. The frequency of mention in the *information base* and in the *actions* components is similar across ES, although values for the latter are slightly higher. The frequency of mention in the *vision and objectives* component is generally lower, with the only two exceptions of food supply and recreation, which are mentioned evenly in the three components.

*Quality of ES inclusion in urban plans*

The overall quality of ES inclusion is generally low. The most common quality score in the *information base* component is 1, but the same pattern discussed for the breadth indicator emerge with respect to the different ES. Although the overall performance is quite poor, the same five ES mentioned earlier are addressed in this component more often and with a higher quality compared to the others. Water flow regulation and run-off mitigation and recreation are the only ones for which some of the plans were given the highest scores. In the *vision and objectives* component, the pattern is less clear.

Here, the most common quality score is 0, which indicates the absence of any reference to ES. However, the highest scores are more frequent than in the knowledge base component, and are found at least in one plan for almost all ES. The depth score indicator (Figure 1b) confirms that, when ES are included, the average quality of the *vision and objectives* component is higher compared to the *information base* component.

*Actions to address ES in urban plans*

Considering the whole sample of 22 plans, we recorded a total of 526 actions addressing urban ES. Recreation is by far the most commonly address, with an average of more than eight actions per plan. An average of three to four actions per plan address water flow regulation and runoff mitigation, noise reduction, and air purification, with implicit acknowledgement of the demand for mitigation of these common urban environmental problems. The other services are addressed on average by less than two actions per plan. Table 1 lists the most recurring actions for each urban ES, based on the type of intervention proposed.

Figure 2 describes the distribution of planning actions according to the three properties analysed (typology, target area, and implementation tool). New interventions represent the most common typology of action (53%). 44% of the actions rely on design-based implementation tools (e.g. projects included in the plan). Regulatory tools, particularly the definition of standards and other specific requirements in building codes, and other tools, such as the suggestion of good practices, are also among the most common, while incentive-based tools and land acquisition programs are the least adopted. In terms of target areas, specific sites are the most common and represent the target of 50% of the actions. These include, for example, the restoration of specific ecosystems, the identification of conservation areas, and the realization of new urban parks. 29% of the actions target specific areas in the municipal territory (i.e., specific zones of the plan, or specific areas identified by the presence of a specific issue). An example of these are regulations to be applied in industrial areas or safeguards to protect agricultural patches. Finally, 21% of the actions are widespread, meaning that they target all the future interventions of a certain typology. These include requirements for new building interventions and rules to respect in case of demolitions and reconstruction.

Actions on specific sites are usually implemented through design-based tools, while actions on specific areas are generally implemented through regulatory tools or other "soft" tools such as the suggestion of good practices. Soft tools also clearly prevail in the case of widespread measures. Concerning

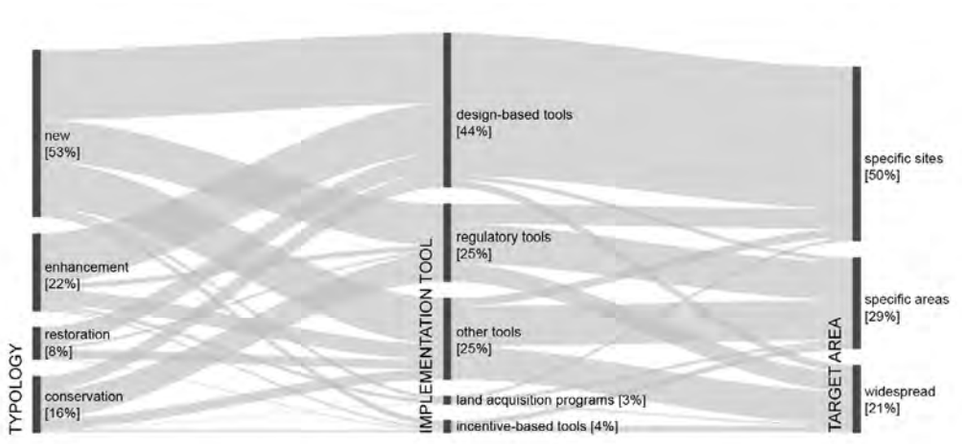


Figure 2 – Distribution of actions per typology, target area, and implementation tool, and recurring combinations.

| what is already there | what is still needed |
|---|---|
| • a great variety of actions to address urban ES<br>• a wide range of local problems addressed through ES-based actions<br>• a large set of tools to implement ES-related actions<br>• focus on recreation<br>• a set of key regulating ES linked to pressing urban environmental problems widely acknowledged and addressed | • better knowledge transfer from science to planning practices<br>• guidance on how to incorporate information on ES in planning<br>• usable methods for ES assessment (scale and multifunctionality)<br>• analyses of ES demand and beneficiaries<br>• considering ES as a strategic issue |

Table 2 – Summary of the main findings.

typologies, conservation actions are more often implemented through regulatory tools, while for both enhancement and restoration activities the preferred tools are design-based. This general picture is partly different when looking at single ES: more details can be found in the Supplementary material of the original paper.

## Discussion

The main findings of the analysis are summarized in Table 2.

*What is already there*

One of the main findings of the research regards the actions to address urban ES. The full list of actions that we found is much more comprehensive than the list of possible interventions proposed by the European Commission (2015), demonstrating the capacity of planning practices to creatively address urban ES. Interestingly, our findings expand not only the number of solutions proposed, but also the range of issues that are addressed. Issues and respective solutions such as safeguarding traditional food supply in cities through sustainable fishery, providing wind shielding by vegetation, protecting against wildfires by maintaining agricultural practices, just to name few, indicate local problems to which ecosystem-based actions may offer a sustainable solution.

Implementation tools are essential for an effective integration, and our analysis demonstrates that, despite being largely overlooked by ES research, many tools are already present in practice. Planners are equipped with a large toolbox, assembled during the last two centuries of urban planning history, which is now applied to address ES. Although there is a prevalence of the most traditional tools, looking creatively at the whole toolbox can help exploring new possibilities to also address the least considered ES, and to further engage local stakeholders and communities.

Possibly our most predictable finding concerns the strong focus on recreation, which has been among the main concerns of urban planners since the very beginning of the discipline. This is in line with analyses of plans of other cities around the world (Hansen et al., 2015; Kabisch, 2015; Wilkinson et al., 2013)and how human-nature relations and the valuation and trade-off discussions regarding ES were framed. An ES coding protocol was developed that categorized and identified 39 ES drawing from the Millennium Ecosystem Assessment and other relevant literature. Only two of the 39 ES were addressed in every plan for both cities, namely freshwater and recreation. While the number of ES referred to in plans has generally increased over time, just under a third of ES in Melbourne and Stockholm were not addressed at all. References to individual ES showed little continuity over time. This variability reveals a time-scale mismatch that has been overlooked in the ES literature with potential urban policy implications. Despite considerable variation in ES addressed across the plans, there is a striking similar pattern in the total numbers of ES addressed over time in both cities. Plans for both cities showed a spike in the late 60s/early 70s, followed by a significant decline in the late 70s/early 80s with the highest number of ES addressed in the most recent plans. Furthermore, our analysis shows that strategic spatial plans generally demonstrate awareness that urban populations are dependent on ecosystems and this framing is an important part of the policy discourse. While specific monetary values were not placed on any ES in the plans, resolution of land-use conflicts requiring tradeoffs between ES and equity of distribution of ES is a central feature of most of the examined plans. We argue that longitudinal policy document analysis represents a useful complement to any attempt to improve understanding of the implications of and opportunities for operationalizing an ES approach in urban practice.", (Barbosa et al., 2007; Kabisch et al., 2016; La Rosa, 2014) we assess green space availability in 299 EU cities according to land use and a population data grid. The results show a diverse picture across the EU. Southern European cities show below-average availability values, which may be explained by their low forest and tree cover and reflect the history of cities in Southern Europe. Comparatively, the above-average availability values in Northern European cities are a result of not only their biophysical conditions and the presence of rich forestland in general but also of Northern European attitudes toward urban living that naturally value having forests close to home. This assessment is complemented by a detailed case study analysis of two European cities \u2013 Berlin, Germany and

\u0141\uoof3d\u017a, Poland. Results showed that this approach's explanatory power depends on the data used, scale of interest, resolution of data and estimated threshold value. By comparing results using different datasets and threshold values, we discuss opportunities and limitations for developing indicators of green space availability. We conclude that UGS availability is an important indicator to navigate urban complexity to improve human health and wellbeing but is only one component of the intricate social-ecological interactions within cities."

Beside recreation, four other ES are acknowledged by almost all the reviewed plans. These ES are related to environmental issues specific of urban contexts, such as soil sealing, urban heat island, and noise and air pollution, which have been key topics in the discourse around urban sustainability and resilience during the last years. Publications and initiatives, both at the EU and at the global level, as well as the growing popularity of ecosystem-based actions (Brink et al., 2016; Geneletti, Zardo, 2016)\u201chard\u201d adaptation measures are often associated with high costs, inflexibility and conflicting interests related to the dense urban fabric, and ecosystem-based adaptation (EbA have contributed to raising awareness and spreading knowledge about these issues and potential interventions to address them.

*What is still needed*

A locally-specific application of the ES concept is a clear gap in the *information base* of current plans, where existing methods, models, and tools for ES mapping and assessment are almost completely overlooked. This can be considered an indicator of the low level of knowledge transfer from ES science to practice, and a warning for ES research. Urban planners need an active support from research to integrate ES in current planning practices (Palo et al., 2016). To this aim, little guidance is provided by existing planning guidelines: their enhancement would be an effective mean to summarize scientific knowledge and promote a better consideration for ES in urban plans.

Looking at the actions proposed by the reviewed plans, some issues emerge about current methods to map and assess urban ES. To effectively support urban planning in the operationalization of the ES approach, usable methods are needed to map current conditions of urban ES and to measure expected and actual outcomes of planning actions at the very local scale (Haase et al., 2014). Moreover, methods should better integrate consideration for multi-functionality, providing ways to simultaneously assess the provision of multiple ES under different planning scenarios (Kremer, Hamstead, 2016)modeling, and valuing urban ecosystem services are important for integrating the ecosystem services concept in urban planning and decision-making. However, decision-support tools able to consider multiple ecosystem services in the urban setting using complex and heterogeneous data are still in early development. Here, we use New York City (NYC.

With the only exception of recreation, analyses of demand and of existing and expected beneficiaries are lacking in the reviewed plans. The explicit consideration for demand and beneficiaries should be among the main improvements brought by the ES concept to the urban planning practice. An effective *information base* should consider not only ES supply within the city, but also the distribution of beneficiaries, and their different levels of demand for each specific ES. Methods and indicators exist in the literature to assess demand for most ES; however, applications at the urban scale, especially in spatially-explicit, multi-ES assessments able to reveal distributional inequalities, are only few (Baró et al., 2016), and still too demanding to be applied in real-world practices.

Finally, our results indicate a lack of consideration for ES in the strategic component, also confirmed by other studies (Beery et al., 2016). A weak strategic vision, lacking specific objectives and targets for ES enhancement, undermines the perspective of a long-term commitment that could guarantee action implementation and persistence of ES consideration beyond the time horizon of the single plan (Wilkinson et al., 2013) and how human-nature relations and the valuation and trade-off discussions regarding ES were framed. An ES coding protocol was developed that categorized and identified 39 ES drawing from the Millennium Ecosystem Assessment and other relevant literature. Only two of the 39 ES were addressed in every plan for both cities, namely freshwater and recreation. While the number of ES referred to in plans has generally increased over time, just under a third of ES in Melbourne and Stockholm were not addressed at all. References to individual ES showed little continuity over time. This variability reveals a time-scale mismatch that has been overlooked in the ES literature with potential urban policy implications. Despite considerable variation in ES addressed across the plans, there is a striking similar pattern in the total numbers of ES addressed over time in both cities. Plans for both cities showed a spike in the late 60s/early 70s, followed by a significant decline in the late 70s/early 80s with the highest number of ES addressed in the most recent plans. Furthermore, our analysis shows that strategic spatial plans generally demonstrate awareness that urban populations are dependent on ecosystems and this framing is an important part of the policy discourse. While specific monetary values were not placed on any ES in the plans, resolution of land-use conflicts requiring tradeoffs between ES and equity of distribution of ES is a central feature of most of the examined plans. We argue that longitudinal policy document analysis represents a useful complement to any attempt to improve understanding of the implications of and opportunities for operationalizing an ES approach in urban practice.", "author" (Wilkinson et al., 2013). In the reviewed plans, the distance between the high number of actions addressing some ES and the low quality of their baseline assessments and strategic objectives indicate that current approaches are largely based on the reference to general good practices, rather than on the analysis of current needs and the consequent formulation of local strategies. Even though good practices may be an important source of knowledge and co-learning among cities, replicating the same solutions without tailoring them to the specific local context may lead to suboptimal results.

## Conclusions

Overall, our findings reveal that the integration of ES in planning practices is proceeding through a sort of "internalization" process that builds on what was already part of the planning tradition. Current urban plans already include a high number of ES-related actions and a variety of tools for their implementation. However, only recreation and some regulating services are widely addressed, while other are hardly considered. Advancements in the usability of methods

for ES assessment and guidance for planners are still needed. At the same time, a further integration of the ES approach, particularly in terms of strategic objectives and identification of demand and beneficiaries, would strengthen planning decisions and increase the quality of current urban plans.

1. The full-length paper is published in *Land Use Policy* (https://doi.org/10.1016/j.landusepol.2017.10.017).

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# La valutazione dei servizi ecosistemici: una sperimentazione del modello InVEST al territorio dei Campi Flegrei

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## Introduzione

Gli ecosistemi, se adeguatamente tutelati, offrono un flusso di servizi che sono vitali per il benessere dell'umanità, come la produzione di cibo, la depurazione delle acque e dell'aria, l'assimilazione di rifiuti, la conservazione della biodiversità, la valorizzazione degli aspetti culturali e storico-artistici.

Per valutare l'impatto che i cambiamenti degli ecosistemi possono avere sul benessere dell'umanità, le Nazioni Unite hanno finanziato il progetto "Millennium Ecosystem Assessment" (MEA, 2005), un programma di ricerca che ha coinvolto oltre mille esperti, finalizzato ad identificare i principali cambiamenti naturali in corso e le possibili alternative per ripristinare e migliorare l'uso delle risorse naturali. I risultati di questo studio hanno destato preoccupazione nella comunità scientifica poiché è stato stimato che, alla fine del secolo scorso, circa il 60% dei servizi ecosistemici del pianeta era in uno stadio di degrado e immiserimento; il livello più critico riguardava la biodiversità, in particolar modo quella delle specie marine, minacciate dai cambiamenti climatici e dall'inquinamento. Al fine di contrastare il processo di depauperamento di beni naturali ed ambientali, negli ultimi vent'anni, i governi stanno adottando provvedimenti politici e strategici ("Strategic Plan for Biodiversity 2011-2020" delle Nazioni Unite) per sottolineare la centralità dei servizi ecosistemici per il benessere e per la sopravvivenza delle popolazioni. Più recentemente, il documento "Transforming our World. The 2030 Agenda for Sustainable Development", adottato dalle Nazioni Unite nel 2015, ribadisce la necessità di proteggere gli ecosistemi del pianeta. Il documento è costituito da 17 obiettivi (Goals) e 160 targets, tra cui l'Obiettivo 15 "Proteggere, ripristinare e favorire un uso sostenibile dell'ecosistema terrestre". Inoltre, la protezione degli ecosistemi, terresti ed acquatici, costituisce un tema trasversale presente anche in altri obiettivi e target (2.4, 6.6, 14.2) nonché nell'introduzione generale (punti 33 e 59).

L'approccio ecosistemico sviluppa quanto era stato già proposto negli anni Novanta dal geografo italiano Adalberto Vallega, il quale teorizzò un diverso modo di intendere il rapporto uomo-ambiente. Sulla base del principio dell'olismo e della logica sistemica (Le Moigne, 1990; Morin, 1984), Vallega (1995) illustrò la teoria della complessità, secondo cui è possibile comprendere (dal latino *complecti*, abbracciare) l'ecosistema, costituito da un insieme di elementi biotici e abiotici con una propria organizzazione che si trasforma e si evolve, superando la concezione tradizionale del rapporto uomo-natura. Nel dibattito scientifico è cresciuto il numero di ricerche sul concetto e sulla valutazione dei servizi ecosistemici (Bagstad et al., 2013; Fisher et al., 2009). Dalla progettazione sostenibile delle città moderne alla valutazione d'impatto ambientale dei progetti, affrontare il concetto dei servizi ecosistemici è diventato fondamentale (De Groot et al., 2002, 2010; Geneletti, 2011, 2013; Burkhard et al., 2015) al fine di prevedere come i cambiamenti nell'uso del suolo possono incidere sulla distribuzione delle risorse del territorio. Tuttavia, in Italia, la valutazione dei servizi ecosistemici non è ancora stata inserita in modo strutturato all'interno dei processi di pianificazione e gestione del territorio, a meno di alcuni esempi virtuosi e sperimentazioni in atto (Santolini, 2011; Santolini et al., 2011); persistono reticenze e difficoltà operative, come l'insufficienza di dati per le analisi del territorio. C'è da aggiungere che in Italia la pianificazione del territorio risulta spesso troppo frammentata da una suddivisione di responsabilità tra soggetti, livelli amministrativi e settori di governo che impediscono una visione organica, indispensabile per leggere in maniera integrata i cambiamenti che coinvolgono l'ambiente e la salute della biodiversità. L'obiettivo del presente articolo è quello di proporre una valutazione qualitativa e quantitativa dei servizi ecosistemici in aree altamente sensibili e ricche di risorse naturali e culturali come il territorio flegreo, ed esplorare quali potenzialità possa offrire l'inclusione dei servizi ecosistemici nella pianificazione territoriale.

## Area di studio e metodo di analisi

I Campi Flegrei si estendono ad ovest della città di Napoli su una superficie di 7.800 ettari con una popolazione residente di oltre 400.000 abitanti. L'area abbraccia la fascia costiera della collina di Posillipo, di Bagnoli, di Pozzuoli fino a Cuma. L'amenità del territorio ha catturato da sempre l'interesse di viaggiatori, studiosi ed abitanti, tanto che ancora oggi resta un'area di straordinaria bellezza.

Il paesaggio flegreo è caratterizzato da superfici agricole terrazzate destinate a colture pregiate quali vite, orti, frutteti, oliveti, che si integrano perfettamente con le testimonianze del patrimonio culturale. Le aree di particolare interesse paesistico-ambientale rientrano nel Parco Regionale dei Campi Flegrei, istituito dalla Regione Campania nel 1993, che include testimonianze archeologiche, beni monumentali ed aree naturalistiche ad elevata biodiversità (tra cui oltre undici riserve naturali e nove aree SIC e ZPS). Peraltro, il complesso sistema ambientale e culturale dell'area flegrea costituisce un insieme singolare nel rapporto tra opera dell'uomo e opera della natura anche per la compresenza di un sistema vulcanico in grado di produrre eruzioni esplosive di grandi dimensioni (il rischio vulcanico dell'area è uno dei più alti al mondo) e la concentrazione sul territorio di suoli densamente urbanizzati.

Dalla costruzione nei primi anni del Novecento del grande polo industriale di Bagnoli, il territorio è stato investito da una grande trasformazione urbana, mutando la tradizionale vocazione turistica e balneare dell'area, con la realizzazione di quartieri residenziali al fine di ospitare nuclei familiari che da Napoli e provincia si spostarono per avvicinarsi alla sede delle industrie. Si stima che dagli anni Sessanta ad oggi si sia consumato circa il 40% del suolo agricolo ed i centri storici sono stati inglobati in un tessuto edilizio amorfo che ha determinato la perdita di peculiarità e valenze identitarie del sistema insediativo nella fascia costiera (PTC, 2016).

Data la complessità del territorio flegreo, al fine di circoscrivere l'area da analizzare nella valutazione dei servizi ecosistemici, sono state raffrontate due fonti: quelle storica del geografo Dainelli, il quale ha definito la regione flegrea quella parte di territorio che si estende dai rilievi collinari dei Camaldoli a Monte di Procida, e dal cratere di Quarto alla collina di Posillipo, e quella relativa all'attuale perimetrazione dell'area flegrea stabilita nella proposta di Piano Territoriale di Coordinamento della Città Metropolitana di Napoli (PTC).

Infine, dall'osservazione della struttura territoriale si è scelto di considerare nella valutazione in oggetto i comuni di Pozzuoli, Bacoli, Monte di Procida e Quarto, e parte dei comuni di Giugliano in Campania, di Marano di Napoli, le aree di alcune municipalità di Napoli (Soccavo e Pianura, Bagnoli e Fuorigrotta), nonché alcune porzioni delle municipalità di Posillipo e Arenella. Sono state escluse le isole vulcaniche che presentano una stessa natura geomorfologica ma problemi ambientali e urbani differenti.

L'analisi è stata suddivisa in tre diverse fasi. Nella prima fase sono state mappate le risorse culturali ed ambientali, mentre nella seconda fase le stesse risorse sono state analizzate con un approccio integrato, utilizzando i "tool" di valutazione InVEST (Integrated Valutation of Ecosystem Services and Trade off), sviluppato dall'Università di Stanford e dalla fondazione Natural Capital Project insieme ad altri partner internazionali per valutare l'impatto sull'ecosistema dei cambiamenti d'uso del suolo (InVEST, 2015). In particolare, sono stati applicati due modelli: "Habitat Quality", per la valutazione dei servizi di supporto, e "Tourism and Recreation", per la valutazione dei servizi ecosistemici culturali. Nella terza parte della ricerca è stato elaborato uno scenario futuro alla luce delle previsioni del PTC.

## Costruzione del quadro conoscitivo della regione flegrea

Nella prima fase del lavoro, utilizzando strumenti GIS, è stata predisposta una descrizione completa dell'area di studio mappando le risorse del territorio. In particolare, sono state individuate:

- le risorse culturali: beni archeologici ed architettonici, chiese, musei e punti di belvedere;
- il patrimonio ambientale: Parchi e le Riserve Regionali, aree SIC e ZPS, aree agricole di pregio, aree costiere;
- le infrastrutture per la mobilità ed i servizi turistici: porti e approdi, strade a scorrimento veloce, strade comunali e provinciali, linee ferroviarie e stazioni;
- i servizi per il tempo libero e per il turismo: strutture ricettive ed attrezzature sportive.
- La raccolta dei dati di input ha richiesto una preliminare ricerca bibliografica ed una specifica elaborazione di informazioni: molte delle conoscenze acquisite sull'area in esame sono state rese disponibili dall'ufficio S.I.T. della Città Metropolitana di Napoli.

Dalle prime carte del quadro conoscitivo si può ritenere che i Campi Flegrei conservano una spettacolare stratificazione di risorse culturali ed ambientali di notevole interesse. Si può evidenziare che la densità di beni culturali si colloca maggiormente sulla fascia costiera, mentre la zona interna presenta ancora una pregevole vocazione agricola nonostante la forte urbanizzazione degli ultimi decenni.

Alle differenti caratteristiche delle due aree, interna e costiera, corrispondono esigenze diverse di pianificazione urbanistica. Se adeguatamente valorizzato e gestito, il milieu locale potrebbe innescare un favorevole processo di crescita economica e territoriale culturalmente compatibile ed ecologicamente sostenibile, perseguimento l'obiettivo dell'Unione Europea di sviluppo integrato tra risorse e opportunità.

## La valutazione della qualità degli habitat

Nella seconda fase del lavoro sono stati presi in esame i benefici e la qualità dei servizi ecosistemici di supporto; questi comprendono tutti i servizi legati alla creazione di habitat e alla conservazione della biodiversità. Essi includono la fotosintesi, la formazione del suolo ed il ciclo dei nutrienti, cioè elementi minerali quali azoto, fosforo e potassio, indispensabili per la crescita e lo sviluppo degli organismi; in breve, tutti i servizi che sostengono e permettono la fornitura delle altre categorie di servizi ecosistemici.

Per la valutazione è stato sperimentato il tool "Habitat Quality" del modello InVEST, con l'obiettivo di analizzare la qualità degli habitat, cioè la capacità dell'ecosistema di fornire condizioni appropriate per la persistenza individuale e della popolazione, capacità considerata una variabile continua nel modello che può essere basso, medio o alto, in base alle risorse disponibili per la sopravvivenza, la riproduzione e la persistenza della popolazione. Per generare una carta sulla qualità degli habitat, il modello di InVEST processa

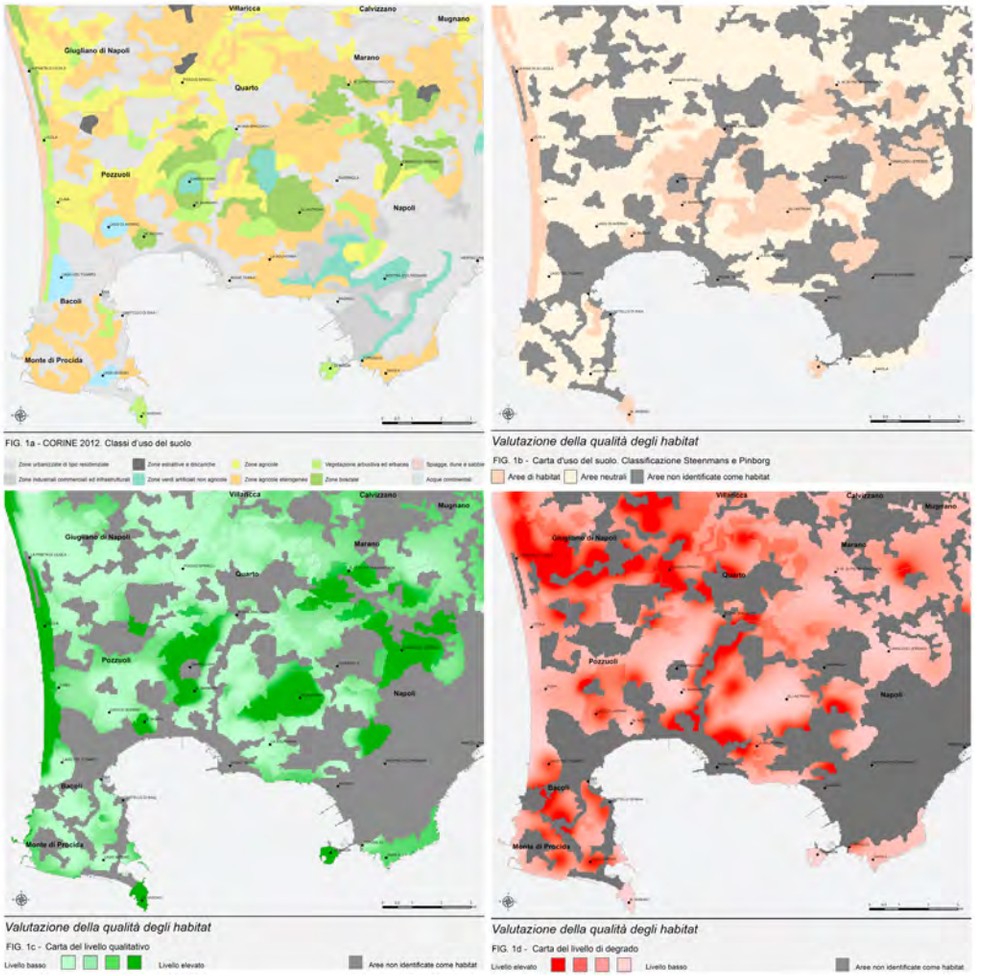


Figura 1– Classificazione dell'uso del suolo (a, b) e valutazione della qualità degli habitat (c, d)

due tipi di informazioni che sono, da una parte, la copertura del suolo, e, dall'altra, le fonti di minacce geo-localizzate sul territorio che possono indurre alterazioni degli habitat nell'ecosistema. L'impatto di ciascuna minaccia sugli habitat viene mediato secondo due fattori: un peso (ad esempio, si considera che la minaccia derivante da un ambiente urbano risulti più significativa di quella originata da un contesto agricolo) e la distanza dalla fonte espressa in Km.

L'approccio innovativo del modello consente di quantificare la biodiversità senza ricorre a dati sulle popolazioni o sulle specie, informazioni solitamente non disponibili e talvolta operativamente impossibili da raccogliere. I cambiamenti di qualità e quantità degli habitat sono considerati rappresentativi dell'andamento della biodiversità e del numero di specie ospiti.

Il modello viene eseguito utilizzando dati raster, applicando una griglia a celle quadrate all'area di studio. Ad ogni cella è attribuito un tipo di LULC (Land Use Land Cover) che può essere un ecosistema naturale, come pascoli o bacini d'acqua, oppure un ecosistema artificiale, come una superficie urbanizzata. Inoltre, il livello di classificazione della LULC può essere mediamente dettagliato.

Sul piano operativo, per l'applicazione del modello è stata innanzitutto predisposta la carta d'uso del suolo dei Campi Flegrei estrapolata dalla CORINE Land Cover, IV livello (2012). Alla classificazione della CORINE (Fig. 1a) è stata applicata la metodologia di Steenmans e Pinborg (2005) sulla frammentazione delle aree naturali, la quale riclassifica la CORINE in: aree sensibili "S" (aree naturali e semi-naturali), aree di pressione "P" (aree che hanno un impatto sulle zone adiacenti del territorio) e aree neutrali "N".

Pertanto, la riclassificazione della CORINE Land Cover dei Campi Flegrei (Fig. 1b) è costituita da: aree di habitat, che le zone sensibili "S" a cui viene attribuito un valore pari a 1; le aree di non habitat, che sono le zone di pressione "P" con valore pari a 0; le aree neutrali "N" che vengono interpretate come aree ibride a cui si è attribuito un valore pari a 0,5.

Per una lettura corretta delle informazioni, il modello InVEST richiede che i dati siano organizzati in matrici. Pertanto, sono state predisposte due tabelle: l'una, sulla sensibilità degli habitat, l'altra, sulle fonti di degrado. La matrice sulla sensibilità degli habitat raccoglie i dati sulle classi della CORINE dei Campi Flegrei con i rispettivi valori delle suddette zone S, N e P, mentre la matrice delle fonti di degrado riporta le minacce che insistono sul territorio. Tali fonti di minacce sono le cave utilizzate per le attività estrattive (PRAE, 2006), le aree destinate allo smaltimento di rifiuti urbani (PRGRU, 2012), i siti inquinati (PRB, 2013), il suolo con la produzione agricola intensiva (ARPAC, 2009) e le infrastrutture per la mobilità. Per ciascuna fonte di degrado (cave, siti inquinati, discariche, strade, aree agricole intensive) è stato attribuito un peso relativo. La costruzione dei pesi è stata supportata dalla tecnica del confronto a coppie utilizzando il metodo Macbeth (Measuring Attractiveness by a Categorical Ba-sed Evaluation TecHnique) (Bana e Costa e Vansnick J.-C., 1997).

La valutazione delle minacce (velocità di propagazione, raggio di espansione nel sottosuolo o in atmosfera) sono il risultato di informazioni desunte dalla letteratura scientifica (Terrado M., 2015). Attribuito il peso alla minaccia, il modello InVEST, infatti, richiede di specificare la distanza di propagazione della minaccia sul territorio e la modalità di espansione. Il risultato ottenuto dalla valutazione è costituito da due carte tematiche sulla qualità degli habitat e sulle aree di degrado.

La prima carta illustra le aree dove si rileva la presenza di un'elevata biodiversità, come nel caso del cratere degli Astroni, Monte nuovo, Monte S. Angelo ed il Campiglione (Fig. 1c); la seconda carta, invece, rappresenta le aree di pressione con livello di degrado basso, medio alto e alto in prossimità di zone urbanizzate ed in alcune aree SIC e ZPS, come il lago del Fusaro, il lago d'Averno ed il lago di Miseno (Fig. 1d).

La consapevolezza dei rischi e delle potenzialità delle risorse è di fondamentale importanza per la pianificazione del territorio, in quanto essa determina i futuri scenari possibili di utilizzo del suolo e necessita di un ampio sistema di informazioni per adeguare le esigenze di trasformazione con la

salvaguardia dell'integrità degli ecosistemi. Infatti, conoscere la qualità degli habitat per i Campi Flegrei può aiutare i decisori politici ad intraprendere provvedimenti adeguati per rallentare il depauperamento del suolo e per tutelare le aree che offrono maggiori servizi ecosistemici alla comunità.

## La valutazione dei servizi ecosistemici culturali

I Campi Flegrei offrono un sistema diffuso di servizi culturali di grandissimo pregio inseriti in un contesto naturale di elevatissimo rischio. In un'ottica di sviluppo sostenibile della regione flegrea dal punto di vista sociale, economico ed ambientale è fondamentale conoscere l'attrattività del territorio anche in previsione di una futura approvazione e attuazione della proposta del PTC.

Per la valutazione dei servizi ecosistemici culturali è stato sperimentato il tool "Tourism and Recreation" del modello InVEST. La peculiarità del tool è il calcolo dell'attrattività utilizzando come indicatore la stima del numero medio di fotografie pubblicate ogni giorno dagli utenti (Photo User Days - PUD) e rese disponibili sulla piattaforma on line di condivisione di immagini Flickr. Il vantaggio di tale indicatore è di ottenere informazioni sull'andamento delle visite anche in assenza di dati empirici sul numero effettivo di presenze per ogni sito di pregio del territorio.

Per completezza, al fine di valutare, non soltanto l'attrattività, ma la qualità dei servizi ecosistemici culturali si è considerata la PUD insieme ad altri indicatori, costruiti sulla base della metodologia che è di seguito illustrata.

Gli input sono le risorse individuate nel quadro conoscitivo. Utilizzando il modello InVEST, a ciascuna risorsa è stata attribuita una funzione di calcolo tra quelle indicate nel tool (*line intersect length*, *point nearest distance*, *polygon percent coverage*, *raster mean*) per ottenere i seguenti indicatori: accessibilità pedonale, accessibilità veicolare e percentuale di copertura. Il risultato ottenuto è costituto da 18 carte tematiche che mappano le risorse del territorio sulla base dei suddetti indicatori. Ciascuna carta è stata successivamente rasterizzata in ambiente GIS ed i valori ottenuti sono stati gerarchizzati su quattro livelli secondo un ordine crescente o decrescente a seconda dei diversi tematismi.

Operativamente, per riportare un esempio, nella carta degli "Elementi antropici di interesse paesaggistico" è stata calcolata l'accessibilità pedonale rispetto ai punti di rilevanza del paesaggio (Fig. 2a). I dati ottenuti sono stati distribuiti in quattro classi di distanze: la prima comprende l'intervallo di valori da 0 a 300 m; la seconda include i valori che oscillano da 300 m a 1.000 m; la terza include l'intervallo dei valori da 1.000 a 3.000 m e la quarta racchiude tutti i valori che superano i 3.000 m di distanza dai punti di rilevanza culturale e paesaggistica. In un passaggio successivo, la stessa carta in formato shape file è stata trasformata in formato raster (in ambiente GIS) assegnando a ciascuna classe di valori un punteggio da 1 a 4 sulla base della maggiore o minore accessibilità della zona di interesse. Analogamente, il medesimo metodo è stato ripetuto in tutte le altre 17 elaborazioni

Pertanto, al fine di comprendere la "vocazione turistica" dei Campi Flegrei, ed in assenza di dati empirici sui visitatori, è stata elaborata la carta dell'attrattività dei luoghi calcolando la PUD (Photo User Days) per l'arco temporale di dieci anni 2005-2015, poiché attualmente non sono disponibili dati relativi agli anni precedenti al 2005 e successivi al 2015. Dall'esplorazione di Flickr, si è ottenuto un numero complessivo di circa 8.000 foto per utente nel decennio considerato, con valori medi della PUD che oscillano da 0 a più di 5 fotografie al giorno per utente. La carta in formato shape file è stata rasterizzata e riclassificata attribuendo alle quattro classi di valori un punteggio da 1 a 4 (Fig. 2b).

I risultati ottenuti evidenziano che i Campi Flegrei presentano innumerevoli opportunità per lo sviluppo di un turismo sostenibile, colto e stanziale. Infatti, è possibile evidenziare che:

- i valori del PUD sono alti lungo la fascia costiera da Mergellina a Capo Miseno e nelle aree interne in prossimità di Quarto e Pianura;
- i posti dell'area flegrea più fotografati, con oltre cinque fotografie per utente al giorno, sono Mergellina, Capo Posillipo, la Gaiola, il Parco Virgiliano, Coroglio e Bagnoli, il Rione Terra, la Solfatara, il Lago d'Averno, il tempio di Apollo, le Terme ed il Castello aragonese di Baia, il Lago di Miseno, il Lago del Fusaro, gli scavi archeologici di Cuma;
- i valori della PUD sono molto bassi da Cuma a Licola e nelle aree interne da Giugliano a Mugnano, nonostante la presenza di estese aree naturali, soprattutto agricole.

Pertanto, dalla valutazione dell'attrattività dell'area flegrea ne deriva un paesaggio con due volti, l'uno agricolo, l'altro culturale. Il carattere speculare di questi luoghi (perché il termine "cultura" deriva dalla matrice latina di *colere* che significa coltivare, prendersi cura) costituisce specificamente l'unicità e l'identità dei Campi Flegrei, che non sono il prodotto definito una volta per tutte, non rappresentano l'immagine di uno stato dell'arte, ma costituiscono il risultato concreto e tangibile di un processo evolutivo e dinamico che ha avuto luogo nel tempo.

La carta della qualità dei servizi ecosistemici culturali evidenzia una distribuzione areale di valori positivi (le aree in verde) che include i quartieri di Mergellina, Fuorigrotta, Bagnoli e Coroglio, la riserva naturale degli Astroni e l'isola di Nisida, il quartiere storico di Rione Terra, il sito della Solfatara, i laghi Averno e Lucrino. Ad ovest di Pozzuoli, i valori sono positivi nel comune di Bacoli, in prossimità del golfo di Baia e di Capo Miseno, di Monte di Procida e nel tratto costiero da Cuma a Licola. Diversamente dalla costa, nei comuni di Quarto, Giugliano, Marano, Villaricca e nella parte interna del comune di Pozzuoli si evidenziano livelli molto bassi (le aree in rosso). Nella parte territoriale intermedia si registrano valori medi e mediobassi che interessano i quartieri napoletani di Cavalleggeri d'Aosta, Agnano, Soccavo e Pianura.

Nonostante la pressione antropica, i Campi Flegrei restano una delle realtà territoriali più importanti del Mezzogiorno d'Italia. La presenza di servizi ecosistemici di supporto e di servizi ecosistemici culturali costituiscono una grande risorsa per la popolazione che vi abita e per i moderni "viaggiatori" che, come accadeva tra Settecento e Ottocento, si aspettano ancora di poter apprezzare le vestigia del passato e poter rivivere attraverso l'opera d'arte il patrimonio tradizionale di miti raccontati da poeti o di aneddoti riportati dagli storici.

Per trasformare le potenzialità del territorio flegreo in concrete opportunità di sviluppo è auspicabile però il contributo della pianificazione territoriale, al fine di implementare il sistema di accessibilità e di connettività

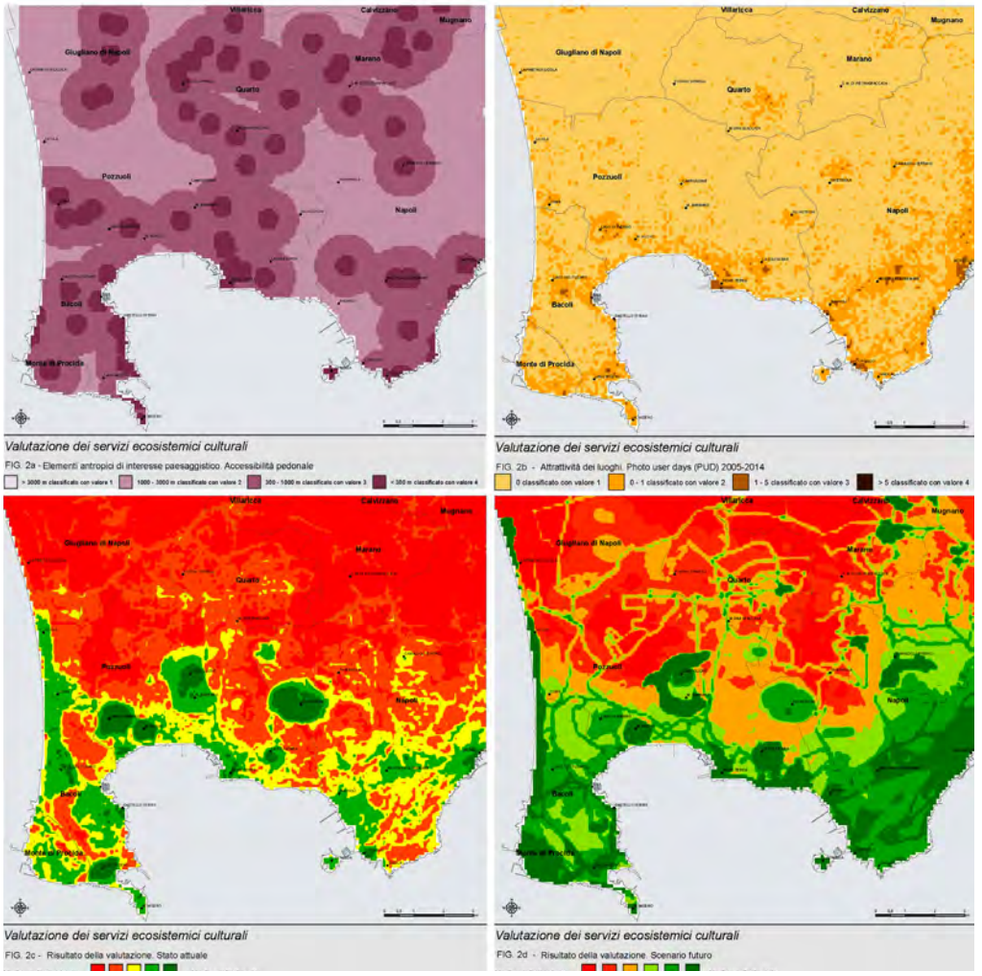


Figura 2– Attrattività dei luoghi (a, b) e valutazione dei servizi ecosistemici culturali (c, d)

territoriale, nonché di progettare la riqualificazione di aree depresse.

## Azioni d'indirizzo del PTCP ed analisi di scenario

Nel presente lavoro si è deciso di applicare InVEST per valutare lo stato attuale dei servizi ecosistemici culturali e per verificare come e quanto alcune scelte di piano potranno in futuro migliorare o non migliorare il territorio flegreo. A tale scopo, è stata valutata la qualità dei servizi ecosistemici culturali nella proposta di PTC della Città Metropolitana di Napoli.

Nel disegno complessivo del Piano riveste particolare rilevanza lo sviluppo di una rete di naturalità diffusa da perseguire ampliando le aree del parco Regionale dei Campi Flegrei ed individuando nuove aree protette, tra cui il nuovo Parco Liternum che include il Lago Patria, gli scavi archeologici di Liternum, le pinete costiere residue, la fascia dunale restaurata, Cuma, il lago del Fusaro e la Casina Vanvitelliana. La proposta di Piano punta ad una riqualificazione del paesaggio costiero attraverso una delocalizzazione edilizia e residenziale verso l'interno cui dovrebbe accompagnarsi, incrementando il trasporto su ferro, un miglioramento dei servizi e delle infrastrutture costiere. Verrebbe in tal modo a formarsi una sorta di città lineare lungo una nuova ferrovia metropolitana, parallela al litorale, articolata in due poli principali che conviva con il sistema agricolo residuo in un paesaggio costiero rinnovato (Fralliciardi, 1999). In particolare, sono stati presi in considerazione, per lo scenario futuro, le Norme di attuazione del PTC, che prevedono (Capo V): l'ampliamento delle aree ad elevata naturalità (art. 33), delle aree boscate (art. 34) e delle aree agricole ordinarie (art. 49) e a rilevanza paesaggistica (art. 47); la riqualificazione di aree da bonificare (art. 61); la valorizzazione dei centri e dei nuclei storici (art. 38); il consolidamento delle infrastrutture per la mobilità (art. 62).

Il risultato della valutazione è costituito da due carte, la prima relativa allo "stato attuale" (Fig. 2c) e la seconda alla "scenario futuro" (Fig. 2d), che illustra il decisivo miglioramento dell'attrattività lungo la fascia costiera da Mergellina a Capo Miseno. Gli assi strategici delineati nella proposta PTC disegnano un contesto metropolitano fortemente connesso ed articolato in un sistema di nodi e di reti che include il patrimonio culturale, ambientale e infrastrutturale in un sistema unico ed integrato, tale da rafforzare i valori identitari, l'attrattività e l'abitabilità.

L'utilizzo di approcci modellistici basati sull'analisi spaziale quali-quantitativa dello stato dei servizi ecosistemici fornisce informazioni consistenti e rilevanti per supportare il processo decisionale e per garantire, di conseguenza, un uso sostenibile delle risorse alle differenti scale territoriali.

## Conclusioni

Nel corso degli anni sono stati implementati molteplici modelli di pianificazione che si sono evoluti in schemi sempre più eterogenei con il principale obiettivo di mettere in rete e preservare la funzionalità degli spazi agricoli, naturali e antropici.

Gli interventi di gestione degli ecosistemi spesso hanno effetti sconosciuti e imprevedibili su altri ecosistemi; di conseguenza i possibili impatti hanno bisogno di un attento esame. Questo può richiedere nuovi modi di organizzazione tra le istituzioni coinvolte nel processo decisionale. La proposta di PTC della Città Metropolitana di Napoli per i Campi Flegrei si muove proprio in questa direzione e potrebbe essere utile inserire in futuro anche la valutazione dei servizi ecosistemici, che consente di mettere in gioco non soltanto i diversi usi del suolo, ma le relazioni ed i flussi dei differenti servizi per tutelare l'ambiente e migliorare la qualità della vita.

In questo lavoro è stato sperimentato il modello InVEST, che offre la possibilità di analizzare i servizi ecosistemici e rendere manifesti a priori, attraverso l'elaborazione di scenari, gli effetti derivanti dell'attuazione dei piani, con ricadute positive in termini di comunicazione e gestione dei conflitti.

Tuttavia, ad oggi, non esistono ancora procedure chiare per strutturare l'integrazione dei servizi ecosistemici nel processo decisionale. In Italia l'interesse del mondo della pianificazione verso questo tema è stato di recente attestato da una pubblicazione dell'ISPRA (2016) dal titolo "Consumo di suolo, dinami-

che territoriali e servizi ecosistemici", mentre in altre parti del mondo la valutazione dei servizi ecosistemici è già inclusa nei processi di piano, come in Canada, Portogallo, Germania, Australia, Sudafrica.

Il tema dei servizi ecosistemici può costituire una sfida importante per la pianificazione perché, da una parte, mette in gioco strategie conoscitive ed interpretative interdisciplinari capaci di superare lo specialismo e la settorialità della scienza moderna, e dall'altra, pone in discussione la tradizionale lettura del territorio prediligendo un approccio integrato ai problemi ambientali, come auspicato dalla Unione Europea e dalle Direttive internazionali sull'ambiente.

L'ecosistema può essere compreso soltanto nell'interazione tra processi ecologici, aspetti culturali e di uso delle risorse, conservazione della memoria tra comunità e luoghi. È necessario, pertanto, un metodo che aiuti a pensare la complessità del reale, invece di dissolverla e di mutilarla: come ha evidenziato Edgar Morin il modo di vedere le cose è più importante del cambiamento delle idee.

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# Il ruolo dei servizi ecosistemici di regolazione in un contesto regionale

Maddalena Floris, Daniela Ruggeri

## Introduzione

Gli ecosistemi contribuiscono al benessere umano attraverso i servizi ecosistemici (SE). Costantemente l'uomo modifica il territorio per soddisfare le proprie necessità; tuttavia, i cambiamenti talvolta possono determinare conseguenze irreversibili sulle risorse naturali (Aretano *et al.*, 2013). I cambiamenti dell'uso dei suoli agiscono sulle proprietà fisiche e chimiche dei suoli e provocano effetti rilevanti sui SE; di conseguenza, la comprensione degli effetti dei cambiamenti degli usi dei suoli sono decisivi.

La Rete Natura 2000, istituita ai sensi della Direttiva Habitat, garantisce, attraverso la conservazione degli habitat naturali e semi-naturali, della flora e della fauna selvatiche, il mantenimento della biodiversità nel territorio europeo degli Stati membri. Tuttavia, nonostante le grandi superfici occupate dai siti della Rete Natura 2000, spesso questi non riescono ad essere elementi di sviluppo dei territori, ma sono percepiti in gran parte esclusivamente come vincoli; inoltre sebbene la valutazione dei SE possa facilitare l'accettazione della Rete Natura 2000, raramente la ricerca si è focalizzata sui SE (Blicharska et al., 2016).

In questo contributo si analizza la distribuzione di due servizi di regolazione: il sequestro di carbonio e la purificazione dell'acqua nel contesto regionale della Sardegna; al fine di approfondire la relazione tra SE e Rete Natura 2000.

La conoscenza della distribuzione potenziale e la quantità di SE è infatti cruciale e può essere determinante nel processo decisionale, al fine di sviluppare un nuovo approccio pianificatorio che sia la chiave per lo sviluppo regionale sostenibile.

## I benefici offerti dagli ecosistemi

Gli ecosistemi terrestri forniscono all'uomo benefici materiali e immateriali definiti "servizi ecosistemici" della cui tutela si occupa la Strategia Europea per la biodiversità fino al 2020, che promuove l'ambizioso obiettivo di «porre fine alla perdita di biodiversità e al degrado dei servizi ecosistemici nell'UE entro il 2020 e ripristinarli nei limiti del possibile». Il Common International Classification of Ecosystem Services (CICES), individuato al fine di garantire un approccio omogeneo nella valutazione e nella mappatura dei SE in tutti i Paesi dell'Unione Europea, identifica tre diverse classi di servizi, tutte di fondamentale importanza per il benessere umano:

- servizi di approvvigionamento, che forniscono i beni veri e propri, quali cibo, acqua, legname e fibre;
- servizi di regolazione, che regolano il clima e le precipitazioni, l'acqua (ad es. le inondazioni), i rifiuti e la diffusione delle malattie;
- servizi culturali, relativi alla bellezza, all'ispirazione e allo svago che contribuiscono al nostro benessere spirituale.

La Rete Natura 2000, che ricopre oltre il 18% (1) del territorio dell'Unione Europea, rappresenta una pietra miliare nelle politiche europee di tutela dell'ambiente, garantisce la conservazione della biodiversità per le generazioni future, contribuisce ad aumentare la resilienza non solo delle aree sottoposte a tutela ma anche di quelle limitrofe e assicura una vasta gamma di vantaggi socio-economici attraverso i SE. I siti appartenenti alla Rete contribuiscono infatti a mitigare i cambiamenti climatici riducendo la percentuale di anidride carbonica nell'atmosfera, svolgono un ruolo importante nella regolazione dei flussi idrici, contribuiscono a purificare e trattenere l'acqua, forniscono alimenti e materie prime, ospitano specie importanti per l'impollinazione e danno ampie possibilità per le attività turistiche e di ricreazione; pertanto è di fondamentale importanza valutare in che misura questi servizi vengono forniti (Duràn *et al.*, 2013). Questi benefici contribuiscono in modo diretto (servizi ecosistemici di approvvigionamento e culturali) e in modo indiretto (servizi di regolazione) al benessere umano. Il riconoscimento dei benefici offerti dai Siti può incentivare atteggiamenti di supporto alla Rete Natura 2000 e contribuire all'integrazione delle aree protette nello sviluppo territoriale e nella pratica pianificatoria (European Union, 2013).

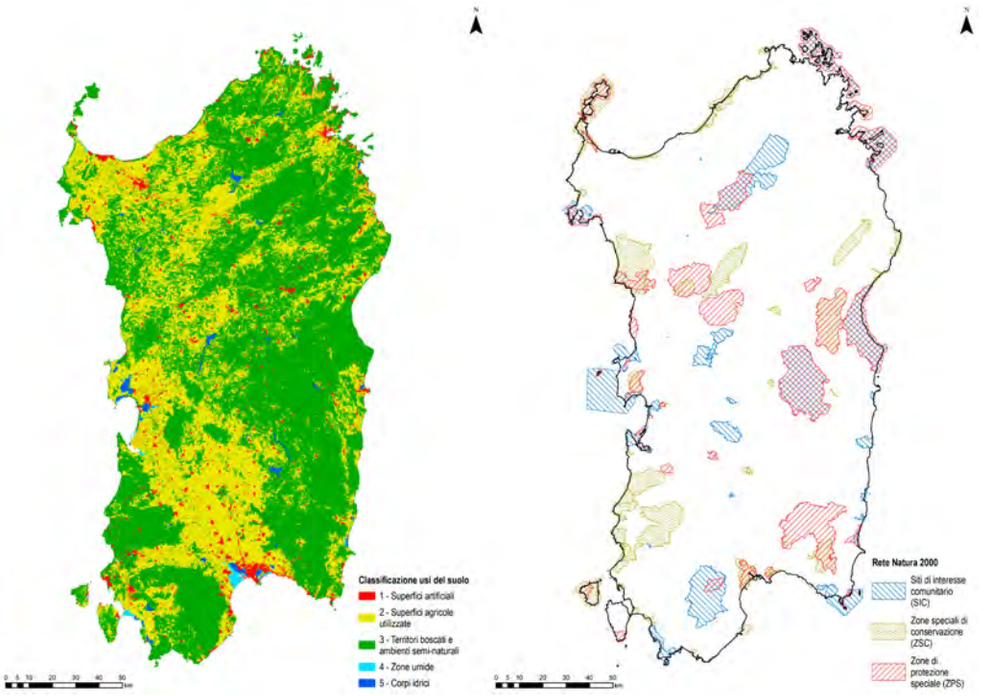


Figura 1 - A sinistra, la carta dell'uso dei suoli della Sardegna, aggiornata al 2008; elaborazione su dati di SardegnaGeoportale (3). A destra, I siti della Rete Natura 2000 in Sardegna, elaborazione su dati European Environment Agency (4).

## Analisi di due servizi di regolazione nel contesto regionale della Sardegna

*L'ambito di studio*

Il caso di studio analizzato coinvolge tutto il territorio regionale della Sardegna, situata al

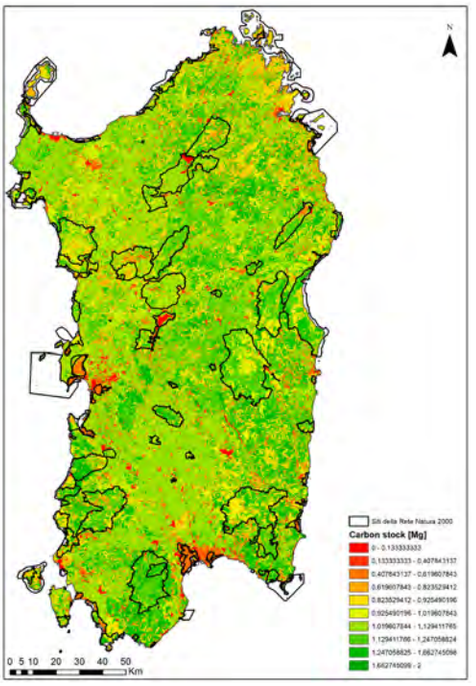


Figura 2- La mappa dello stoccaggio di CO2 generata con il modello Carbon Storage e Sequestration.

centro del Mar Mediterraneo, che si estende per circa 24.000 km² e in cui risiedono oltre 1.650.000 abitanti.

Dal punto di vista dell'uso dei suoli, attraverso lo strato informativo della Carta dell'uso dei suoli (

Figura 1, a sinistra) della Regione Autonoma della Sardegna si può osservare la distribuzione degli usi delle superfici nel contesto regionale. Il 3,2% è identificato in "Superfici artificiali", il 38,3% in "Superfici agricole utilizzate", il 57,3% in "Territori boscati e ambienti semi-naturali", lo 0,4% in "Zone umide" e lo 0,8% in "Corpi idrici". Le "Superfici artificiali" sono prevalentemente distribuite nelle aree costiere (in cui i maggiori nuclei si ritrovano nell'area metropolitana di Cagliari e nei contesti di Sassari, Olbia e Oristano), mentre le "Superfici agricole" si concentrano prevalentemente negli ambiti pianeggianti tra il cagliaritano e l'oristanese e in generale nel settore occidentale dell'Isola.

All'interno del territorio regionale sono stati identificati 124 siti della Rete Natura 2000 (

Figura 1, a destra), che occupano complessivamente circa il 32,3% della superficie: 31 siti di tipo A, costituiti dalle Zone di Protezione Speciale (ZPS), 87 siti di tipo B, ossia Siti di Interesse Comunitario (SIC) e 6 siti di tipo C, in cui i siti di tipo A e di tipo B coincidono (2). Degli 87 SIC, 56 sono stati designati in Zone Speciali di Conservazione (ZSC) con Decreto del Ministero dell'Ambiente del 07/04/2017. Tutti i siti sono inquadrabili nelle caratteristiche tipiche della regione biogeografica mediterranea e al loro interno le tipologie di habitat di interesse comunitario individuate sono 61, di cui 14 sono habitat prioritari.

*Il servizio ecosistemico di sequestro di carbonio*

Gli obiettivi e i vincoli sulle emissioni di biossido di carbonio ($CO_2$) imposti dalle politiche sul cambiamento climatico, hanno spinto la comunità scientifica verso l'individuazione di opportuni processi per la riduzione del $CO_2$ contenuto in atmosfera. Allo stato attuale delle conoscenze, la riduzione del $CO_2$ può essere raggiunta attraverso la combinazione di tecniche di contenimento delle emissioni e tecniche di sequestro, così come riconosciuto dal protocollo di Kyoto. Tra i processi di sequestro, uno viene fornito dal ciclo di accrescimento dei vegetali: questo consiste in un meccanismo naturale attraverso il quale il $CO_2$ presente in atmosfera viene prelevato e stoccato nella biomassa vegetale e nel suolo sotto forma di carbonio organico. Il suolo, base vitale per gli ecosistemi terrestri, svolge un ruolo fondamentale nel ciclo globale del carbonio fornendo quasi tre quarti delle scorte di carbonio dei biomi terrestri (Edmondson *et al.*, 2014). Il suolo rappresenta infatti la più grande riserva di carbonio organico (Lal, 2004), oltre che la più influenzabile dall'azione umana. Pertanto, l'uso sostenibile del suolo, quale bene comune e risorsa non rinnovabile, svolge un ruolo chiave nelle politiche di mitigazione dei cambiamenti climatici e dei loro impatti. Questa funzione è esercitata da tutti i suoli, ma in misura differente in relazione alla perdita di naturalità indotta dai cambiamenti di uso del suolo. L'impatto dei cambiamenti di uso e copertura del suolo sul servizio è massimo nei contesti territoriali caratterizzati da un elevato grado di naturalità (Assennato *et al.*, 2015).

La misura del carbonio stoccato nel suolo è legato alla dimensione di quattro serbatoi di carbonio:

- la biomassa epigea, include l'insieme dei tessuti che costituiscono le parti aeree degli organismi vegetali viventi (fusti, rami e ceppaie, inclusa la corteccia, foglie, semi e frutti);
- la biomassa ipogea, include gli apparati radicali di organismi vegetali viventi;
- la necromassa e lettiera, include i residui vegetali legnosi più grossolani e residui più fini (foglie, fiori ed infiorescenze, frutti ed infruttescenze, rametti, etc.) non ancora decomposti;
- il suolo, include gli strati organici e minerali e le radici più fini.

## La valutazione del sequestro di carbonio

Per la valutazione e la spazializzazione del servizio di stoccaggio del $CO_2$ nel suolo ci si è avvalsi del modello Carbon Storage and Sequestration del software InVEST (6), sviluppato da Natural Capital Project. La stima è basata sulla spazializzazione del valore dei Mg di carbonio organico stoccati per tipologia d'uso/copertura del suolo (NCP, 2015).

Il modello Carbon Storage and Sequestration richiede come dati di input la carta dell'uso del suolo in formato raster e una tabella riportante per ogni classe Land Use/Land Cover (LULC) l'informazione del carbonio espressa in Mg/ha.

Nel caso di studio del territorio regionale della Sardegna i dati utilizzati sono:

- la Carta dell'uso dei suoli della Sardegna in formato raster, che costituisce un database geografico delle coperture dei suoli della Sardegna, classificata con i codici CLC fino al quinto livello (8);
- la tabella delle classi Land Use/Land Cover (LULC) contenente i dati sul carbonio (Mg/ha) immagazzinato in ciascuno dei quattro serbatoi di carbonio per ogni classe LULC. Il dataset di input per i quattro serbatoi, con l'esclusione di quello relativo alla biomassa ipogea, di cui non si hanno dati a livello regionale, è composto dai dati prodotti nell'ambito del progetto della Regione Sardegna "Carta delle unità delle terre e della capacità d'uso dei suoli - Primo Lotto" (2011-2013), dai dati contenuti negli archivi storici delle stesse istituzioni in occasioni di altri studi e rilevamenti (2) e dell'Inventario Nazionale delle

Foreste e dei Serbatoi Forestali di Carbonio (Gasparini *et al.*, 2014).

Il modello genera una mappa per ogni serbatoio di carbonio in cui ogni pixel contiene l'informazione espressa in Mg di carbonio stoccato; una successiva elaborazione in ambiente Gis genera una mappa complessiva del contenuto di carbonio nel territorio regionale della Sardegna (Figura 2).

In corrispondenza del colore verde scuro si riportano i suoli con alta capacità potenziale di stoccare carbonio, in rosso si riportano i suoli che hanno bassa capacità potenziale di stoccare carbonio. Tra tutti i suoli, quelli appartenenti alla classe "Territori boscati e ambienti semi-naturali" hanno maggiore capacità di stoccare carbonio; per contro i suoli appartenenti alla classe "Superfici artificiali" e "Corpi idrici" hanno valori minimi.

Dall'elaborazione spaziale emerge il ruolo importante delle aree protette per il mantenimento del SE di stoccaggio del $CO_2$ nel suolo, infatti circa il 15,2% del totale del carbonio terrestre è stoccato nelle aree protette (Campbell *et al.*, 2008). Emerge inoltre che i siti ricadenti nelle classi CLC "Territori boscati e ambienti semi-naturali", "Superfici agricole" e "Zone umide" con il loro alto potenziale di stoccare carbonio, contribuiscono a ridurre il contenuto di $CO_2$ in atmosfera e a mitigare i cambiamenti climatici (European Union, 2013).

La conoscenza delle funzioni rese dal suolo per lo stoccaggio di $CO_2$ consente inoltre di individuare quegli stock di carbonio attualmente conservati al di fuori dei siti della Rete Natura 2000, sui quali si dovranno concentrare le future strategie di gestione e pianificazione dell'uso del suolo.

Il modello, che si basa sulla spazializzazione del valore assoluto dei Mg di $CO_2$ stoccati per tipologia d'uso/copertura del suolo, per una maggiore affidabilità dell'output necessita di misurazioni dirette, in continuo aggiornamento e di scale di analisi appropriate all'ambito territoriale di riferimento, al fine di limitarne l'errore di valutazione e mappatura dovuto alle approssimazioni e assimilazioni talvolta necessarie per sopperire alla carenza dei dati.

*Il servizio ecosistemico di purificazione dell'acqua*

L'acqua è un elemento essenziale per la vita e la sua qualità ha conseguenze per il benessere delle persone e dell'ambiente in generale in numerosi campi: per l'uso potabile, per gli scopi ricreativi o legati alle attività di pesca, per la vita degli ecosistemi. La stretta relazione tra l'acqua e il territorio sono state riconosciute e indagate sin dai tempi degli antichi greci (Lassen *et al.*, 1952).

In questo studio il SE di purificazione dell'acqua viene analizzato in riferimento alla ritenzione dei nutrienti, in particolare l'azoto. L'azoto è essenziale per la crescita degli organismi e per questo viene definito "nutriente"; è il principale regolatore delle condizioni funzionali ed ecologiche della biosfera, nonché il principale costituente dell'aria dell'atmosfera terrestre.

A causa delle attività antropiche, nell'ultimo secolo il ciclo naturale dell'azoto si è alterato in maniera significativa, determinando gravi squilibri nei sistemi ambientali: eutrofizzazione dei corpi idrici, presenza di ossidi di azoto nelle emissioni gassose, degradazione della qualità delle acque sotterranee (Breuer *et al.*, 2008), con effetti sulla biodiversità non ancora stimabili. I carichi di azoto possono essere presenti sia come fonti puntuali, come aziende di allevamento o aree di stoccaggio di alimenti, che come fonti diffuse, le aree urbane e le zone industriali, le aree destinate al pascolo, le aree agricole.

Con la Direttiva 91/676/CEE l'Unione Europea pone l'accento sul tema dell'inquinamento da nitrati, definendolo come «lo scarico effettuato direttamente o indirettamente nell'ambiente idrico di composti azotati di origine agricola, le cui conseguenze siano tali da mettere in pericolo la salute umana, nuocere alle risorse viventi e all'ecosistema acquatico, compromettere le attrattive o ostacolare altri usi legittimi delle acque». Successivamente, con la Direttiva 2000/60/EC si riconosce la crescente pressione sulle risorse idriche, sia in termini di sfruttamento che in termini di inquinamento, nonché la necessità di una politica di tutela delle acque. A tal fine, l'identificazione delle aree a maggior fornitura di questo servizio di regolazione diviene determinante e prioritario.

## La valutazione della purificazione dell'acqua

Il servizio di purificazione dell'acqua è naturalmente fornito dagli ecosistemi per mezzo di filtrazione, infiltrazione, assorbimento o deposizione di sedimenti, nutrienti, pesticidi e inquinanti in generale (Zhang *et al.*, 2010), depurando il deflusso idrico prima che possa raggiungere i corsi d'acqua. Tutte le acque, sia superficiali che sotterranee, hanno una certa capacità di reagire all'immissione diretta ed indiretta di carichi inquinanti; tuttavia, se l'immissione delle sostanze inquinanti è eccessiva, si supera la capacità autodepurativa dei corpi idrici, per cui si evidenziano fenomeni quali la eutrofizzazione e/o la contaminazione chimica e microbiologica.

Al fine di individuare nel territorio le aree che hanno una maggiore potenzialità di fornire questo SE, si è utilizzato il software InVEST (6), in particolare il modello Nutrient Delivery Ratio (NDR), che stima la ritenzione di azoto e fosforo legata al deflusso superficiale e sotterraneo. Il modello simula il movimento nello spazio di masse di acqua contenente nutrienti fino al raggiungimento dei corsi idrici, tenendo conto delle sorgenti puntuali e diffuse presenti sul territorio. Il concetto principale del modello è che ciascun elemento del bacino idrico è caratterizzato da uno specifico carico di nutriente e da un coefficiente di trasporto, funzione della pendenza, nonché da una particolare efficienza di ritenzione propria del tipo di copertura del suolo (NCP, 2015).

In questo studio il nutriente considerato è l'azoto e viene fatto riferimento ai soli bacini idrici superficiali. Si considera una definizione spaziale delle sorgenti di nutrienti come caratteristica potenziale legata alla tipologia di copertura di suolo.

Il modello NDR necessita dei seguenti dati di input:

- un modello digitale del terreno, in formato raster, contenente un valore di elevazione per ogni cella. Il modello digitale utilizzato è disponibile nel Geoportale della Sardegna (7);
- una carta dell'uso dei suoli, in formato raster. Si utilizza la Carta dell'uso dei suoli della Sardegna (8), con classificazione Corine Land Cover al terzo livello;
- la rappresentazione del deflusso potenziale, in formato raster. A partire dalle misurazioni di precipitazione delle stazioni

pluviometriche distribuite in tutto il contesto regionale, il deflusso potenziale viene elaborato con metodo geostatistico (Phillips *et al.*, 1992). La purificazione dell'acqua aumenta con una diminuzione delle precipitazioni, corrispondente a un dilavamento ridotto (Terrado *et al.*, 2014);

- i bacini idrici superficiali, in formato shape. I bacini sono elaborati in base alla definizione spaziale riportata negli elaborati del Piano di gestione del distretto idrografico della Sardegna (9);
- la relazione tra gli usi dei suoli e i carichi di nutrienti, in formato tabellare. In analogia a studi approfonditi in altri contesti territoriali (Bachmann Vargas, 2013), nella tabella biofisica in corrispondenza di ciascuna classe di uso dei suoli vengono riportati dei valori potenziali di carico di azoto prodotto, efficienza di rimozione dell'azoto e massima distanza di ritenzione per ciascuna classe.

Il modello NDR genera una mappa di esportazione dell'azoto: ogni pixel contiene l'informazione sulla quantità di nutriente che, eventualmente, può raggiungere il corso d'acqua. La mappa riportata in Figura 3 rappresenta i contributi della vegetazione e del suolo alla purificazione dell'acqua attuata dal deflusso superficiale attraverso la rimozione degli inquinanti. La suscettività alla purificazione dell'acqua di alcuni contesti territoriali è così messa in evidenza. In particolare, in corrispondenza del colore verde scuro la purificazione dell'acqua è maggiore e i valori di esportazione sono bassi, in quanto il nutriente presente nel deflusso idrico viene trattenuto dalla vegetazione, nel suolo o imbrigliato nelle aree umide. Per contro, in corrispondenza del colore rosso la purificazione dell'acqua è minore e i valori di esportazione sono alti, in quanto grosse quantità di nutriente presente nel deflusso idrico non vengono intercettate e possono raggiungere i corsi d'acqua.


Figura 3 - La mappa dell'esportazione dell'azoto generata utilizzando il modello NDR.

Il modello presenta alcune criticità legate soprattutto ai numerosi dati in input difficilmente misurabili, all'elevata sensibilità alle variazioni dei dati stessi e alle stime sui dati che compongono la tabella biofisica.

Tuttavia, nonostante le numerose approssimazioni determinate dalle semplificazioni assunte, questa analisi consente di identificare i contesti che presentano le maggiori potenzialità in termini di fornitura del SE di purificazione dell'acqua, nonché quelli più critici. La mappa mette in evidenza il ruolo svolto dai siti della Rete Natura 2000: la gran parte dei siti, e le aree che li circondano, contengono valori elevati nella ritenzione dei nutrienti, quindi potenzialmente hanno un peso importante per la fornitura di questo SE. Questo dato conferma che le aree protette rappresentano una sorgente insostituibile di naturalità, capace di fornire elevati livelli di SE (ISPRA, 2014).

## Conclusioni

La crescente richiesta di materie prime e energia crea una pressione sempre maggiore sugli ambienti naturali (Cumming *et al.*, 2014) e, nonostante l'istituzione di numerose aree protette, l'indice di perdita di biodiversità sembra non arrestarsi (Butchart *et al.*, 2010). Per superare queste difficoltà sono necessarie soluzioni di gestione innovative nonché l'integrazione dei SE nelle politiche e nei processi decisionali (Guerry *et al.*, 2015). Le recenti strategie e politiche europee sulla gestione e conservazione dell'ambiente sottolineano la consapevolezza dell'importanza delle relazioni tra i cambiamenti negli ecosistemi e le conseguenze dirette e indirette sulla fornitura di SE (Haslett *et al.*, 2010); eppure l'effettiva importanza dei SE nella definizione delle decisioni pianificatorie è ancora notevolmente limitata (Barò *et al.*, 2016). L'aspettativa tra i policy-makers e scienziati è che le strategie di conservazione e mantenimento della biodiversità forniscano dei benefici anche in termini di SE. (Eigenbrod *et al.*,2009).

Recentemente l'interesse per l'analisi e la mappatura dei SE nelle pratiche pianificatorie, sia a livello urbano che a livello rurale, sta aumentando. L'analisi qui proposta costituisce un input al percorso di accrescimento delle conoscenze che devono essere riconosciute come essenziali nel processo pianificatorio a qualunque livello; esse suggeriscono la presenza di correlazioni tra biodiversità e SE analizzati (stoccaggio di carbonio e purificazione dell'acqua) a conferma che le aree protette sono fonte di biodiversità e fanno parte delle aree più produttive di SE (ISPRA, 2011). L'esempio discusso, relativamente al caso regionale della Sardegna, permette di individuare la distribuzione delle aree strategiche per la fornitura dei SE di sequestro di carbonio e di purificazione dell'acqua e costituisce uno strato informativo importante per la definizione delle strategie pianificatorie regionali, al fine di assicurare maggiormente un uso sostenibile delle risorse naturali. Tuttavia, emerge anche l'evidente criticità per cui non sempre si hanno a disposizione i dati necessari per questo tipo di analisi nel breve lasso di tempo in cui è necessario prendere le decisioni nel processo pianificatorio (Trepel *et al.*, 2002), conseguentemente semplificazioni e approssimazioni sui dati disponibili diventano necessarie.

La riflessione tenta di definire un percorso di accrescimento delle conoscenze territoriali basato su un approccio ecosistemico fondamentale per il mantenimento dei SE; la loro quantificazione e distribuzione è infatti essenziale affinché questi possano essere integrati nei processi di pianificazione territoriale (Grasso *et al.*, 2010).

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1. http://ec.europa.eu/environment/nature/natura2000/index_en.htm
2. https://portal.sardegnasira.it/sic-e-zps.
3. http://www.sardegnageoportale.it/index.php?xsl=2420&s=40&v=9&c=14480&es=6603&na=1&n=100&esp=1&tb=14401.
4. Progetto realizzato da Agris Sardegna per l'area Muravera-Castiadas; Laore Sardegna per l'area Arzana e Nurra sud; da UNICA per l'area Pula-Capoterra e da UNISS per l'area Nurra nord e Nurra sud e finanziato dall'Assessorato EE.LL. Finanze e Urbanistica della Regione Autonoma della Sardegna.
5. http://natura2000.eea.europa.eu/#.
6. Sviluppato dal progetto Natura Capital Project (NCP), disponibile all'indirizzo http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/.
7. http://www.sardegnageoportale.it/areetematiche/modellidigitalidielevazione/.
8. La carta dell'uso dei suoli della Sardegna è aggiornata al 2008, in scala 1:25000, ed è disponibile all'indirizzo http://www.sardegnageoportale.it/index.php?xsl=2420&s=40&v=9&c=14480&es=6603&na=1&n=100&esp=1&tb=14401.
9. Disponibile all'indirizzo: http://www.regione.sardegna.it/index.php?xsl=509&s=1&v=9&c=10460&tb=6695&st=7&tb=6695&st=7.

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# Modelling regulation services of green scenarios to support climate adaptation plans. An example of urban regeneration in Bari

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**Abstract**

Nature-based solutions and green infrastructures are a sustainable passive strategy for enhancing thermal comfort of urban environments, reducing the energy demands of buildings and, consequently, carbon emissions. Local attuned climate adaptation plans require spatially explicit acknowledge of green action benefits as the quantification of the air temperature drop at neighborhood scale in dominant summer climates. Given the recent development in computing power, climate modelling has been increasingly used even in urban contexts. However, these modelling approaches have still the drawback of high computational cost and complexity, so their use is often limited to research purposes or/and transdisciplinary collaborations among experts and planners. Moreover, spatially explicit measures of climate regulation services are rarely used to support plans and urban regeneration actions. In this paper, we report an application of the free ENVI-met model to quantify the tempering effect of two green scenarios in Bari city in a typical heat day. The nature-based scenarios are designed in a parking area located in a densely urban district. The greening has also a water regulation function as in the area the storm water runoff is not correctly managed by the current drainage system. In particular, the effect of permeable pavements, grass coverage and tree plantations on the air temperature and the PMV thermal comfort index are evaluated. A modified synthetic form of PMV is then proposed as microclimate regulation service indicator supporting planning and design process. The paper then aims to display the operational character of ENVI-met model in ES-based planning purposes for the climatic adaptation of cities.

## Introduction

The urbanization and climate change in progress act together pointing out the UHI phenomenon and the even more dangerous summer heat waves. Among the different strategies to increase the resilience of cities to heatwaves and extreme temperatures, there are the so-called Nature-based solutions. NBS, like permeable pavements and tree plantations, can provide flexible, cost-effective and broadly applicable alternatives to cope with the magnitude, speed and uncertainty of climate change (Pelorosso, Gobattoni, and Leone 2016). The wellness status of citizens depends in large part on the microclimatic condition of public and open spaces where people are going to move, meet each other and carry out work and pleasant activities for important part of the day and the night. In those spaces, urban planners can address NBS taking into account their cooling capacity (i.e. their climate regulation services) in order to create conditions for healthy and cool islands within the urban environment. Such actions aim to increase climate adaptation of cities and their planning should take into account the spatial climatic vulnerability of cities. Indeed, people's cooling needs can be different and spatially distributed in the landscape urban pattern. Moreover, each NBS has a different cooling capacity that varies in function of the local conditions and the interaction with the other natural and anthropogenic structures present in the site. Several studies have highlighted the relations between wind, exposition, albedo, NBS size and combinations, canyon effect and so on. Since the complexity of such interrelation, spatially explicit measures of climate regulation services are rarely used to support plans and urban regeneration actions. Urban planners can adopt different ways to carry out the NBS planning and the consequent green infrastructure creation. Practice planning frameworks of urban green infrastructures aimed to climate adaptation have been presented by some urban planners (e.g. Norton et al. 2015; Zardo et al. 2017). Such methods are based on the data reported by scientific literature about the cooling capacity of NBS and green areas in different conditions. The proposed planning frameworks therefore discuss how to strategically plan NBS in the different urban context and different urban morphologies

considering for example a mean cooling effect. Another strategy to support urban planning is based on environmental modelling. Indeed, modelling allows system complexity to be investigated by analysing the energy and matter fluxes underlying environmental and territorial processes at different temporal and spatial scales. Models could allow planners to understand the general behaviour of the system and, consequently, to decide strategic proposals in terms of land use with respect to the considered processes (Pelorosso, Gobattoni, and Leone 2017). Modelling of cooling effect of NBS is nowadays even more easy thanks to the development of software (also free and open source) and low cost high-performance hardware. The main advantage of modelling is the possibility to simulate very specific contexts and NBS arrangements, pointing out a quantitative measure of their environmental performance. On the other hand, the complexity of models needs specific expertise that must be integrated in the planning process. Indeed, the definition of research (planning) objectives is fundamental for the model setting and the selection of useful output avoiding then useless and expensive elaborations that, for example, point to unnecessary information details. Moreover, several issues related with the scale of simulation and calibration need to be considered to obtain meaningful results. These difficulties have limited the spreading of modelling approaches in common urban planning practice. This paper aims to give a contribute to the planning approach based on the modelling of cooling capacity of NBS. In particular, we present a ENVI-met implementation (one of the most used software for urban micro-climatic simulations) on a densely urban context to show the potential operational character, as well as the limits, of this modelling approach to provide synthetic information for planning decisions. Four scenarios of NBS are then simulated considering different arrangements among tree plantations and permeable pavements. The scenarios have been compared in terms of two model output (air Temperature and PMV index).

The objectives of this work are then: 1) to identify the best NBS arrangement among those proposed in terms of cooling capacity; 2) to propose model-based indicators of microclimate regulation services by NBS able to support urban climate adaptation planning.

## Material and methods

The study area is located in the Bari Municipality in a densely populated urban district (II Municipio) (Fig. 1). Meteorological data in the last fifty years show an increase of the heat weave intensity with the higher value of 44.8 C° registered in 1994. In particular, the model simulation of NBS has been realised on a parking area of around 2300 m² at the service of the close Santa Maria Hospital. This area was identified as very critical for the mitigation of urban floods and the use of permeable pavements for this parking lot has been indicated as an appropriate urban regeneration action for the reduction of the water runoff and the sewerage network load (Gobattoni, Pelorosso, and Leone 2016; Pelorosso, Gobattoni, Lopez, et al. 2016). In order to evaluate how the green strategies affect the microclimate and outdoor thermal comfort of the study area, ENVI-met version 4.2 was used (Bruse 2017). ENVI-met is a free 3D microclimate model designed to simulate the interactions among buildings, surfaces, vegetation and air in urban environment. It relies on the fundamental laws of fluid dynamics and thermodynamics and it can be used for neighboured urban scale evaluations. The software is able to calculate several meteorological and microclimatic variables and thermal comfort indexes.

The present work focuses on air temperature at pedestrian level and Fanger's Predicted Mean Vote (PMV) index. PMV is one of the most widely used indexes to evaluate outdoor thermal comfort. PMV considers some environment variables as air temperature, mean radiant temperature, relative humidity, wind speed and some operative variables as clothing insulation and metabolic rate (Pelorosso, Gobattoni, and Leone 2016). PMV scale ranges between −4 (very cold) and +4 (very hot) where 0 is the thermal neutral (comfort) value. However, the PMV depends on the local climate and its values can exceed the interval **(−4) ÷ (+4)**. Negative PMV values are possible also in nighttime during hot days.

Beside the scenario base (current situation with only asphalt coverage), three different scenarios of NBS were designed considering a fixed tree plantation (39 *Quercus Ilex* 7 meter high) associated with asphalt, plastic grid pavers and porous concrete pavements, respectively.

ENVI-met works in a three-dimensional environment and the output data are registered for defined time steps (usually 1 hour or less) and for every cell of the simulated system. Thus, higher resolution (minor cell dimension) and larger simulation areas allow more detailed and extended evaluation of the interaction between microclimate and NBS. On the other hand, increasing cell resolutions means increasing the processing time and the amount of information to manage. In this work, we decide to set-up the model with a 2 meters grid resolution and a 3D model area with a base of 55 x 55 cells (110 x 110 meters) (Fig. 1). It is worth to note that the free version only allows simulations under 100 x 100 grids. The simulated heat weave is the one occurred on July 24 2017 with an extreme air temperature of 39 C°. For more details on model settings and NBS scenarios see Galli (2017).

Finally, we proposed the following PMV-based index as synthetic proxy indicator of climate regulation services:

(1)

$$I_{PMV} = \frac{\sum_{h=1}^{24} I_{PMV}^{h}}{24}$$

where

(2)

$$I_{PMV}^{h} = \sqrt{\frac{\sum_{i=1}^{n} PMV_{ih}^{2}}{n}}$$

$PMV_{ih}$ is the PMV index of the *i-th* cell at the hour *h*; *n* is the number of cells at pedestrian level (in this study case 1929 cells). Note that the closer is $I_{PMV}$ to zero the more suitable is the microclimate for people (comfort zone).

## Results and discussions

Figure 2 reports some of the simulation results considering the mean air temperature and PMV differences between scenario base and scenario 3 at pedestrian level. In general, the scenario 3 is resulted the most able to improve the microclimate of the area both in terms of air temperature and PMV. Obviously, several differences of evaluations have been emerged considering night and day hours and discrepancies between scenario

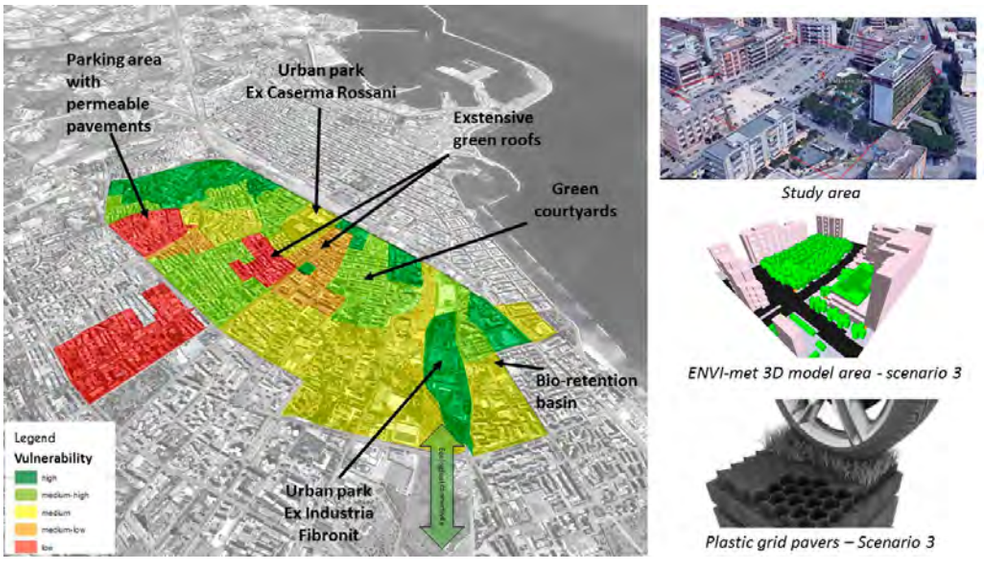


Figure 1- Parking area within hydrological vulnerability map, Envi-met 3D model area and an example of plastic grid paver of scenario 3.

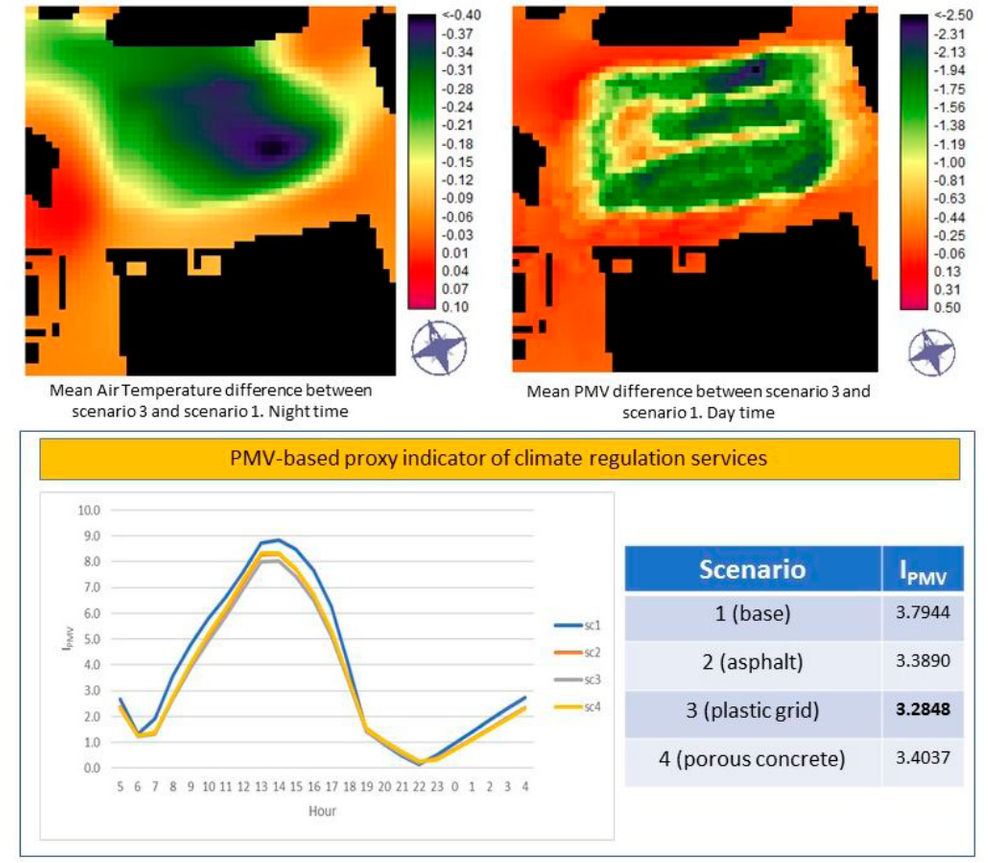


Figure 2 – Some results of the ENVI-met simulations and the PMV-based proxy indicator for climate regulation services

comparisons has been highlighted even if negligible (i.e. decimal points of T and PMV). The proposed PMV-based indicator allows us to identify numerically the best NBS arrangement (see fig. 2). Indeed, the $I_{PMV}$ displays how the scenario 3 (tree plantations on a plastic grid paved) is the most performing solution with respect to the scenario base in terms of thermal comfort perceived by people at pedestrian level both at hourly (eq.2) and daily scale (eq. 1).

The amount of data needs to be carefully managed in order to provide synthetic but significant information to the urban planners. In this case, among the numerous possibilities of representation, we decide to focus on the mean difference between scenarios instead of singular representation of data relative to a specific hour or scenario. Indeed, the latter can add confusion (e.g. the increase in T for some NBS scenario in some hours of the day), be incorrect (no calibration was done) and provide excessive information with respect to the objectives of urban planners. On the other hand, the spatial and temporal data variability generated by models cannot be neglected to improve traditional planning approaches. Synthetic indicators should then embed essential spatial and temporal information and be able to discriminate also small benefit difference among scenarios. Moreover, the comparison among scenarios allows to avoid erroneous evaluations of the singular scenario due to lack of calibration. Indeed, the calibration of model is very important for design objectives but for large areas and in several planning contexts represents a hard challenge. Usually, urban planners focus on spatial data, the definition of actions within ranges of uncertainties and the dialogue with multiple planning variables (e.g. multiple ecosystem services, citizen preferences, policy constrictions). Thus, also meta models and ranks among planning opportunities as the proposed one can be of support in the complex land use decision making process. Obviously, several improvements are still necessary under the modelling framework point of view. Further developments should for example consider the analysis of cooling buffer effects, an increase of simulated days (in order to define an annual $I_{PMV}$ index), the effect of wind intensity and direction. Last but not the least, the investigation of the suitability of model implementation on large areas for wide planning purposes. However, the proposed $I_{PMV}$ index appears as a promising proxy indicators of climate regulation services. Indeed, it has wide transferability at different urban contexts and NBS arrangements, as well as the opportunity to be easily calculated through the free ENVI-met model version.

## Conclusions

NBS are sustainable solutions to adapt cities to climate changes but their effectiveness is location sensitive (EU 2015). Indeed, the socio-ecological complexity of urban structure and the geographic variability of cities require strategies adapted to the local conditions to maximize the NBS effectiveness.

The translation of these notions in urban planning practice seems still inadequate. Models can allow NBS planning and design to be supported on the basis of the optimization of environmental processes (i.e. ecosystems services). Models can allow planners to understand the general behavior of the system and, consequently, to decide the best strategic proposals in terms of land use with respect to the considered environmental and territorial processes (Pelorosso, Gobattoni, and Leone 2016). In particular, climate simulation modelling to support planning and design of NBS is still reduced in planning practice due to difficulties of implementations and necessity of transdisciplinary collaborations among experts and planners. This work, together with others (Gobattoni et al. 2016; Pelorosso, Gobattoni, Lopez, et al. 2016), aims to be a contribute for the integration of modelling evaluation into urban planning and the climate adaptation strategies of cities.

Under the technical point of view, the evolution of the modelling approach is ineluctable considering also the increasing pc calculation power and availability of free (and open) software as well as digital information (i.e. big data, spatial data). The main issue appears to be the translation of these concept in urban planning practice.

The case presented in this study shows that there are instruments to act in this direction, with techniques now consolidated. The advantages are manifold: the system acquires complexity and robustness, the costs are contained, and the traditional green design remains substantially unchanged, while its product is enriched with functions, otherwise called ecosystem services. In the case study, the ability to regulate the urban climate by the urban green (climate regulation service) is evaluated through a reformulation of the PMV indicator of the thermal comfort. This proxy indicator for urban green ecosystem service, as demonstrated by the case study, is able to support planning and design choices through a scenario comparison. This indicator, although not related to direct economic benefits, defines numerically the complexity of climate/land use relationships occurring in urban transformation proposals and, therefore, it can provide an objective criterion of judgement for the realization of interventions. Such ecosystem service indicators derived from the modelling approach can be a key leverage point to move from traditional planning based on normative standards to a more flexible, site-specific one, based on the performance of land use (see also Frew, Baker, and Donehue 2016)and hybrid approaches that rely on a mix of activity based zones in addition to prescriptive and subjective standards. Jurisdictions in the USA, Australia and New Zealand have attempted this type of land use regulation with varying degrees of success. Despite the adoption of PBP legislation in these jurisdictions, this paper argues that a lack of extensive evaluation means that PBP is not well understood and the purported advantages of this type of planning are rarely achieved in practice. Few empirical studies have attempted to examine how PBP has been implemented in practice. In Queensland, Australia, the Integrated Planning Act 1997 (IPA.

The strategic idea should then be to integrate the traditional logic, of plant interventions only, in retrospect, to make the system more robust, through the instrument that supports the plan, the Strategic Environmental Assessment in primis. Ideally, a suitable planning implementation of models appears the general plan of the vast area (the regional and/or provincial coordination plan), which should have the resources to realize the information system, based on the modelling analysis of land uses. The above plan should then make available to local administrations simple and immediate tools (e.g. meta-models derived from the information system, which could also accessible online) to be used at the municipal plan scale. The proposed ENVI-met modelling approach still have some limits that hamper cost-effective, large and rapid implementations. Further research efforts are then required to overcome these technical limits. In the present state of the research, urban regeneration actions and SEA procedures appear the most suitable field to apply the proposed model approach. However, specific study cases within climate adaptation projects would be necessary to investigate real opportunities and resistances for such a model integration in urban planning practice.

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# Is spatial planning taking advantage of Ecosystem services? A review of Italian experiences

Daniele La Rosa

## Introduction

Urban and regional planning have the capacity to induce changes in quality or quantity of Ecosystem Services (ES), by determining a set of development options and regulating how these options are spatially translated in a given territory. Land-use changes and soil sealing can quickly produce severe ecological, economic and political issues or even increase the level of particular type of natural or anthropic hazards, therefore affecting the provision of services by those ecosystems that are directly involved in those changes (Mascarenhas et al., 2015). For this reason, the effects of spatial plans on ES provision and use are perhaps more evident and straightforward than other type and form of planning (Geneletti, 2011). The explicit use of the ES at the level of land-use public urban policies will allow such effects to be considered and evaluated within the entire planning processes.

Despite the growing attention in recent years, the relation between ES and planning is still a fragmented field and many issues still remain unresolved to better integrate the ES concept into current planning process and spatial decision-making (de Groot et al., 2010). One of the many reasons is related to the several available definitions and relative terminology of ES, especially after the boost of its use by scientific disciplines and scientific fields. The concept has become pretty varied, difficult to grasp and being applied in fields that can diverge significantly from its original purpose (Gomez-Baggethun et al., 2010). Diverse and monodisciplinary approaches have therefore make use of ES, focusing on the biophysical (mainly ecological) or the socio-economic aspects. New ES research will require a strong cross-cutting work to better interconnect the social and the ecological dimensions of ES.

For these issues, the use of ES concepts to support real planning decisions and the integration of ES in policies and plans have been reported being poor or limited. The integration of ES concerns in to spatial planning can best be achieved by taking advantage of existing procedures to support plan making, such as strategic environmental assessment (SEA) (Geneletti 2011). SEA of spatial plans can play a role in ensuring ES consideration in planning processes and provide better guarantees that ES are taken into account in planning. However, the integration of ES in SEA has so far been essentially limited to technical reports or seen as a generic environmental objective to reach.

Furthermore, governance of ES requires the inclusion of those actors who understand, manage and benefit from the services, as well as an appropriate knowledge of existing policies, institutional context and planning systems (Opdam et al. 2015). Most of the research does not include (at least explicitly) the views and knowledge of the practitioners and decision-makers who are ultimately the main actors in each specific spatial planning context. This is an important point since ES integration is unlikely to happen if spatial planners are unaware for example of what ES are, what are the benefits of ES integration in the spatial planning process and what tools can be used to achieve such integration.

Furthermore, the recognition of the complex and context- specific nature of environmental decisions, and the centrality of institutional systems in charge of the planning decisions should be carefully analysed at begin of the planning process (Woodruff and BenDor, 2016). Finally, there is a lack of plan quality guidance to incorporates ES. Plan quality guidance should be intended to help all the subjects involved in planning process to improve plans by identifying elements that should be included in plans themselves. Plan quality guidance can also serve as a tool to evaluate the extent to which plans incorporate ecosystem services. To promote the incorporation of ES into spatial planning a greater attention must be placed to understanding by which instruments current plan quality guidance can better incorporate ES (Woodruff and BenDor, 2016).

This paper briefly analyses the state of the art of the use and inclusion of ES in Italian spatial plans, by reviewing in webpages of official public bodies if and that which extent the concept is explicitly used in spatial planning processes.

## A review of spatial planning processes in Italy

For Italian contexts, there are few works that looked at use of ES in planning processes. Lai (2015) analyzed the content of 46 SEA reports about three categories of plans in Sardinia, land use municipal plans, regional plans and management plans of protected areas. The author highlighted that no municipal plans explicitly mentioned the ES and very few SEA

Reports somehow used reference to ES. In a very recent review, Cortinovis and Geneletti (2017), looked to 22 recent municipal land use plans of Italian cities, approved at the regional level since 2012. In those plans, the authors looked at actions that were somehow addressing urban ES. Recreation/cultural and water regulation were the service categories more represented. Interestingly, the authors highlighted that the type and number of planning actions related to ES was much more comprehensive than the list of possible interventions proposed at European level, therefore demonstrating the potential of planning processes to creatively make use of ES. Authors also concluded that the integration of ES in planning practices is proceeding through a sort of "internalization" process that builds on what has been historically subject of the planning tradition and therefore already include planning action that could be related ES.

Similarly, to these previous works, the review here proposed was meant to evaluate the explicit use of the concept of ES in spatial plans for Italy. The review was based on the use of some sets of keywords in Microsoft BING search engine (table 1) to find the planning documents that mentioned the ES concepts in webpages of public administrations in charge of planning. The choice of the web as a broad source to search in was due to the absence of a database or other reference sources of spatial plan considering of Italian plans. It is important to underline that the use of the keywords is intended to look for planning documents/processes that were explicitly referred to ES concept and not to aims or actions that could be somehow related to it. The choice of Italian keywords aimed at looking at spatial plans that could be named in different ways in the different regions, with particular reference to urban municipal plans.

| Set of Keywords | Results (# of web pages found) |
|---|---|
| "servizi ecosistemici" AND "piano" | 481 |
| "piano di governo del territorio" AND "servizi ecosistemici" | 302 |
| "piano regolatore" AND "servizi ecosistemici" | 185 |
| "piano urbanistico comunale" AND "servizi ecosistemici" | 290 |

Table 1 – Set of keywords used (September, 2016)

| Administration | Name of Plan | Role of Ecosystem Services in the Plan |
|---|---|---|
| Comune di Cassalnovo | Studio di Incidenza http://halleyweb.com/c018035/images/vas/VI%20PGT%20Cassolnovo.pdf | Quick reference to European framework for Ecosystem Services |
| Comune di Genova | Piano del Verde | Reference to the ES by urban greenery trees. |
| Comune di Lomello | PGT http://www.lomellopgt.it/index.php?option=com_content&view=article&id=14&catid=2&Itemid=132 | Refernce to Ecosystem Services in the description of the agricultural systems of the municipality |
| Comune di Sesto SG | PGT http://download.sestosg.net/documenti/Governo%20del%20territorio/PGT/PIANO%20DEI%20SERVIZI/Allegato_IV_REC_VAR%20FEB2015.pdf | Reference to Ecosystem Services in the Ecological Network document |
| Parco Delta del PO | Piano di gestione SIC/ZPS Valli di Comacchio http://www.parcodeltapo.it/media/pdf/PdGvalli/Minacce_Obiettivi_strategiaGetione.pdf | Reference to Ecosystem Services for in the plan's document |
| Autorità di Bacino del Fiume PO | Piano di Gestione del Fiume PO | Reference to Ecosystem Services in the plan's document |
| Parco Adda SUD | VAS sul Piano d'Indirizzo Forestale http://www.parcoaddasud.it/portale/images/pdf/PPT%20prima%20di%20VAS%20PAS.pdf | Reference to Ecosystem Services in the norms to be used for forestry planning |
| COMUNE DI LIMONE SUL GARDA Provincia di Brescia | PGT http://www.ilimone.it/pdf/4_documenti%20recepiti%20nel%20pgt/3_rete_ecologica_comunale/12-05-25_relazione_rete-ecologica_limone_sul_garda.pdf | Reference to Ecosystem Services in the Ecological Network document |
| Comune di Fino al Monte (BG) | PGT http://www.comune.finodelmonte.gov.it/upload/fino/PGT/PGT/05_Documento_di_Piano/02_Relazione.pdf | Reference to Ecosystem Services in the Ecological Network document |
| Provincia di Lucca | PTCP (variante) http://www.provincia.lucca.it/pianificazione/assets/tiny/file/Pianificazione/PTCP2010/Avvio-procedimento/Quadro-conoscitivo/F/F1-0-RELAZIONE-BIODIVERSITA.pdf | Reference to Ecosystem Services in the National Strategy for Biodiversity |
| Regione Liguria | PTR http://www.regione.liguria.it/component/docman/doc_download/9968-bozza-delle-norme-di-piano.html | In progess – New regional planning laws with reference to new urbanistic standard to safeguard and increase ES for municipal plans |
| Città metropolitana di Milano | Piano di Indirizzo forestale http://www.cittametropolitana.mi.it/agricoltura/foreste_territorio/Revisione_PIF/ | Reference to Ecosystem Services among the general objectives of the Forest Planning |
| Comune di Valliterno | Rapporto ambientale - PUC | Reference to Ecosystem Services as an objective of European biodiversity target in the National Strategy for Biodiversity |
| Parco Regionale del Mincio | Piano di Indirizzo Forestale del (PIF) | Presence of ES indicator in the SEA |
| Riserva Torre Guaceto (LE) | Piano di Gestione | Map of ES provision |
| Comune di Pordenone | PRG http://www.comune.pordenone.it/it/comunichiamo/pordenone-piu-facile/materiali<br><br>http://www.comune.pordenone.it/it/comunichiamo/pordenone-piu-facile/materiali/140303tavola9b.pdf | Map of ES provision by soil, water and air components |
| Comune di Ranica (BG) | PGT http://www.comune.ranica.bg.gov.it/upload/ranica_ecm8/PGT/2%20PGT/DOCUMENTO%20DI%20PIANO/DP_relazione.pdf | Reference to Ecosystem Services in the Ecological Network document |
| Comune di Montecchio Emilia (RE) | PSC http://www.comune.montecchio-emilia.re.it/allegati/Relazione%20sul%20progetto%20di%20rete%20ecologica%20comunale_140718082819.pdf | Reference to Ecosystem Services in the Ecological Network document |
| Comune di Brescia | VARIANTE GENERALE AL P.G.T. VALUTAZIONE AMBIENTALE STRATEGICA (VAS) http://www.comune.brescia.it/servizi/urbanistica/PGT/Documents/ADOZIONE%20VARIANTE%20PGT%202015/Valutazione%20Ambientale%20Strategica%20Variante/RA_Rapporto%20Ambientale.pdf | Reference to Ecosystem Services in the SEA scoping document |
| Regione Marche | Rete ecologica Regionale http://www.ambiente.marche.it/Ambiente/Biodiversit%c3%a0eretee cologica/Biodiversit%c3%a0/ReteEcologicaRegionale.aspx | Reference to Ecosystem Services in the Ecological Network document |
| Comune di Perego (LC) | PGT – Rete Ecologica http://www.comune.lavallettabrianza.lc.it/userfiles/All/La_valletta_brianza/PGT%20ex%20Perego/C)%20PIANO%20DELLE%20REGOLE/14_NdA_Perego_con_controdeduzioni.pdf | 2014<br>Reference to Ecosystem Services in the Ecological Network document |
| Comune di Osnago (LC) | PGT<br>Rete Ecologica<br>http://www.comune.osnago.lc.it/export/sites/default/risorse/documenti_vari/Variante-parziale-PGT-Nov.-2013/REC_Osnago_approvazione.pdf | 2013<br>Reference to Ecosystem Services in the Ecological Network document |
| Provincia di Parma | Piano Territoriale di Coordinamento Provinciale<br>LA RETE ECOLOGICA DELLA PIANURA PARMENSE<br>VALSAT | Reference to Ecosystem Services in the SEA for the plan of Ecological Network |
| Comune di Pavia | VAS PGT | Reference to Ecosystem Services in the SEA documents |
| Comune di Passirano (BS) | Rete Ecologica | 2013<br>Reference to Ecosystem Services in the Ecological Network document<br>Municipal ecological networks as places for the location of ES defined by the Plan of Services. |

Table 2 – Plans and planning documents resulted from the review

| Types of reference to ES | Municipal Land use Plan | Provincial/Regional Plan | SEA/EIA documents | Other (ecological network planning, parks, protected areas) |
|---|---|---|---|---|
| Use of analyses/assessment on ES to delivery planning decisions | / | 1 | / | / |
| Analyses/assessments | 1 | / | / | 1 |
| General reference | 3 | 1 | 5 | 12 |

Table 3 – cross relation between types of plans and use of the ES concepts

The final set of webpages to review was derived by the combination of results of the keywords listed in table 1: particularly the not-overlapping set obtained by the union of the results from the 2nd, 3rd and 4th set of keywords was used, for a total of 431 webpages. The plans mentioned in the final set of webpages are reported in table 2.

Although the choice of the keywords was made to address plans at the municipal levels, the returned webpages included different types of plans and at different administrative and scales. Table 3 summarized the types of plans and the use they made of the ES concept.

Although partial and not aiming a thorough scan of existing spatial processes, the review provides some evidence on the high genericity in the consideration of ES by Italian plans, at all different planning scales returned. The majority of the plans makes a simply reference of the terms ES as a straight and simplistic label to state their overall environmental/ecological objectives. This can be found in many instances of preliminary study/analysis for the planning of local ecological networks and within SEA documents (especially for scoping documents).

The only relevant exception is given by the municipal plan of the city of Pordenone, recently adopted by the city, including specific analyses and mapping on some categories of

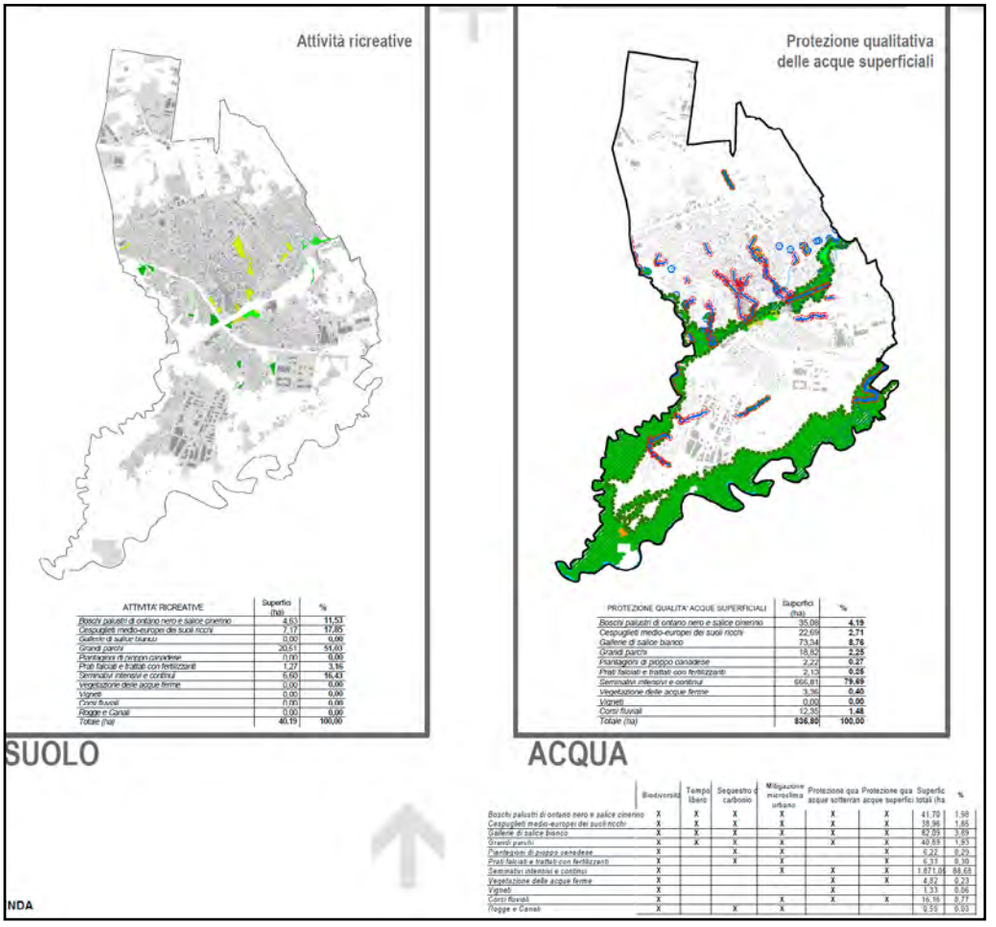


Fig. 1 – Examples of maps of the ecosystem services provided by soil and water for the city of Pordenone (source: Comune di Pordenone (2017))

ES (namely supporting and regulating) (fig. 1). However, these analyses have not directly used to support planning decisions, but rather were part of the basic assessment package of the plan. The plan also underlines the role of Payment for Ecosystem Services mechanism to maintain and increase –where possible- the supply of ES in the city and introduces a specific plan on the valorization of rural areas for ES provision.

Changing scale and administrative level, another interesting exception is given by the new Regional Planning law for Liguria. For this region, the new law fosters the safeguard of the integrity of the Capital Natural, in terms of ES provision, in the norms for its implementation. This plan proposes the possibility for each municipal plan to identify the areas where new developments are allowed only at the condition that these developments are compensated by actions for the increasing of slow mobility (pedestrian or cycling pathway) and public green spaces. Interestingly, the plan foresees the introduction of a specific compensative mechanism not based on quality/quantity of areas to compensate for the developments but on the SE that these new public areas can provide.

Results of the review also highlighted a straightforward but interesting point. The plans highlighted by the review are from regions where new planning laws recently promulgated and included some references – although still immature- to ES, as in the case of north Italian regions (Lombardy, Emilia-Romagnia, Liguria). Plans of cities or regions from south Italy regions were totally absent.

## Discussions and conclusions

Results from the performed review, although limited and not comprehensive of all the planning processes ongoing in Italy, demonstrate the limited inclusion of the ES as an explicit way to inform planning decision and therefore shape spatial choices. To date, only in some strategic environmental assessments of spatial plans, explicit references to ES can be found. This is in line with other recent reviews (Cortinovis and Geneletti, 2018; Mascarenhas et al., 2015), which demonstrated that if the ES concept is only implicitly part of urban spatial plans and in the planning documents, there is a kind mismatch between planners' perceptions and the its real level of integration. Existing sustainability based planning perpetuates the traditional approaches of recognizing ecosystem services without explicitly using them to improve land-use decisions. As such, practitioners interested in using an ecosystem service-based framework for planning have no resource about the type of norms, goals, information, and strategies they should take into account or aim to (Woodruff and BenDor, 2016). The big gap found in the reviewed plans can also be due to the absence of a mandatory inclusion of ES in planning processes. This is probably related to the historical relation between spatial planning and national and regional norms and planning systems that shape scopes and contents of each plan. This issue therefore highlights the opportunity to normatively and mandatorily embed ES through new forms regulations and planning standard. Theoretically, ES provide an opportunity to improve spatial planning by recognizing and explicitly put on the discussion's table the relationship between (urban) ecosystems and well-being. To achieve this potential, new standards for high-quality ecosystem service plans should be set (Woodruff and BenDor, 2016). One possible way recently advocated from researchers is to design a new way to define the urban services that are required by the 1968 national law for urban minimum requirements (Standard Urbanistici). To this end, Pelorosso et al. (2016) advocate for new standards for spatial planning based on ecological processes and relative functions of Non Urbanised Areas delivering the ES (La Rosa and Privitera, 2013), that should be grounded in new measurements able to quantify these services at different scales (from the municipal to the district scale). Such measurements will be able to spatially quantify the performance of planning decisions and alternatives, and therefore making the ecosystems' values spatially explicit (La Rosa et al., 2016).

On a different level, further integrations should also lead to the inclusion of ES in terms of strategic objectives and identity demands and beneficiaries, so to strengthen planning decisions and increase the quality of current urban plans (Cortinovis and Geneletti, 2018), especially when ecosystems are part of wider metropolitan contexts needing

cross-administrative spatial governance.

The uptake of the concept of ecosystem services in spatial planning research and practices will be the main indicator the concept's real success, but its adoption in everyday urban planning will be even more important. Nevertheless, spatial planners must be aware of the diversity of perspectives on ecosystem services and their value (Hubacek and Kronenberg, 2013), taking that diversity into account when developing making relevant decisions for urban contexts. However, it will remain to be proved whether a plan that explicitly makes use of ES could actually be able to reach better levels of sustainability such as improve environmental protection and social well-being in urban contexts.

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# A methodological approach to identify a multifunctional green infrastructure at the regional scale. A case study from Sardinia, Italy

Sabrina Lai, Federica Leone

## Multifunctional green infrastructures: definition and its key components

The European Commission (2013, p. 3) in its Communication "Green Infrastructure: Enhancing Europe's Natural Capital", defines Green Infrastructure (GI) as "...a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services." This definition of GI integrates three concepts: ecological connectivity, biodiversity conservation and multifunctionality of ecosystems (Liquete et al., 2015). As a consequence, the concept of multifunctionality plays a key role in the spatial identification of a GI because the multifunctional use of natural capital allows to deal with significant issues such as biodiversity conservation and production of ecosystem services (Spanò et al., 2017).

Multifunctionality in relation to GI is conceived as the capacity of a single area to perform several functions and/or to provide various benefits (European Commission, 2012); it aims at integrating several functions (environmental, social, cultural, economic, etc) and, thus, at using enabling a more efficient use of space (Ahern, 2011). In fact, without an appropriate management, competition for the use of a given parcel land could entail potential conflicts (Iojă et al., 2014).

According to some authors (Madureira and Andresen, 2014), the use of the concept of multifunctionality in relation to GI is a stratagem in order in order not to choose among competing functions, based on the assumption that a GI can provide simultaneously several functions (European Commission, 2012; Horwood, 2011). However, in reality, some functions can conflict with each other and not all the functions can be performed simultaneously (Madureira and Andresen, 2014). Therefore, potential conflicts between functions cannot be addressed effectively only through appropriate management because they can negatively affect biodiversity conservation (Garmendia et al., 2016).

Spatial identification of a GI represents an unresolved issue for spatial planning at various scale levels. In our view, integrating GI within planning policies could support those decisions that affect conservation and protection of landscapes and environment; at the same time, it could promote the integration of biodiversity conservation within planning policies as stated by art. no. 10 of Council Directive 92/43/EEC "on the conservation of natural habitats and of wild fauna and flora" (Habitats Directive).

On this basis, our study integrates the methodology developed by Arcidiacono et al. (2016) to identify a multifunctional GI in relation to four values (conservation value, natural value, recreational value and anthropic heritage) taking Sardinia (Italy) as a case study. We aim at developing a methodological tool to support planners in identifying a GI starting from those functions that landscapes should support and perform.

The conservation value looks at the presence of those habitats defined by art. no. 1 of the Habitats Directive as "natural habitat types of community interest" and listed in Annex I of the same Directive.

The natural value goes beyond the intrinsic conservation value of biodiversity and assesses the quality of biodiversity in relation to three aspects: ecological integrity, actual levels of ecosystems functions, and capacity to provide ecosystem services despite pressures and threats that affect habitats.

The recreational value concerns the quantitative assessment of an ecosystem service, categorized by the Millennium Ecosystem Assessment (2003) under the "cultural services" group, and accounts for landscape and natural habitats as key factors that influence people's behaviour in relation to their leisure time. Recreational services can be assessed through monetary (Lankia et al., 2015) or non-monetary evaluations (Eagles et al., 2000). In particular, non-monetary analyses include approaches based on social media, such as Flickr (Sonter at al., 2016) and Instagram (Hausmann et al., 2017), that estimate visitors' preferences in relation to the number of geotagged pictures uploaded by users.

The anthropic heritage indicator accounts for interactions between natural capital and human factors in relation to the definition of landscape provided by European Landscape Convention, according to which landscape includes all those elements that have contributed to define cultural identities within the European Union. Landscapes are interpreted, protected, managed and planned through specific plans, called "Landscape plans", whose structure and implementation varies depending on the national context.

This article is structured into four sections. The second presents the Sardinian case study and explains the methodology we use to identify a multifunctional GI. The third section presents the results of our analysis, and the last section provides a discussion and some final considerations and policy recommendations.

## Case study and methodology

Sardinian is one of the two largest Italian islands, with a population of around 1.6 million (ISTAT, 2017). Its Regional Landscape Plan (RLP), approved in 2006, does not provide explicit rules for identifying GI; however, art. nos. 23 and 26 of the plan implementation code provide restrictions to maintain ecological functions and art. no. 34 promotes the integration of Natura 2000 sites within a coherent ecological network. In fact, Sardinia is characterized by a significant Natura 2000 network that concerns 37 Sites of Community Importance (SCI), 56 Special Areas of Conservation (SAC), and 37 Special Protection Areas (SPA)) (Italian environmental ministry, 2017).

From a methodological viewpoint, each of the four above mentioned values was calculated individually and independently in relation to a specific methodology; all values were mapped through the software ArcGIS® ESRI.

Conservation value (C_Val) is calculated through a methodology that builds upon a recent regional report (CRITERIA and TEMI, 2014a, pp. 27-28), where habitats of community interest are categorized in order to elaborate a monitoring plan for Sardinia. In particular, C_Val equals zero in those areas that do not host any habitats of community interest; otherwise it is calculated according to the following expression:

$$C\_Val = P * (R+T+K)$$

where P accounts for priority, which equals 1.5 in case of priority habitats[1] and 1 other-

wise. R indicates the rarity of a given habitat and it is calculated in relation to the number of Sardinian Natura 2000 sites in which the habitat is present; higher values of R correspond to lower number of presences. T evaluates the number of threats recorded in the standard data forms of the Sardinian Natura 2000 sites; in this case higher values of T correspond to higher number of occurrences. K accounts for knowledge and it is based on a recent regional monitoring project where the level of knowledge is evaluated qualitatively through experts' judgements (CRITERIA and TEMI, 2014b). Apart from K, whose values were ranked in the interval (1±4), all values were normalized in the interval (1±5). As a consequence, C_Val can initially take values ranging from 0 (areas where no habitats of community interest are present) to 21 (maximum conservation value), but is next normalized in the interval (0±1). The natural value (N_Val) is assessed through the tool "Habitat quality"[2] of the software "InVEST" that maps habitat quality in relation to land covers and threats to biodiversity. In particular, input data for the model are as follows:

1. 2008 Land Cover Map elaborated by Sardinian regional administration converted into a raster map;
2. a list of 10 threats identified through an analysis of standard data forms of the Sardinian Natura 2000 sites; for each threat we assign a weight and decay distance in relation to experts' judgements and a decay function (Table 1);
3. a raster map representing the spatial layout of each threat;
4. a vector map that shows accessibility to sources of degradation, conceived as protection that legal institutions provide against threats, where the higher the level of protection, the lower the value of accessibility. We identify three levels of protection: regional and national parks (value=0.2); Natura 2000 sites (value=0.5); the remaining study area (value=1);
5. a matrix of habitat types starting from land covers, and, for each habitat type, its sensitivity to each threat. Values are identified through an expert-based approach.
6. a "half-saturation constant", set at the tool's default value.

| *Threat name* | *Weight* | *Decay distance (km)* | *Decay function* |
|---|---|---|---|
| Cultivation | 0.58 | 1.63 | linear |
| Grazing | 0.68 | 0.58 | linear |
| Removal of forest undergrowth | 0.79 | 0.65 | linear |
| Salt works | 0.63 | 0.83 | linear |
| Paths, tracks | 0.53 | 0.55 | linear |
| Roads, motorways | 0.95 | 3.00 | linear |
| Airports | 0.95 | 4.75 | linear |
| Urbanized areas | 0.95 | 3.25 | linear |
| Discharges | 1.00 | 3.50 | linear |
| Fire | 0.95 | 2.05 | linear |

Table 1 – List of threats to biodiversity in Sardinian Region and related weights, decay distances and decay functions.

The recreational value (R_Val) is calculated and mapped through the tool "Visitation: Recreation and Tourism"[3] of the software InVEST that uses data from the social media Flickr and the unit of measure is the "photo-user-day" (PUD) that corresponds to number of users that in a given spatial unit and day took at least one photo. Data was retrieved within the 2010-2014 timeframe, and the average PUD per year was normalized in the interval (0±1).

The anthropic heritage (A_Her) concerns the protection level that the RLP defines for each landscape asset; a value between 0 and 1 was assigned depending on the strictness of the rules defined by the plan (the strictest, the higher the value).

Finally, in order to obtain the total value the two raster maps concerning N_Val and R_Val were converted into vector maps, and next a GIS geoprocessing tool calculated the total value as the sum of the four single values (C_Val, N_Val, R_Val and A_Her). Since all of the four values range between 0 and 1, the total value ranges in the interval (0±4).

## Results

Figure 1 displays the spatial layout of the four values in our case-study area.

A large part of the island (approximately 66%) takes null C_Val, which means that it does not host any habitats of community interest. Out of the rest of the island (34%), in which such habitats can be found, the most part takes low values: only 0.90% of the island's surface takes values higher than 0.75; 4.95% takes values between 0.50 and 0.75, and finally 27.80% shows values below 0.50. Moreover, since the regional Natura 2000 network covers around 19% of the region (Italian environmental ministry, 2017), it follows that a good deal of habitats of community interest are not included within any Natura 2000 sites.

As for N_Val, only a small part of the island (3.26%) takes null values; 34.29% of the region hosts middle-quality habitats taking values around 0.50, while 62.45% corresponds to high quality habitats taking values above 0.90.

R_Val equals 0 in the vast majority of the island (84.86%). Out of the remaining 15.14%, 13.43% of the island's land area takes values between 0.01 and 0.10, hence only a very small part of the island (mostly in the main towns and along the coastline) takes middle or high values.

Finally, A_Her equals 0 in 38.82% of the region. Furthermore, this variable is categorical and only takes the following values: 0.20 (0.26% of the regional land mass); 0.5 (4.21%); 0.8 (4.17%) and 1 (30.18). Therefore, among non-null values, the maximum value spatially dominates, mainly because of three main environmental assets ("Coastal strip", "Lakes, reservoirs, wetlands and their 300-m buffers" and "[listed] Rivers, creeks and their 150-m buffers"). A fourth type of asset also brings about the maximum value, and comprises both "Listed archaeological heritage" and "Areas with prehistoric, historic, cultural remnants". The total value map (Figure 2) shows that in no point is the maximum possible score (i.e., 4) achieved. This also implies that no land parcel simultaneously achieves the maximum score in each of the four values. Null total values only concern 0.76% of the region, while the highest value (corresponding to 3.53) concerns a negligible area of 1.5 hectares. The highest values are associated either with coastal areas (and especially within coastal wetlands) or with the summit of hills and mountains; rivers and creeks also stand out, as they always show total values higher than those of their surrounding landscapes.

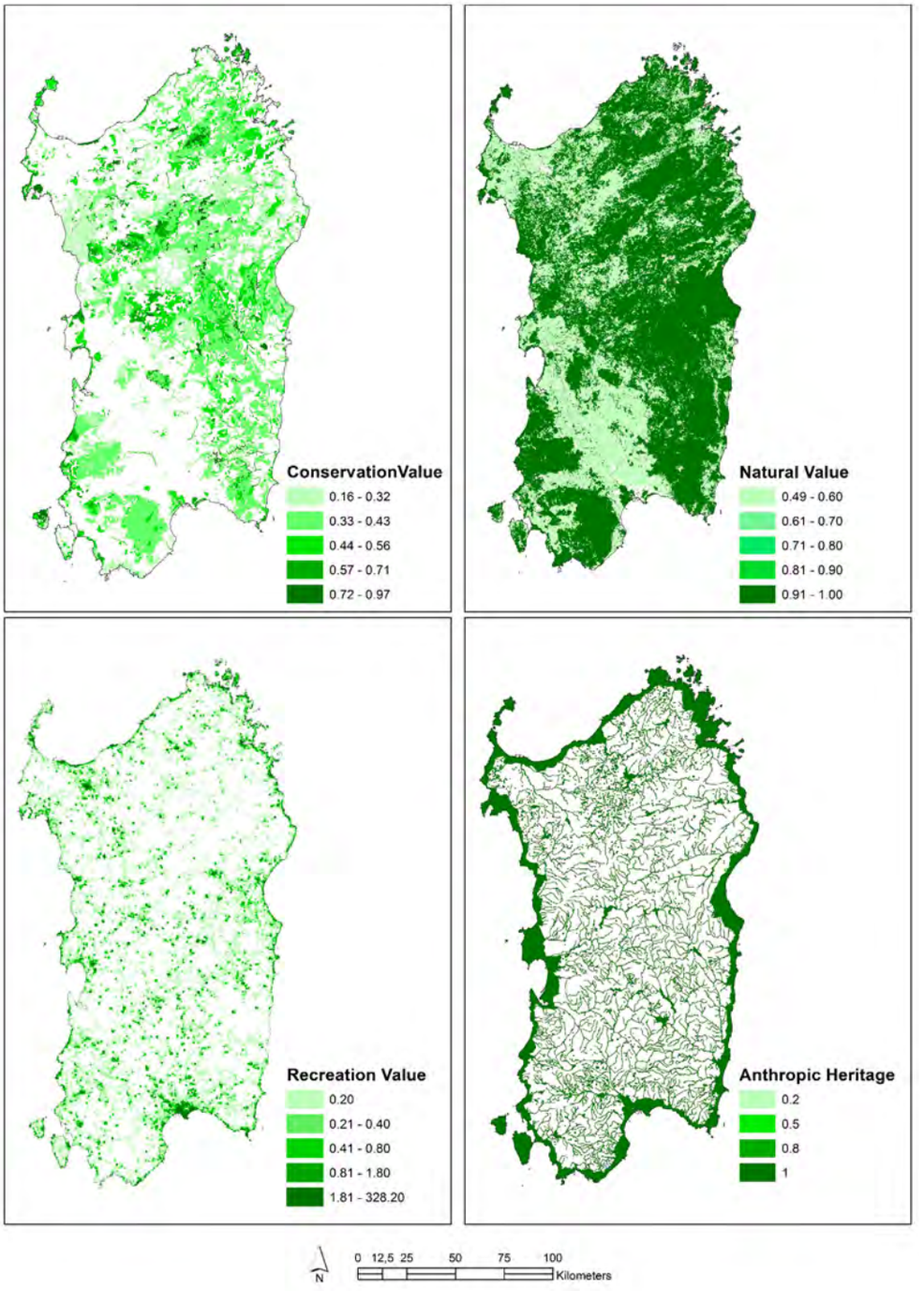


Figure 1 – Spatial distribution of conservation value, natural value, recreational value and anthropic heritage in the Sardinian case study

## Discussion and concluding remarks

In this study we have proposed a methodology to support the spatial identification of a multifunctional GI by singling out four main functions (conservation of endangered or otherwise valuable habitats, biodiversity support, recreation, interactions between people and landscapes) that a GI should support and ensure; for each function, a quantitative index was proposed, assessed and mapped.

A first, not surprising, outcome of the study is that the four values vary differently across space; this was to be expected, because each value captures a specific aspect or function relevant to landscape planning. For instance, within urban and rural settlements C_Val is null and N_Val tends to be null, either; to the contrary, within built-up areas R_Val can take high values, as well as A_Her in case historic districts or listed buildings and monuments can be found inside the settlements. This is consistent with the view that multifunctionality is an ideal objective (Meerow and Newell, 2017) when designing a GI, because each land parcel is somewhat "specialized", meaning that it performs at least one main function, and different parcels complement each other. Consequently, a first recommendation to planners and policy makers is that tradeoffs between areas performing different functions need to be preliminarily brought to the fore in planning processes that concern the spatial identification and management of GI.

A second striking outcome is that that no land parcel achieves the maximum possible total score, which equals 4. This is related to the previous comment, and it is due to the fact that no land parcel simultaneously achieves the maximum score in each of the four values here considered, because a single land parcel is unlikely to perform all of the functions at the highest level. The highest values (3.51-3.53) in our case study characterize some parts of a wetland and former saltwork within the built-up area of Cagliari, where N_Val, R_Val and A_Her take the maximum value while C_Val scores approximately 0.5. This is certainly a peculiar situation, in which habitats of community interest (C_Val) and in comparatively favorable status notwithstanding threats and pressures (N_Val) are protected by the landscape plan (A_Her) because of their being included in the coastal strip and because of the conservative regime that applies to coastal wetlands, while being at the same time easily accessible and enjoyed (R_Val) by local communities and visitors. Hence, a second recommendation is that natural and semi-natural habitats, be they of community interest or not, that survive and thrive within, or in proximity to, urban areas should be granted a special protection regime which should not turn them into strict nature reserves or wilderness areas (respectively, categories I.a and I.b of the IUCN protected area management category scheme). Controlled access to these habitats is, actually, important not only because it enables visitors to spend time in contact with nature, but also because such habitats and their landscapes are, in the words of the European Landscape Convention (Council of Europe, 2000), "an essential component of people's surroundings [...] and a foundation of their identity".

A third outcome concerns the spatial distribution of C_Val. By superimposing the spa-

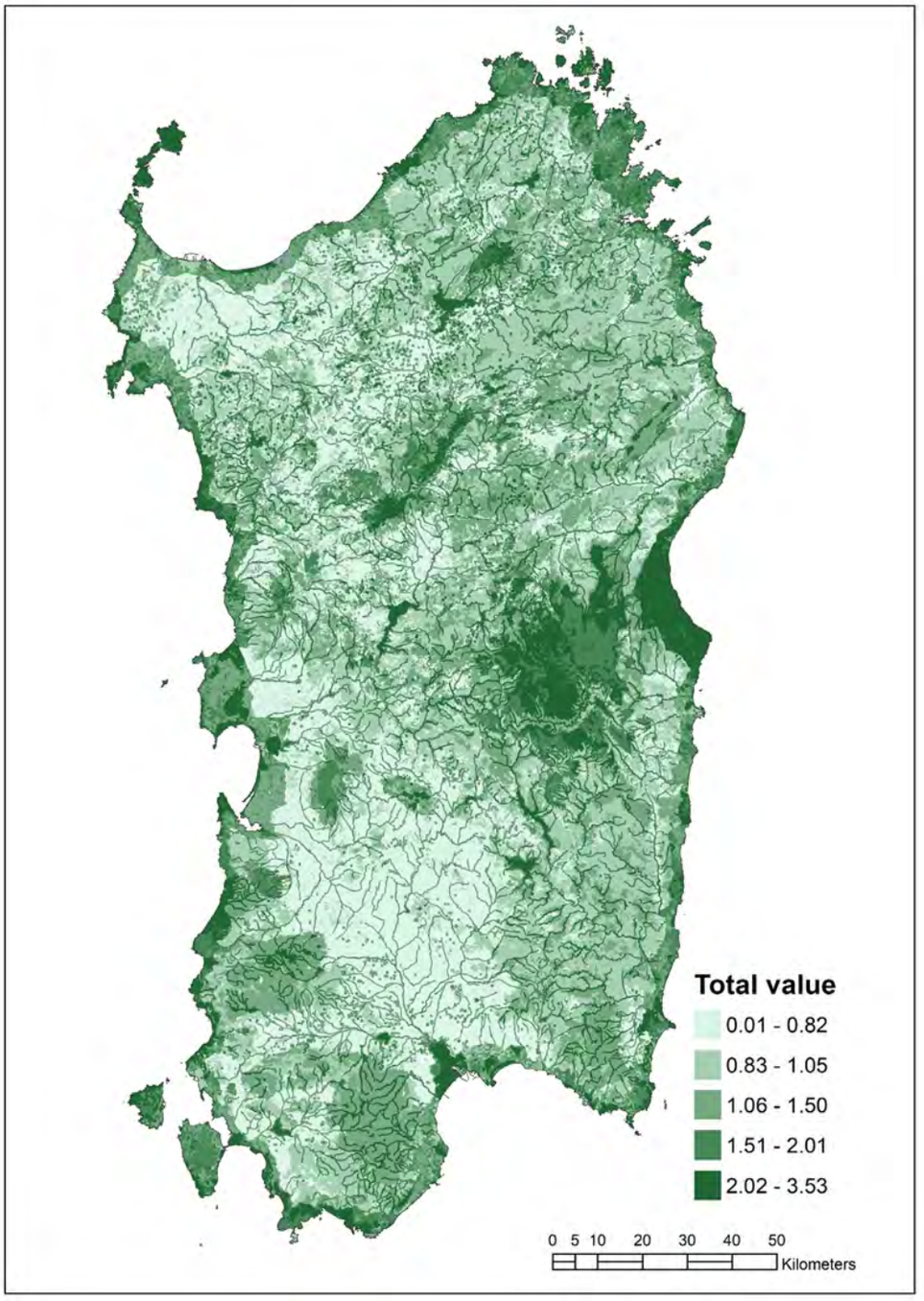


Figure 2 – Spatial distribution of total value in the Sardinian case study

tial layout of the regional Natura 2000 network upon the maps representing C_Val, it is quite easy to notice that quite a large area hosting habitats of community interest is not included within any Natura 2000 sites. While the presence of an habitat or species of community interest does not automatically call for the designation of a Natura 2000 site (in particular, for SCIs and SACs, criteria listed in Annex III of the Habitats Directive apply), effective protection policies should be envisaged in relevant planning tools so as to maintain these habitats or species. The RLP currently in force in Sardinia does provide both regulations and planning directions aiming at preserving specific habitats of community interest listed in the Habitats Directive, and especially priority habitats: for instance, art.no. 17 of its planning implementation code includes *Posidonia* beds (priority habitat ∗1120) and steppic habitats (priority habitat ∗6220), as well as any priority habitat listed in the Directive, among landscape assets, which are subject to several restrictions; art. no. 23 forbids any non-conservative forestry interventions in any priority habitats; art. no. 39 forbids land cover changes and transformations in areas outside the Natura 2000 network hosting habitats listed in the Directive if the habitat's structure and function can be adversely affected. However, all of these provisions are not effective because such areas are not mapped in the plan's maps, which are legally binding, hence restrictions cannot be enforced.

A fourth remark concerns the map presented in Figure 2, which should not be conceived as the spatial configuration of a Sardinian GI, but rather as a tool to help policy makers choose which possible areas could be included in a GI within a regional and normative spatial plan.

To sum up, in this study we have attempted to address the current "limited success" (Lovell and Tayor, 2013) in institutionalizing GI: our view is that, if the identification of GI, as well as the provisions for its management, were mandatorily included within landscape plans, then GI could effectively be institutionalized. As per legislative decree 42/2004, Italian regional administrations have the duty to prepare and approve landscape plans; in these plan-making processes, participation is compulsory and is integrated within the strategic environmental assessment procedure pursuant to European Directive 2001/42/EC. A key aspect of such participatory processes is their capability of including ecosystem services beneficiaries' (Landsberg et al., 2011) knowledge, needs, and priorities in the plan-making process. This kind of participation could possibly enhance the methodology we have proposed in this study, because it could allow for the integration of ecosystem services beneficiaries' views and priorities in regards to the four constituent values, which we assessed and mapped here on the basis of official data and expert views only.

## Acknowledgments

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University of Cagliari, Italy. This paper is to be equally attributed to Sabrina Lai and Federica Leone, who collaboratively designed the paper and jointly wrote Sections 1 and 4. Federica Leone has written Section 2, while Sabrina Lai has written Section 3

1. Priority Habitats are defined in the art. No. 1 of Habitats Directive as "...natural habitat types in danger of disappearance, which are present on the territory referred to in Article 2 and for the conservation of which the Community has particular responsibility in view of the proportion of their natural range which falls within the territory referred to in Article 2; these priority natural habitat types are indicated by an asterisk (*) in Annex I.
2. Further information is available online at http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/habitat_quality.html.
3. Further information is available online at http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/recreation.html.

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# L'analisi di Coerenza Esterna Quale Componente del Protocollo Sperimentale per la Redazione del Regolamento di un'Area Marina Protetta

Francesca Leccis[1 2] Salvatore Pinna[1 2]

**Abstract**

Il contributo illustra il lavoro, finora svolto nell'ambito del progetto GIREPAM, concernente le Aree Marine Protette di Tavolara – Punta Coda Cavallo e di Capo Carbonara per le quali è in corso la definizione di un Protocollo sperimentale finalizzato alla stesura dei Regolamenti delle Aree Marine Protette integranti i Piani di gestione dei Siti di Importanza Comunitaria (SIC), le misure di conservazione delle Zone di Protezione Speciale (ZPS), le disposizioni del Protocollo sulla gestione integrata delle zone costiere (GIZC) e del Protocollo sugli interventi standardizzati di gestione efficace in area marina protetta (ISEA). In particolare, si presenta l'analisi di coerenza esterna, attraverso la quale si individuano i contenuti e gli obiettivi dei piani e programmi riguardanti il territorio delle aree oggetto di studio, finalizzata al superamento di eventuali contraddizioni e ridondanze individuate tra i diversi strumenti e alla definizione degli obiettivi del Regolamento in fase di redazione.

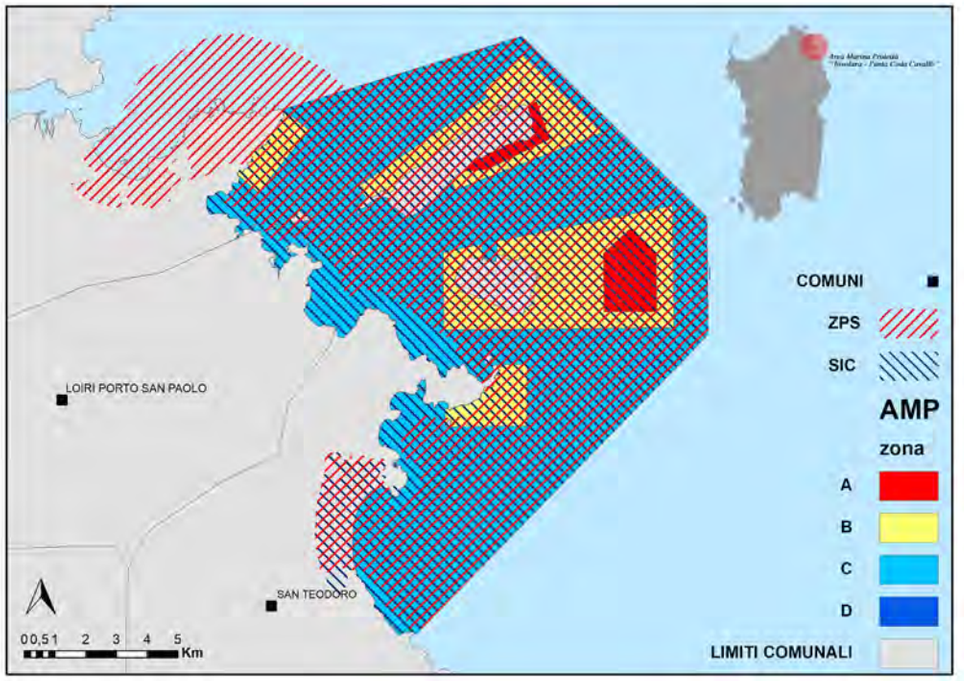


Figura 1 – Sovrapposizione tra AMP "Tavolara – Punta Coda Cavallo" e aree della rete Natura 2000 (Elaborazione degli autori).

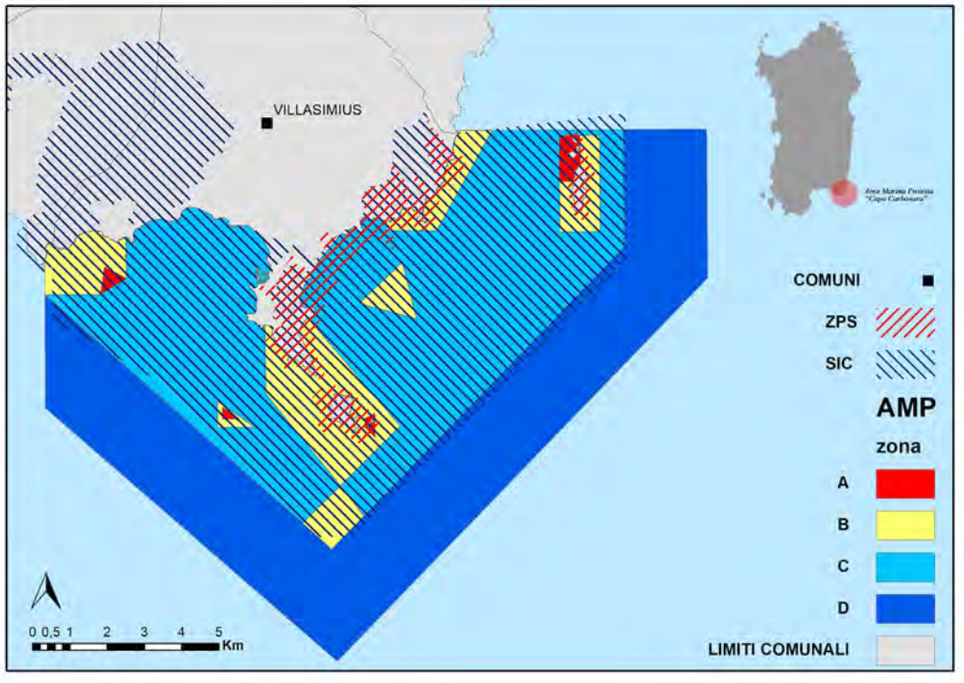


Figura 2 - Sovrapposizione tra AMP "Capo Carbonara" e aree della rete Natura 2000 (Elaborazione degli autori).

## Introduzione

Il Millennium Ecosystem Assessment (2005) ha individuato nella biodiversità un elemento essenziale per il funzionamento degli ecosistemi e per la conseguente fornitura di servizi ecosistemici. Per questo motivo, l'Europa ha individuato nella perdita di biodiversità, causata dalla distruzione e dall'eccessivo sfruttamento degli habitat, una delle sfide ambientali bisognose di un intervento prioritario. Poiché tale deterioramento è causato da una molteplicità di fattori, appare evidente la necessità di un approccio olistico che integri gli obiettivi ambientali all'interno delle varie politiche settoriali (AEA, 2015).

Tuttavia, gli strumenti finora adottati per l'implementazione delle politiche volte alla conservazione degli habitat e alla protezione delle specie, sono spesso carenti di organicità e sistematicità, in quanto non sono integrati tra loro né mostrano sinergie positive con altri strumenti di pianificazione territoriale per la gestione della matrice biofisica del territorio in una visione d'insieme (Gurrutxaga San Vicente & Lozano Valencia, 2009). Una delle conseguenze di questa mancata integrazione è la frammentazione delle aree protette, che si configurano come unità spazialmente e funzionalmente isolate e quindi indipendenti fra loro. Tale frammentazione, non solo determina la riduzione degli habitat, ma costituisce anche un ostacolo ai movimenti degli individui delle diverse specie (Crooks & Sanjayan, 2006) rappresentando, così, una delle principali minacce di perdita di biodiversità (Hanski, 2005). Il progetto

| Piano o Programma – livello regionale | |
|---|---|
| Documento strategico unitario per la programmazione dei fondi comunitari 2014/2020 | |
| Piano paesaggistico regionale | |
| Piano regionale di qualità dell'aria ambiente | |
| Piano stralcio per l'assetto idrogeologico | |
| Piano di gestione del rischio di alluvioni | |
| Piano stralcio delle fasce fluviali | |
| Piano di gestione del distretto idrografico | |
| Piano di tutela delle acque | |
| Piano stralcio di bacino regionale per l'utilizzo delle risorse idriche - Sardegna | |
| Piano regolatore generale degli acquedotti | |
| Piano d'ambito | |
| Piano regionale di gestione dei rifiuti – Sezione rifiuti urbani | |
| Piano regionale di gestione dei rifiuti speciali | |
| Piano regionale di gestione dei rifiuti – Piano regionale di protezione, decontaminazione, smaltimento e bonifica dell'ambiente ai fini della difesa dai pericoli derivanti dall'amianto | |
| Programma per la riduzione dei rifiuti biodegradabili da collocare in discarica - Integrazione Piano regionale rifiuti | |
| Piano di bonifica siti inquinati | |
| Piano faunistico venatorio regionale | |
| Piano regionale delle attività estrattive | |
| Piano forestale ambientale regionale | |
| Piano regionale di previsione, prevenzione e lotta attiva contro gli incendi boschivi 2014/2016 | |
| Piano regionale di sviluppo turistico sostenibile | |
| Piano regionale dei trasporti | |
| Piano energetico ambientale della Regione Sardegna (PEARS) 2015-2030 | |
| Piano d'azione regionale energie rinnovabili Sardegna – Documento di indirizzo sulle fonti energetiche rinnovabili | |
| Piano d'azione dell'efficienza energetica regionale – Documento di indirizzo per migliorare l'efficienza energetica in Sardegna 2013/2020 | |
| **Piano o Programma – livello provinciale** | |
| Piano provinciale di gestione dei rifiuti urbani – Prov. Olbia-Tempio | Piano Provinciale raccolta e trasporto rifiuti urbani e assimilati della Provincia di Cagliari |
| Piano urbanistico / Piano territoriale di coordinamento provinciale – Prov. Sassari e Olbia-Tempio | Piano Urbanistico Provinciale/Piano Territoriale di Coordinamento (PUP/PTC) della Provincia di Cagliari |
| Piano faunistico venatorio provinciale – Prov. Olbia-Tempio | Piano di Assetto Organizzativo dei Litorali (PAOL) Cagliari |
| **Piano o Programma – livello comunale** | |
| Piano urbanistico comunale di San Teodoro | Piano Comunale di Emergenza di Protezione Civile per il rischio di incendi di interfaccia |
| Piano urbanistico comunale di Loiri-Porto San Paolo | Piano di Classificazione Acustica Villasimius |
| Piano urbano della mobilità - Olbia | Piano di Utilizzo dei Litorali Villasimius |
| Piano di utilizzo dei litorali di Olbia | Piano di raccolta e di gestione dei rifiuti prodotti dalle navi e dei residui del carico per il porto di Villasimius |
| Piano di utilizzo dei litorali di Loiri - Porto San Paolo | |
| Piano di utilizzo dei litorali di San Teodoro | |
| Piano di raccolta e di gestione dei rifiuti prodotti dalle navi e dai residui del carico - Porto Di Puntaldia | |
| Piano di raccolta e di gestione dei rifiuti prodotti dalle navi e dai residui del carico - Porto di La Marina di Costa Corallina | |

Tabella 1– Quadro programmatico e pianificatorio

GIREPAM (Gestione Integrata delle Reti Ecologiche attraverso i Parchi e le Aree Marine), all'interno del quale si inserisce il presente contributo, è volto al miglioramento e all'innovazione degli strumenti di gestione delle aree marino-costiere secondo una visione d'insieme del territorio, al fine di contrastare la perdita di biodiversità e il degrado dei servizi ecosistemici.

Il contributo illustra parte del lavoro svolto per la redazione dei Regolamenti delle Aree Marine Protette (AMP) di "Tavolara - Punta Coda Cavallo", afferente ai comuni di Olbia, Loiri-Porto San Paolo e San Teodoro in provincia di Sassari (ex Provincia di Olbia-Tempio, abrogata con L.R. 2/2016) e di "Capo Carbonara", situata nel comune di Villasimius in provincia di Cagliari, integranti le misure di conservazione delle aree della rete Natura 2000 incluse nei rispettivi territori delle AMP, così come mostrato dalla Figura 1 e dalla Figura 2.

Le AMP sono istituite ai sensi delle leggi n. 979 del 1982 e n. 394 del 1991 tramite Decreto del Ministro dell'Ambiente, che include la denominazione e la delimitazione dell'area, gli obiettivi e la disciplina di tutela a cui è finalizzata la protezione. Sono costituite da ambienti marini (acque, fondali e tratti di costa prospicenti) dal rilevante valore storico, archeologico-ambientale, ecologico, scientifico, economico e culturale legato alle loro caratteristiche naturali, geomorfologiche, fisiche, biochimiche, con particolare riguardo alla flora e alla fauna marine e costiere (MATTM, 2013).

Natura 2000 è una rete ecologica che include le Zone di Protezione Speciale (ZPS) istituite ai sensi della Direttiva 2009/147/CE "Uccelli", sostituita dalla Direttiva 2009/147/CE concernente la conservazione degli uccelli selvatici, e i Siti di Interesse Comunitario (SIC), istituiti ai sensi della Direttiva 92/43/CEE "Habitat" per garantire il mantenimento a lungo termine degli habitat naturali e delle specie di flora e fauna minacciati o rari a livello comunitario (MATTM, 2017).

Nei territori delle due AMP insistono sia Zone di Protezione Speciale (ZPS), sia Siti di Importanza Comunitaria (SIC). L'AMP di Tavolara include la ZPS "ITB013019 Isole del Nord-Est tra Capo Ceraso e Stagno di San Teodoro" e il SIC "ITB010010 Isola di Tavolara, Molara e Molarotto", mentre l'AMP di Capo Carbonara include le ZPS "ITB043026 Isola Serpentara", "ITB043027 Isola dei Cavoli" e "ITB043028 Capo Carbonara e Stagno di Notteri – Punta Molentis", e il SIC "ITB040020 Isola dei Cavoli, Serpentara, Punta Molentis e Campulongu". La loro gestione è affidata, secondo quanto stabilito dall'art. 2, comma 3, e l'art. 3, comma 4 del Decreto del Ministero dell'Ambiente e della Tutela del Territorio e del Mare (MATTM) del 17 ottobre 2007 "Criteri minimi uniformi per la definizione di misure di conservazione relative a Zone speciali di conservazione (ZSC) e a Zone di protezione speciale (ZPS)", ai rispettivi enti gestori delle AMP.

In coerenza con questa disposizione, il MATTM ha richiesto l'integrazione delle misure di conservazione delle aree della rete Natura 2000 all'interno dei Regolamenti delle AMP, al fine di promuovere una gestione efficace del territorio.

Con questo obiettivo, il gruppo di lavoro del Dipartimento di Ingegneria Civile, Ambientale e Architettura (DICAAR) dell'Università di Cagliari, all'interno del progetto GIREPAM, in accordo con gli enti gestori delle due AMP, è impegnato nella redazione dei rispettivi Regolamenti che integrino, in maniera scientifica e organica, le misure di conservazione relative ai SIC e alle ZPS ricadenti nei loro territori. La complessità di tale

integrazione ha richiesto la definizione di un Protocollo Sperimentale (PS), un apposito strumento valutativo in grado di garantire l'inclusione nel Regolamento degli aspetti ambientali, economici e sociali, caratterizzanti i territori oggetti di studio.

Il PS definisce un sistema di indirizzi, obiettivi e regole che amplia e completa quello definito dal Regolamento vigente, non soltanto integrando al suo interno le misure di conservazione delle aree della rete Natura 2000, ma anche garantendo la partecipazione di tutti i soggetti competenti e interessati al processo decisionale, dalla quale "possono emergere nuovi spunti, prospettive e criticità" (Calenda, 2008), aspetto fondamentale per l'apporto di nuovi contenuti il più possibile condivisi.

L'importanza della partecipazione è legata anche all'opportunità, per tutti i soggetti coinvolti, di contribuire attivamente alla definizione delle strategie prima che queste vengano adottate, assicurando al processo, non solo adeguata trasparenza (Therivel, 2004), ma anche legittimità sostanziale (Zavattini, 2011). Infatti, solo se i soggetti coinvolti riconoscono nell'alternativa adottata la migliore possibile tra quelle effettivamente praticabili, lo strumento sarà condiviso e dunque legittimato nella sua funzione (Spaziante, 2005).

Al termine dell'attività, sulla base dell'esperienza svolta, verranno stilate delle Linee Guida al fine di consentire l'esportabilità dell'approccio scientifico definito per i due casi di studio in altre realtà europee.

Componente fondamentale del PS è l'analisi di coerenza esterna, che assicura che gli obiettivi del Regolamento in fase di redazione non contrastino con quelli derivanti dagli strumenti di programmazione e pianificazione vigenti ai vari livelli (regionale, provinciale e comunale) nei territori in esame.

Il presente contributo illustra la metodologia adottata per l'analisi di coerenza esterna e i risultati sinora raggiunti nel corso della definizione del PS delle AMP di "Tavolara – Punta Coda Cavallo" e di "Capo Carbonara", a cui segue la discussione relativa ad alcuni esempi. Infine, si presentano le conclusioni e i possibili sviluppi del lavoro in itinere.

## L'analisi di coerenza esterna

L'analisi di coerenza esterna, finalizzata alla definizione degli obiettivi del Regolamento, considera l'intero piano programmatico e pianificatorio in vigore nel territorio di ciascuna Area Marina Protetta, analizzando gli strumenti di pianificazione e programmazione economica, sociale e territoriale, di livello regionale, provinciale e comunale, rilevanti per il contesto analizzato, così come riportato in Tabella 1.

Per ciascun Piano o Programma vengono riportati i riferimenti normativi e una breve descrizione dello strumento, dei suoi contenuti e finalità. Da ogni piano vengono estrapolati tutti gli obiettivi dichiarati e quelli ritenuti significativi per il Regolamento sono riproposti identicamente a come enunciati nel piano o programma di origine, oppure riformulati in modo da calarsi adeguatamente nel contesto in questione.

Gli obiettivi riproposti sono identificati tramite il codice "A_Ob_CE_X", indicante il numero (X) dell'obiettivo (Ob) derivante dall'analisi (A) di coerenza esterna (CE).

A titolo di esempio, si riporta un piano o programma per ciascun livello pianificatorio, riferito al contesto dell'AMP "Tavolara – Punta Coda Cavallo". Lo stesso approccio è stato adottato nel contesto dell'AMP "Capo Carbonara".

Per quanto concerne il livello regionale, nel "Documento Strategico Unitario e delle priorità di finanziamento della Regione Sardegna per il ciclo di programmazione 2014-2020 dei fondi UE ricompresi nel Quadro Strategico Comune (QSC)" sono stati individuati i seguenti obiettivi:

- rafforzare la ricerca, lo sviluppo tecnologico e l'innovazione;
- migliorare l'accesso alle tecnologie dell'informazione e della comunicazione, nonché l'impiego e la qualità delle medesime;
- promuovere la competitività delle piccole e medie imprese, il settore agricolo (per il Fondo europeo agricolo per lo sviluppo rurale, FEASR) e il settore della pesca e dell'acquacoltura (per il Fondo europeo per gli affari marittimi e la pesca, FEAMP);
- sostenere la transizione verso un'economia a basse emissioni di carbonio in tutti i settori;
- promuovere l'adattamento al cambiamento climatico, la prevenzione e la gestione dei rischi;
- tutelare l'ambiente e promuovere l'uso efficiente delle risorse;
- promuovere sistemi di trasporto sostenibili ed eliminare le strozzature nelle principali infrastrutture di rete;
- promuovere l'occupazione e sostenere la mobilità dei lavoratori;
- promuovere l'inclusione sociale e combattere la povertà;
- investire nelle competenze, nell'istruzione e nell'apprendimento permanente;
- rafforzare la capacità istituzionale e promuovere un'amministrazione pubblica efficiente.
- Considerando che il Regolamento può influenzare, in maniera diretta o indiretta le risorse presenti sul territorio, tra gli obiettivi derivanti dall'analisi di coerenza esterna, si ritiene opportuno includere i seguenti obiettivi:
- tutelare l'ambiente e promuovere l'uso efficiente delle risorse;
- promuovere sistemi di trasporto sostenibili ed eliminare le strozzature nelle principali infra-strutture di rete.

Formulati e codificati come segue:

A_Ob_CE_1 "Tutelare l'ambiente e promuovere l'uso efficiente delle risorse".

A_Ob_CE_2 "Promuovere sistemi di trasporto sostenibili"

Si noti che A_Ob_CE_1 è riproposto con formulazione identica a quella originale, mentre A_Ob_CE_2 è riformulato, escludendo la parte sull'eliminazione delle "strozzature nelle principali infrastrutture di rete", in quanto la gestione delle infrastrutture esula dalle competenze del Regolamento dell'AMP.

Per quanto concerne il livello provinciale, nel "Piano provinciale di gestione dei rifiuti urbani (PPGRU)" della Provincia di Olbia-Tempio sono individuati i seguenti obiettivi:

- assicurare le massime garanzie di tutela dell'ambiente e della salute, nonché di salvaguardia dei valori naturali e paesaggistici e delle risorse presenti nel territorio provinciale, anche al fine di avere un impatto sistemico (risparmio di materia vergine, risparmio energetico, minori emissioni di gas serra) coerente con il Protocollo di Kyoto;
- conformare la gestione dei rifiuti ai principi di responsabilizzazione e cooperazione di tutti i soggetti coinvolti, perseguendo l'economicità, l'efficienza

e l'efficacia delle attività;
- assicurare una gestione unitaria ed integrata dei rifiuti urbani adottando soluzioni innovative, efficaci e sostenibili per le fasi di raccolta e trasporto dei rifiuti urbani, perseguendo il superamento della frammentazione istituzionale della gestione e favorendo processi di aggregazione e razionalizzazione della gestione tra i Comuni;
- favorire la cooperazione con Regione, Province, Comuni, Unioni di Comuni, Comunità Montane, Consorzi Intercomunali e loro Società e valorizzare la concertazione con le forze economiche e sociali, utilizzando strumenti innovativi quali accordi/contratti di programma e protocolli d'intesa (art. 4, comma 4 e 25 del D. Lgs. 22/97) - e con il sistema CONAI e dei Consorzi di filiera, le Associazioni (di categoria, del volontariato, ambientaliste, etc.), gli organismi di controllo, gli Enti di ricerca e le Università, per rendere più operativo ed efficiente il sistema, anche introducendo agevolazioni ed incentivi che favoriscano le buone pratiche ambientali;
- perseguire lo sviluppo di una "diffusa cultura ambientale", basata su: attività di comunicazione e formazione, valorizzazione di capacità e competenze tecniche, ecofiscalità, consapevolezza sociale, accordi volontari, sensibilità ambientale e partecipazione con specifici riferimenti alle seguenti categorie:
- popolazione residente
- popolazione turistica
- giovani in età scolare
- pubblica amministrazione
- operatori economici
- associazionismo
- Individuare le soluzioni innovative ed ottimali per la gestione di particolari tipologie di rifiuti entranti nel circuito dei rifiuti urbani ed assimilabili, quali:
- rifiuti verdi
- rifiuti ingombranti
- rifiuti elettrici ed elettronici (RAEE)
- farmaci
- rifiuti di origine agricola (pericolosi e non pericolosi)
- oli vegetali
- previa valutazione delle possibilità di recupero e riciclo, applicando le Migliori Tecniche Disponibili (M.T.D.) e coinvolgendo l'ARPAS, gli Enti di ricerca, l'Università e le associazioni dei produttori ed utilizzatori.
- In riferimento al PPGRU, tra gli obiettivi derivanti dall'analisi di coerenza esterna, si reputa di includere gli obiettivi:
- assicurare le massime garanzie di tutela dell'ambiente e della salute, nonché di salvaguardia dei valori naturali e paesaggistici e delle risorse presenti nel territorio provinciale, anche al fine di avere un impatto sistemico (risparmio di materia vergine, risparmio energetico, minori emissioni di gas serra) coerente con il Protocollo di Kyoto;
- conformare la gestione dei rifiuti ai principi di responsabilizzazione e cooperazione di tutti i soggetti coinvolti, perseguendo l'economicità, l'efficienza e l'efficacia delle attività;
- assicurare una gestione unitaria ed integrata dei rifiuti urbani adottando soluzioni innovative, efficaci e sostenibili per le fasi di raccolta e trasporto dei rifiuti urbani, perseguendo il superamento della frammentazione istituzionale della gestione e favorendo processi di aggregazione e razionalizzazione della gestione tra i Comuni;
- perseguire lo sviluppo di una "diffusa cultura ambientale", basata su: attività di comunicazione e formazione, valorizzazione di capacità e competenze tecniche, ecofiscalità, consapevolezza sociale, accordi volontari, sensibilità ambientale e partecipazione con specifici riferimenti alle seguenti categorie:
- popolazione residente
- popolazione turistica
- giovani in età scolare
- pubblica amministrazione
- operatori economici
- associazionismo
- Individuare le soluzioni innovative ed ottimali per la gestione di particolari tipologie di rifiuti entranti nel circuito dei rifiuti urbani ed assimilabili, quali:
- rifiuti verdi
- rifiuti ingombranti
- rifiuti elettrici ed elettronici (RAEE)
- farmaci
- rifiuti di origine agricola (pericolosi e non pericolosi)
- oli vegetali
- previa valutazione delle possibilità di recupero e riciclo, applicando le Migliori Tecniche Disponibili (M.T.D.) e coinvolgendo l'ARPAS, gli Enti di ricerca, l'Università e le associazioni dei produttori ed utilizzatori.
- Formulati e codificati come segue:

A_Ob_CE_42 "assicurare le massime garanzie di tutela dell'ambiente e della salute, nonché di salvaguardia dei valori naturali e paesaggistici e delle risorse presenti nel territorio"

A_Ob_CE_43 "conformare la gestione dei rifiuti ai principi di responsabilizzazione e cooperazione di tutti i soggetti coinvolti, perseguendo l'economicità, l'efficienza e l'efficacia delle attività"

A_Ob_CE_44 "assicurare una gestione unitaria ed integrata dei rifiuti adottando soluzioni innovative, efficaci e sostenibili per le fasi di raccolta e trasporto dei rifiuti, perseguendo il superamento della frammentazione istituzionale della gestione e favorendo processi di aggregazione e razionalizzazione della gestione tra i Comuni"

A_Ob_CE_45 "perseguire lo sviluppo di una "diffusa cultura ambientale", basata su: attività di comunicazione e formazione, valorizzazione di capacità e competenze tecniche, ecofiscalità, consapevolezza sociale, accordi volontari, sensibilità ambientale e partecipazione con specifici riferimenti alla popolazione residente e turistica, ai giovani in età scolare, alla pubblica amministrazione, agli operatori economici e all'associazionismo"

A_Ob_CE_46 "Individuare le soluzioni innovative ed ottimali per la gestione di particolari tipologie di rifiuti, quali i rifiuti verdi, previa valutazione delle possibilità di recupero e riciclo"

Si noti che A_Ob_CE_43, A_Ob_CE_44 e A_Ob_CE_45 sono riproposti con formulazione identica a quella originale, mentre A_Ob_CE_42 e A_Ob_CE_46 sono riformulati. Nel primo è stato eliminato il riferimento al territorio provinciale e agli obiettivi del protocollo di Kyoto, in quanto il territorio di competenza del regolamento è circoscritto all'AMP, e l'incidenza delle azioni previste dal Regolamento è a una scala non commensurabile con quella degli obiettivi previsti dal Protocollo di Kyoto. Nel secondo, invece, sono stati mantenuti solo i rifiuti verdi, l'unica tipologia di rifiuto la

cui produzione è significativa all'interno del contesto di riferimento.

Per quanto concerne il livello comunale, nel "Piano di utilizzo dei litorali" (PUL) di Olbia sono individuati i seguenti obiettivi:

- garantire la conservazione e la tutela dell'ecosistema costiero;
- armonizzare ed integrare le azioni sul territorio per uno sviluppo sostenibile anche in relazione al territorio immediatamente attiguo;
- rapportare l'organizzazione dell'arenile al carattere naturale, rurale e urbano del contesto;
- migliorare l'accessibilità e la fruibilità del sistema litoraneo in maniera da contrastare i processi di erosione e degrado della risorsa spiaggia;
- promuovere e incentivare la riqualificazione ambientale;
- regolamentare e coordinare le diverse attività di servizio sui litorali attraverso processi di integrazione e complementarietà fra le stesse;
- favorire la qualità, l'innovazione e la diversificazione dell'offerta di servizi turistici;
- incentivare l'autonomia energetica delle strutture a servizio della balneazione attraverso l'utilizzo delle energie alternative con modalità morfologicamente integrate con le architetture.
- In riferimento al PUL di Olbia, tra gli obiettivi derivanti dall'analisi di coerenza esterna, si reputa di includere gli obiettivi:
- garantire la conservazione e la tutela dell'ecosistema costiero;
- armonizzare ed integrare le azioni sul territorio per uno sviluppo sostenibile anche in relazione al territorio immediatamente attiguo;
- rapportare l'organizzazione dell'arenile al carattere naturale, rurale e urbano del contesto;
- migliorare l'accessibilità e la fruibilità del sistema litoraneo in maniera da contrastare i processi di erosione e degrado della risorsa spiaggia;
- promuovere e incentivare la riqualificazione ambientale;
- regolamentare e coordinare le diverse attività di servizio sui litorali attraverso processi di integrazione e complementarietà fra le stesse;
- favorire la qualità, l'innovazione e la diversificazione dell'offerta di servizi turistici;
- incentivare l'autonomia energetica delle strutture a servizio della balneazione attraverso l'utilizzo delle energie alternative con modalità morfologicamente integrate con le architetture.

Formulati e codificati come segue:

A_Ob_CE_58 "garantire la conservazione e la tutela dell'ecosistema costiero"

A_Ob_CE_47 "armonizzare ed integrare le azioni sul territorio per uno sviluppo sostenibile anche in relazione al territorio immediatamente attiguo"

A_Ob_CE_48 "rapportare l'organizzazione dell'arenile al carattere naturale, rurale e urbano del contesto"

A_Ob_CE_49 "migliorare l'accessibilità e la fruibilità del sistema litoraneo in maniera da contrastare i processi di erosione e degrado della risorsa spiaggia"

A_Ob_CE_50 "promuovere e incentivare la riqualificazione ambientale"

A_Ob_CE_51 "regolamentare e coordinare le diverse attività di servizio sui litorali attraverso processi di integrazione e complementarietà fra le stesse"

A_Ob_CE_52 "favorire la qualità, l'innovazione e la diversificazione dell'offerta di servizi turistici"

A_Ob_CE_53 "incentivare l'autonomia energetica delle strutture a servizio della balneazione attraverso l'utilizzo delle energie alternative con modalità morfologicamente integrate con le architetture"

Si noti che tutti gli obiettivi sono riproposti con formulazione identica a quella originale.

## Discussione e conclusioni

Il contributo propone un approccio per l'inclusione, all'interno dei Regolamenti delle AMP, degli obiettivi dei diversi piani e programmi definiti a livello regionale, provinciale e locale, in vigore nelle AMP considerate. Obiettivi che, qualora questa analisi non venisse condotta, rischierebbero di essere erroneamente trascurati.

Ai fini dell'analisi, sono stati considerati 36 piani nel caso dell'AMP "Tavolara–Punta Coda Cavallo" e 32 per l'AMP "Capo Carbonara", da cui sono stati estrapolati rispettivamente 69 e 41 obiettivi di coerenza esterna. Alcuni obiettivi sono stati riproposti secondo la loro formulazione originale, mentre altri sono stati riformulati al fine di renderli conformi alle caratteristiche dell'area in esame. Sono stati riportati, a titolo di esempio, gli obiettivi A_Ob_CE_2, A_Ob_CE_42 e A_Ob_CE_46, nei quali la riformulazione è volta alla eliminazione rispettivamente di competenze in capo ad altre entità territoriali, di obiettivi a una scala maggiore di quella di un regolamento di un'AMP, e infine di aspetti non caratterizzanti l'area in esame.

Nonostante queste operazioni, negli esempi presentati, è spesso evidente una stretta similitudine tra obiettivi derivanti da strumenti diversi, per cui una loro riproposizione secondo queste formulazioni nel Regolamento risulterebbe ridondante. È questo il caso, degli obiettivi A_Ob_CE_1, A_Ob_CE_42, A_Ob_CE_62, i quali perseguono tutti la tutela e la riqualificazione ambientale. Per tale motivo, a questa prima fase di identificazione degli obiettivi, seguirà una seconda fase, che confronterà tra loro gli obiettivi estrapolati dai vari strumenti pianificatori e provvederà ad una loro rielaborazione finalizzata al superamento di ridondanze e contrasti.

L'analisi di coerenza esterna si configura, quindi, quale componente del Protocollo sperimentale, proposto come metodo di valutazione per la redazione di strumenti pianificatori che integrino gli aspetti legati alle diverse tematiche settoriali, approdando, così, a un sistema olistico di gestione del territorio, che consenta di contrastare efficacemente la frammentazione degli habitat e la conseguente perdita di biodiversità, fondamentale per la fornitura di servizi ecosistemici.

1. Il presente contributo è il risultato del lavoro congiunto dei due autori.
2. Questo studio è sviluppato nell'ambito del Progetto di ricerca di cui alla Convenzione tra il Dipartimento di Ingegneria Civile, Ambientale e Architettura (DICAAR) dell'Università di Cagliari e la Regione Autonoma della Sardegna, Assessorato della Difesa dell'Ambiente, finalizzata al raggiungimento degli obiettivi del Progetto "GIREPAM - Gestione Integrata delle Reti Ecologiche attraverso i Parchi e le Aree Marine" finanziato nell'ambito del Programma INTERREG Marittimo Italia-Francia Maritime 2014-2020, Asse II; Responsabile scientifico: Prof. Corrado Zoppi.

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# Territorial specialization in tourism sector as ecosystem service – the case of Basilicata Region


Francesco Scorza, Federico Amato, Ylenia Fortino, Beniamino Murgante, Giuseppe Las Casas


## Introduction

Since the beginning of the 21st century, ecosystem services have started to be considered as having a primary role in decision-making processes concerning numerous fields, such as economy, public policies, territorial planning and environmental assessment (Leemans and De Groot 2003). The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005; TEEB, 2010) identified four categories of ecosystem services - supplying services (food and fibre production, water production, biological and cosmetics production etc.), regulation services (maintenance of the air quality, climate regulation, flood regulation, erosion or drought, pollination, water purification, etc.), cultural services (cultural diversity, recreational or spiritual services, aesthetic values, ecotourism etc.), and support services (carbon sequestration, soil formation, etc.).

Starting from this classification, this paper investigates interpretative models for the evaluation of a relevant part of the fourth class of ecosystem services: the territorial tourism attractiveness. Specifically, this research aims to assess the territorial specialization level of the Basilicata Region in terms of tourism attractiveness. This is considered a significant index of the presence of natural, cultural and landscape resources (tourism attractors) and of a proper supply system in the tourism field. Hence, it can pointedly be used to support resource-planning processes for the upgrading of the tourism sector.

This is an important outcome, especially considering how the attention to territorial specialization is one of the most important strategic point of the 2014-2020 European Union Cohesion Policy (DG Regio, 2011; EC 2008; EC 2010; EC 2010a) of the Smart Specialization Strategy (McCann and Ortega-Argilés, 2015) and of the Regional Operational Programs according to the indications already formalized by the former Italian minister Barca (2009). Thus, this work is a first step toward the definition of decision support systems (DSS) (i.e. a toolkit, as it is formalised in (Las Casas and Scorza, 2016) to apply a context-based approach in an interpretative system of the territory measured at regional scale.

## Materials and methods

This paper defines a synthetic territorial indicator of the tourism specialization level in the Basilicata Region. Basilicata territory is rich for natural habitats, cultural values (Amato et al., 2017) and traditions that make possible to indicate tourism development as the main key element for socio-economic progress of the entire region. Tourism has gained a consistent weight in the economic and productive system of Basilicata thanks to significant public and private investment. This situation has led to a significant increase in the number of beds and new accommodation facilities, with positive effects on the entire hospitality chains and a substantial increase of tourism demand, with the consequent strengthening of the tourist flows.

The analytical model used is the "Recreation and Tourism" package included in the Invest (Integrated Valuation of Ecosystem Services and Trade-offs) suite by the Stanford University Natural Capital (NCP) project and The University of Minnesota (NCP, 2015). To develop the indicator input variables have been grouped into four domains of interest: natural heritage, cultural heritage, accommodation, tourism and social media. Based on these variables, Invest processes a linear regression model through the equation:

$$y = \beta\_0 + \beta\_1 x\_1 + \beta\_2 x\_2 + \ldots + \beta\_i x\_i + e\_1 \quad i=1,\ldots,N$$

where $\beta\_i$ are the linear regression coefficients $x\_i$ are the territorial components considered as predictive variables to input into the software; $y$ matches with the expected value of the model, which in the specific case is the Basilicata region tourism specialization level. The model was applied on each domain and on their proper combinations to identify the most significant variable ones. The determination coefficient, better known as $R^2$, is used as a measure of the good adaptation of the multiple linear

regression model. This is a value between 0 and 1 expressing the relationship between the variance explained by the model and the total variance. The more the result is close to 1, the more the predictors (input variables) are a good interpreter of the dependent variable value in the sample.

## Results

As mentioned in the previous section, to outline a regional tourist attraction index, predictive variables have been grouped into four domains of interest. The methodology was then applied on each domain and on their combinations. Considering the four domains, the following aspects have been highlighted by the application of the model:

- *Natural heritage:* the model properly recognised the specialization of the southwestern part of the region in terms of supply of naturalistic and environmental attractors. Moreover, it also highlighted the role of other peculiar landscapes characterising the area such as Monte Vulture, the graves area in Matera and the National Park "Appennino Lucano". The contribution of coastal areas and of many protected areas in terms of attractiveness was also perceptible.
- Cultural heritage: the model showed the distribution of the historical/cultural sites and the contribution that historical settlements and the archaeological sites have on the regional tourism specialization. Matera is the main historical/cultural attraction pole in Basilicata while Potenza is recognizable as the centre of cultural services.
- *Accommodation:* considering tourist flows (arrival - presences) and accommodation facilities by the number of available beds, the data provided by the local territorial agency for the promotion did not gave an immediate picture of the tourist consistency in Basilicata. Therefore, it has been necessary to adopt an appropriate procedure to geocode the accommodation facilities (including 1024 Hotels, B&B, camping etc.), thus building a punctual dataset delivering information about the number of beds and the services offered to the tourists (Amato et al., 2014; Di Palma et al., 2014. Based on this database, information on tourist presences and tourist arrivals were distributed depending on the number of beds offered by each accommodation facility. This operation involved a significant approximation. Nevertheless, it allowed overcoming the traditional aggregation of data per over-municipal tourist areas in order to provide results in a detailed-scale, which has been considered to be more useful for the research purposes. Specifically, results showed how the tourist flow has moved from the main seaside tourism destinations (Basilicata coast) to the cultural inner centers and, particularly, to Matera city, which has been recently designated as European Capital of Culture 2019.
- *Tourism and social media:* the INVEST toolbox can extract from the social network "Flickr" data concerning the number of georeferenced pictures published in an area during a fixed time-period. These data were used as an unconventional information layer in the regression model to take into account a measure of the interest of visitors related to each territorial attractor.

Finally, in the last iteration the linear regression model has been applied considering the combination of all domains of interest. The result showed the contributions of each individual domain and the different levels of specialization (Fig. 1).

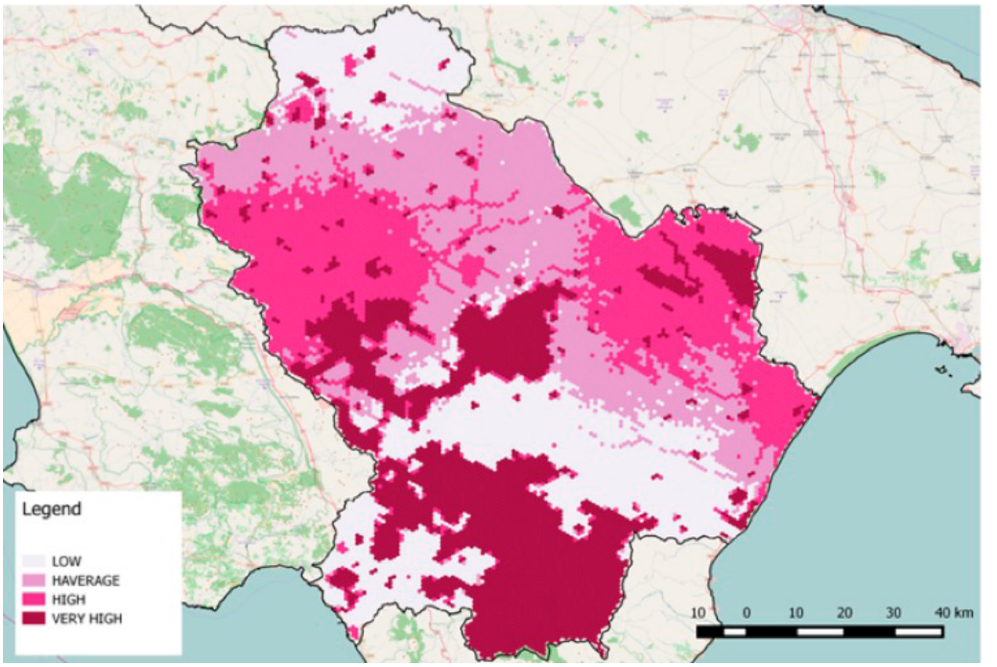


Fig. 1 – The regional territory in terms of tourist attractiveness.

## Discussion and conclusions

This paper proposed a global interpretation of the regional territory in terms of tourist attraction. This information is considered to be relevant in supporting the governance processes of tourism development. The tested methodology showed significant robustness in terms of interpretation capacity of the territorial context in which it has been applied. However, in order to improve it more accurate information on tourism resources and services categories should be provided. Indeed, the research highlighted the absence of complete and consistent information concerning tourism, especially in terms of availability of spatial data. Concerning the methodological profile, the Invest model was found to be useful for the geospatial features offered. Nevertheless, to reach a more significant representation of the territorial tourism attractiveness levels, it should be further developed to allow more possibilities of defining a weighing system associable to input variables.

The results obtained for Basilicata Region are affected by the fragmentation of the local tourism promotion agency's information. Thus, the output of the model provides a different picture of regional tourism from the one provided by the local tourism promotion agency's statistics. This shows hoe the APT regional macro aggregations proposed for the touristic flows assessment and the

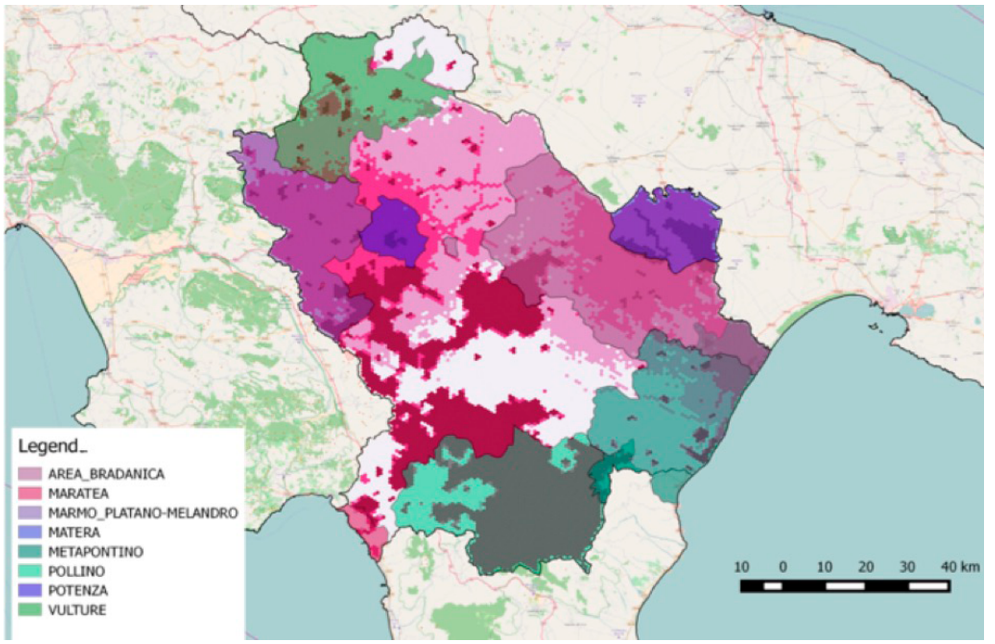


Fig. 2 – Comparison of the tourist aggregations provided by the APT and the homogeneity of the result returned by Invest.

regional tourism consistency are inappropriate to capture the levels of Basilicata tourism specialization. The latter has recently undergone to many deep transformations that, in the specific case of Basilicata region, should be compared with the spatial distribution of natural risks, including land take, and spatial planning system (Nolè et al., 2015; Amato et al., 2015; Amato et al., 2016) together with real estate estimations (Morano and Tajani 2017; Tajani and Morano 2017; Morano et al., 2017; Tajani et al., 2016).

Hence, it is clear how the actual inter-municipal specialization areas defined by the local tourism promotion agency cannot reach the level of specialization obtained through the analysis proposed in this paper (Fig. 2). This means that a renovation of the territorial policies concerning tourism management and governance should be delivered according to the attractive potential of territorial areas excluding municipal administrative borders as markers to represent territorial specialization.

A potential extension of this research should therefore aim at rebuilding the interpretative system into a different scale to extend the spatial analysis area to an interregional or national context.

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# Urban drainage modelling and runoff control: the potential of Sustainable urban Drainage Systems application in land-use planning process

Viviana Pappalardo

## (Rain)water flow regulation and urban planning

In the face of both a changing climate and a more urbanized environment, planning systems were acknowledged of being slow and sometimes unable to solve problems arose from the management of precipitation across most development parts of the word (White, 2010).

There is no doubt that flooding is, to some extent, a matter of land use control. Pluvial flooding in urban areas it is even more.

Spatial planning and its basic tools such as land use masterplans with related actions of local transformations, influence catchment hydrologic response in depth. Thus, understanding the effects of urban patterns and their potential transformation on storm-water drainage modification is a crucial issue since early design stages of plans (Pappalardo et al., 2017b). At the same time, planning policies and building regulations may work as control methods to regulate the negative effects of runoff, with the opportunity of filling in the usual gap between land use control and water quantity control (White, 2010).The role of planning therefore goes beyond a narrow spatial configuration of land uses and addresses the risk and the resilience issues. When thinking about the theme of "too much water" in cities, the awareness that not all floods can be prevented or faced relying only on traditional engineered methods, facilitated the most recent shift in flood management and opened to the perspective of working with nature-based solutions to support a more sustainable urban drainage by making use of regulating services provided by ecosystems.

In particular, innovative drainage-related concepts and methods, such as Sustainable urban Drainage Systems (SuDS), origin from the shift to an ecosystem-based urban drainage approach, which is aimed at restoring or recreating a more naturally-oriented water cycle in urban areas by minimizing the impacts from the development on the quantity and quality of the runoff, maximizing amenity and biodiversity opportunities and specifically slowing water down before it enters a watercourse, providing infiltration, filtration, onsite storage, detention and evapotranspiration (Fletcher et al., 2014).

Moreover, EU policy document on "Natural Water Retention Measures" put SuDS in the class of "urban development" measures, which contribute to achieve the goals of key EU policies such as the Water Framework Directive (WFD) and the Floods Directive (FD). SuDS and the other measures can enhance synergies between the implementation of both directives and support the coordination between the River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs) (European Union, 2014) that work, by the way, as mandatory planning tools for those belonging to a lower planning level.

*Modelling tools in support of planning land-use planning process*

In order to allow water-regulating services clearly inform sustainable planning decisions, indications in planning and policy instruments or norms must be built by understanding and putting into effects information coming from the ES assessment. Modelling tools used by research studies for describing physical phenomena become useful when helping in giving at least a rational base to spatial decisions, which are unavoidably subjective besides.

Relying on models for characterizing territorial phenomena, especially when facing environmental and risk issues, enriches the spatial planning process comprehensively: starting from knowledge building due to the inherent analytic nature of modelling, carrying on with the stage of evaluation and interpretation of spatial dynamics, and ending with strategic decisions that inform land transformations. More broadly, the ES assessment under a spatial planning process is carried out through the use of indicators. Indicators "can lead to better decisions and more effective actions by simplifying, clarifying and making aggregated information available to policy makers. They can help incorporate physical and social science knowledge into decision making, and they can help measure and calibrate progress toward sustainable development goals" (UN, 2007).

## A Dual Drainage Systems approach

Conventional urban drainage models are not suitable for realistically modelling urban flooding processes and representing interactive dynamics of overland flow and subsurface flow (Boonya-aroonenet et al., 2007). During urban flooding the capacity of drainage system is overloaded so that the surcharged flows travel overland along the preferential flood pathways that create a surface flow network typically called the "major system," while the "minor system" refers to an underground sewer network (Maksimovic et al., 2009). The real feature of urban catchments and processes related to the rainfall-runoff transformation are too complex to be simulated in detail and trying some kind of simplification may be even more helpful in order to use information coming from the assessment and to the purposes of the planning process.

The US-EPA-Storm Water Management Model (SWMM) (Rossman, 2010) could be used to simulate the interaction of surface flow processes with flow in sewers, thus modelling the flow exchanges that occur between the minor and major drainage systems at their interconnected underground and surface sections. We applied the approach at the scale of urban catchments by integrating the pipe flow with a 1D surface flow model and basing the analysis on the hypothesis of surcharged flows conveyed downstream through streets and no longer entering the minor system at manholes.

To describe the process under the current conditions of considered urban catchments, the following tasks were carried out: i) the determination of design rain events by using the Chicago synthetic hyetographs (Keifer and Chu, 1957) associated to a range of return periods storms of 1-h duration (5, 50 and 100 years); ii) the delineation of sub-catchments in order to identify sub-areas that contributes the flow to individual drainage elements through inlets, basing on information derived from drainage systems plans and physical characteristics of the urban catchment such as the terrain slope (sub-catchment delineation through DTM-based hydrologic processing); iii) the modelling of the underground storm-water drainage system as a network of hydraulic elements of junction nodes and links (where links represent pipe or channels that move water from one node to another in the conveyance system whilst junctions are drainage system nodes that can physically represent manholes in a sewer system, or pipe connection fittings (Rossman, 2010)); iv) the modelling of the surface systems where streets and squares are considered conveyance elements; v) the overlapping of minor and major systems with the identification of connection nodes for considering vertical flows; vi) the identification of junction nodes (manholes of the minor system) where excess water becomes partially pressurized while connecting conduits are surcharged and is lost from the system, and the respective excess flow rates; vii) the inlet of hydrographs of pressurized flow into correspondent nodes of the major system.

The applied method allows to obtain local (surface) flood flow depths and velocities, thus enabling the analysis of different flood mitigation schemes, among which the potential of SuDS application in providing regulating services in urban contexts.

SWMM allowed the modelling and simulation of a number of SuDS measures (bioretention cells, rain gardens, green roofs, infiltration trenches, continuous porous pavements, rain barrels and vegetative swales) that are considered as features of a given sub-catchment and capture surface run-off providing a combination of detention, infiltration, and evapotranspiration (Pappalardo et al., 2017). The direct consequence is the possibility of examining changes in flood parameters characterizing the considered urban catchments under a range of rainfall events, when simulating deployments of various SuDS combinations according to strategic design of plans and related local policy tools.

The comparison between scenarios of pre- and post-implementation of SuDS, is based on resulting flow depths and velocities, which are considered as basic indicators for assessing the regulating service capacity of the planned scenario.

## The Avola case study

Avola is a municipality located in the Province of Noto, on the south eastern coast of Sicily, Italy. The city has an area of about 7400 ha and is characterized by a dense developed area and large cultivated lands falling within two major river basins (North and South), a mountains plateau (West) and the coast (East). The urban pattern of compact and regular grid of rectangular blocks retraces the models of the foundation cities. At the beginning, the regular grids were aligned to the sides of the primary urban settlement and then they followed the main streets, addressing the demand of urban growth during the long period between the 70ies and 80ies. Progressively, the urban development has been regulated by two land-use masterplans dated back to 1972 and 2003, respectively. Actually, urban growth processes have been governed with planning tools not truly aware of land protection and built an urban pattern of medium density, developed close to the town centre and roughly following the urban rationalist models already existing in the area.

Between 1970 and 1990, along with the urban core development, two spreading processes have determined the current urban pattern. The first one affected the coastline sparsely while the second one concerned peri-urban and rural areas diffusely. The city have experienced great problems of surface and pluvial flooding, outside and inside the urban centre, demanding effective adaptation and mitigation actions to be considered in the updating process of local land use masterplan.

This paper describes how the dual drainage approach was adopted to analyse the hydrologic and hydraulic response of some urban catchments located in the dense city centre and comments on the results of some scenario analyses, where the implementation of SuDS measure such as green roofs and rain barrels is considered as a potential retrofitting action in the analysed urban context.

Once the probability analysis of rainfall and the synthetic storm hyetographs determination have been completed, the hydrologic and hydraulic models of the studied urban catchments have been constructed (systems representation and model setup) in SWMM, in order to simulate the interaction between the minor and major drainage systems. In particular, it was preliminarily necessary to split the considered catchment into smaller sub-catchments, each one characterised by specific parameters for representing their permeability degree, area, slope, etc., and then to proceed by modelling the network of hydraulic elements (minor system/storm-

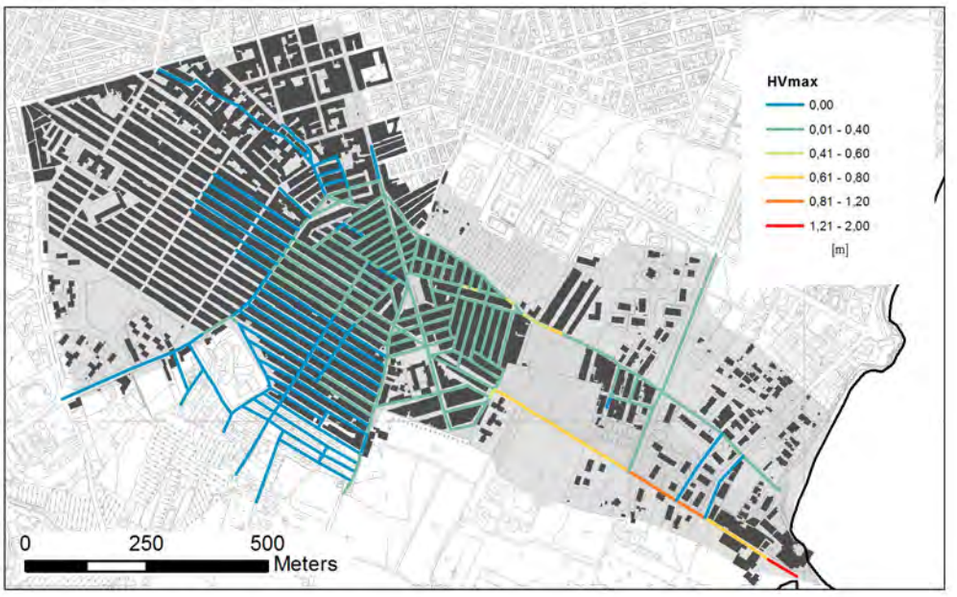


Figure 1– Classification of pluvial flooding hazard in the major drainage system, 50 years return period

| | | | *rain barrels* scenario | | |
|---|---|---|---|---|---|
| | | | (a) | (b) | (c) |
| | | | *1 m³/200 m²* | *1 m³/100 m²* | *1 m³/500 m²* |
| **Urban Catchment** subdivision | *covered area (buildings) [m²]* | *%imp.Area (treated)* | *m³* | *m³* | *m³* |
| Sub-catch.1 (5 ha) | 29800,74 | 59,60 | 149,0 | 298,0 | 596,0 |
| Sub-catch.2 | - | - | - | - | - |
| Sub-catch.3 (5,98 ha) | 34619,44 | 57,89 | 173,10 | 346,2 | 692,4 |
| Sub-catch.4 | - | - | - | - | - |
| Sub-catch.5 | - | - | - | - | - |
| Sub-catch.6 (5,30 ha) | 8849,52 | 16,70 | 44,25 | 88,50 | 177,0 |
| Sub-catch.7 (8,32 ha) | 12144,68 | 14,60 | 60,72 | 121,45 | 242,9 |

Table 1 – Rain barrels scenarios setup

water drainage system) as junction nodes and links. Finally, it was necessary to model streets and intersections of the major drainage system by defining cross section transect objects: irregular shapes were used to represent the cross sections of streets likened to conduits. The transects that define point by point these shapes are created using SWMM's "Transect Editor". The first step was to run the model of the minor drainage system for each design storm event to check its general performance. After running this model, the resulting status report showed that a numbers of nodes surcharged or flooded, indicating that the system was undersized yet for a 5-year return period event. Node flooding referred to all water that overflowed a node and was lost from the minor system becoming the flow rate to be drained by the major system. The total of the discharge variations with respect to time, which are plotted in the hydrographs created from available simulation results at each flooded node junction, represents the volume not conveyed and was used as input parameter for simulating the flow routing within streets of the considered urban catchments.

*Results of the zero-scenario simulations (current conditions)*

We derived from simulations the maximum values of water depth and flow velocity for each link (street) of the major drainage system and mapped the results for each return period (5, 50 and 100 years). The flooding parameters were also used to deduce flood hazard maps expressing the hazard level based on the classification of Cox et al., 2010.

The central area of the major system and the main streets facing SE and NO toward the coastline were the system elements where higher values of water depths were reached but varying below 0,10m and going beyond 0,30m only few times at downstream sections (5 years return period). As expected, here the overall situation get worse if the hazard conditions are considered as a function of the product between the flow depth and velocity, especially when looking at results from 100 years return period simulation event, for which the highest hazard level is obtained. Even though safety conditions are diffusely certain at least for lower return periods, which are traditionally related to urban drainage systems' design, going into details of results and maps allows to better understand the effect of different urban patterns and features on rainfall-runoff transformation process. Upstream urban settlements heavily contribute to the generation of runoff which is conveyed downstream with difficulties that increase with increasing return periods.

*Results of the SuDS-scenarios simulations (retrofitted conditions)*

Results of the zero-scenario simulations showed that the more dense is the urban settlements causing drainage systems failure the more is the need of a widespread flood control project. That means to build policy strategies for encouraging the implementation of mitigation measures such as SuDS as much as possible extensively in the existing urban areas. Retrofitting sustainable drainage measures can be used strategically to tackle known flooding problems, considering that no space is useless and the conventional drainage approach could be challenged in both private land and public realm (Digman et al., 2012). After having considered how SuDS and urban morphology of the urban catchments could be integrated (suitability of measures in the specific location on a sub-catchment scale), this paper describes results from the simulation of rain barrels (Table 1) and green roofs (Table 2) adoption (green roof's layers designed according to site-specific conditions) in one of the analysed urban catchments. In both cases implementation scenarios were modelled basing on increasing percentage of urban catchment retrofitting via the considered SuDS measure (rain barrels or green roofs). Thus, the change in the sub-catchments' responses to design events was analysed, by collecting data of total runoff and peak runoff

| | | green roofs scenario | | | | | |
|---|---|---|---|---|---|---|---|
| | | (a) 10% retrofit | | (b) 30% retrofit | | (c) 50% retrofit | |
| Urban Catchment subdivision | *covered area (buildings) [m²]* | *m² (retrofitted)* | *% Area(Sub-catch)* | *m² (retrofitted)* | *% Area(Sub-catch)* | *m² (retrofitted)* | *% Area(Sub-catch)* |
| Sub-catch.1 (5 ha) | 29800,74 | 2980,07 | 5,96 | 8940,22 | 17,88 | 14900,37 | 29,80 |
| Sub-catch.2 (7,10 ha) | 4121,24- | 4121,24 | 5,80 | 12363,72 | 17,41 | 20606,20 | 29,02 |
| Sub-catch.3 (5,98 ha) | 34619,44 | 3461,94 | 5,79 | 10385,83 | 17,37 | 17309,72 | 28,95 |
| Sub-catch.4 (0,21 ha) | 136,93- | 136,93 | 6,52 | 410,79 | 19,56 | 684,65 | 32,60 |
| Sub-catch.5 (6,70 ha) | 1488,45- | 1488,45 | 2,22 | 4465,34 | 6,66 | 7442,24 | 11,11 |
| Sub-catch.6 (5,30 ha) | 8849,52 | 884,95 | 1,67 | 2654,86 | 5,01 | 4424,76 | 8,35 |
| Sub-catch.7 (8,32 ha) | 12144,68 | 1214,47 | 1,46 | 3643,40 | 4,38 | 6072,34 | 7,30 |

Table 2 – Green roofs scenarios setup

| | *rain barrels* scenario (c) | | | *green roofs* scenario (c) | |
|---|---|---|---|---|---|
| 5 years return period | *Total volume reduction [%]* | *Peak flow reduction [%]* | | *Total volume reduction [%]* | *Peak flow reduction [%]* |
| Sub-catch.1 | 32,92 | 51,67 | | 20,06 | 30,00 |
| Sub-catch.2 | 0,00 | 0,00 | | 19,09 | 19,83 |
| Sub-catch.3 | 32,41 | 48,08 | | 19,15 | 20,19 |
| Sub-catch.4 | 0,00 | 0,00 | | 22,29 | 40,00 |
| Sub-catch.5 | 0,00 | 0,00 | | 7,93 | 15,96 |
| Sub-catch.6 | 16,08 | 16,67 | | 5,80 | 11,11 |
| Sub-catch.7 | 10,63 | 14,41 | | 5,42 | 5,93 |

Table 3 – Results of SuDS scenarios modelling (configuration c - 5 years return period)

at the outlet section of each retrofitted sub-catchments. Depending on the characteristic of the considered retrofitted sub-catchment in terms of urban density and position with respect to the belonging urban catchment, the contribution of SuDS varied importantly but became really useful in mitigating peak flows and reducing flood volumes (up to 50% e 30% for rain barrels adoption and 5 years return period event) only in scenarios of large portions of sub-catchments treated via SuDS, and under events of low return periods (Table 3). Accordingly, the regulating service provided through the variation of flood parameters, which results into the mitigation of flood hazard, were very limited, especially in case of extreme events. This means that it is generally necessary to combine the SuDS designs with the conventional flood control measures when addressing severe flooding events.

*Planning for SuDS*

At a local level the inclusion of policies on sustainable drainage in local authority's masterplans and development frameworks provide an opportunity to encourage sustainable drainage (Dickie et al., 2010). In the case of the city of Avola, the local authority was interested in developing a good plan of action that could transform a vision of sustainability and resilience to risk into reality. Relying also on considerations, maps and results carried out through this research, a first attempt of including the provision of regulating service in norms via policies for SuDS implementation has been recently made (Comune di Avola, 2017).

In particular, to incite better private behaviours, a combination of command-and-control and incentive-based policy instruments has been proposed for areas of new development: on-site retention rules place the responsibility of reducing runoff on the party generating the runoff by requiring the compliance for post-development conditions to meet the pre-development ones, along with the general reduction of impervious surfaces; development incentives are conceived to be offered developers during the permit's application process and consist of density bonus incentive (greater height) for installing SuDS in their properties or supporting retrofitting action in existing settlements within the belonging urban catchment.

## Conclusions

Along with choosing the more suitable model to solve a specific problem of phenomenon representation, the thorny problem becomes to provide information and classifications in terms of some "added value" for expressing on settlements and environments, which could be useful to the definition of spatial strategies and actions addressed to modify site-specific situations, such as urban risks.

For example, a substantial and very common outcome of modelling applications is the mapping, which allows the provision of synthetic charts by conveniently assembling results and information. A big advantage of the use of maps is the possibility of visualizing the phenomenon such as the stormwater flooding, providing an insight to the problem and the cause of it, making this tool ideal both for planning strategies and multidisciplinary decision-making. At the same time, indicators resulting from scenario modelling can help in setting the design criteria by establishing a clear and shared SuDS vision, along with easing the selection of the most appropriate local policies for integrating water regulating service into plans and norms.

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# Second law of thermodynamics and ecosystem services: a systemic approach to urban green infrastructure planning


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## Abstract

Planning of ecosystem services provided by the Urban Green Infrastructure (UGI) is a key issue for urban sustainability. Planning strategies driven by the second law of thermodynamics (SLT) are innovative approaches to sustainability but they are still in seminal phase. In this article, a coupled review of SLT within spatial planning is accomplished looking at the main applications in urban green infrastructure (UGI) planning. The work has supported the definition of a preliminary low-entropy UGI planning strategy (Pelorosso, Gobattoni, and Leone 2017) but it also aims to contribute to the improvement and/or development of even more solid planning strategies based on SLT. In particular, a systemic review of UGI planning and thermodynamics has been carried out to identify all the occurrences to date in the scientific literature. Secondly, a scoping review of SLT-related concepts of exergy, entropy and urban metabolism is presented in order to investigate the main applications of, and gaps in, urban spatial planning. Results indicate that UGI and ecosystem service planning based on SLT is a relatively new field of research. Moreover, some general indications are derived for the development of spatial UGI planning strategies based on SLT.


Keywords: entropy; exergy; urban metabolism; urban planning; low-entropy; ecosystem services


## Introduction

The fundamental functions of natural systems that support citizen life are mainly provided by the Urban Green Infrastructure (UGI). Indeed, UGI is defined as an interconnected network of natural systems and Nature-Based Solutions (NBSs), localised at landscape scale and fully integrated with the built environment, which provides a diversified array of Urban Ecosystem Services (UESs) to the urban socio-ecological system increasing its resilience. NBSs are engineered green/ecological systems inspired or supported by, or copied from, Nature (EU 2015). UESs are benefits that people derive directly or indirectly from natural and managed ecosystems (Pelorosso, Gobattoni, and Leone 2017). Thus, UGI planning aims to enhance the sustainability and resilience of urban systems. However, city sustainability is a complex issue and, we should not only select with care the proper direction for future city development, but also find strong grounds on which to base our moves to avoid expensive and/or late re-thinking. Thermodynamics of open systems, with the Second Law of Thermodynamics (SLT) in particular, is one of the most solid discipline for the study of complex systems and several applications of it have been emerged also in urban planning (see Pelorosso, Gobattoni, and Leone 2017).

Following the SLT, cities are metabolic far-from equilibrium systems, which utilize energy and matter flows to maintain levels of complexity, organization, and functionality releasing entropy (disorder or waste) into the environment (Fath 2017). In pursuit of diverse objectives, humans modify land use and the socio-ecological and technical infrastructures which regulate urban energy and matter metabolisms. In a sustainable and systemic SLT view of the urban metabolism processes, exergy (or work capacity) should be maximised and entropy discharges reduced (Pelorosso, Gobattoni, and Leone 2017). The concepts of entropy, exergy and urban metabolism (UM) are therefore strictly linked to the SLT and several applications of them are present in scientific literature as well as in sustainable urban planning and design (Bristow and Kennedy 2015; Leone, Gobattoni, and Pelorosso 2016)more importantly, the need for raw materials and food products is growing quickly, as a result of the western development model. The energy-consuming (energivorous.

Recently, Pelorosso, Gobattoni, and Leone (2017) have presented a seminal low-entropy UGI strategy which incorporates social and ecological aspects and new operational entropy indicators into an adaptive SLT planning framework. The low-entropy city concept at the basis of the UGI planning strategy calls for innovation and more efficient urban

| Searched terms | Occurrences | |
|---|---|---|
| | Scopus | ISI |
| Q1: "green" AND "thermodynamic/s" AND "urban" | 39 | 9 |
| Q2: "green" AND "thermodynamic/s" AND "planning" | 25 | 8 |
| Q3: "green" AND "infrastructure/s" AND "thermodynamic/s" | 7 | 3 |
| Q4: "green" AND "thermodynamic/s" AND "urban" AND "planning" | 9 | 0 |
| Q5: "green" AND "infrastructure/s" AND "thermodynamic/s" AND "urban" | 3 | 0 |
| Q6: "green" AND "infrastructure/s" AND "thermodynamic/s" AND "planning" | 0 | 0 |
| Q7: "green" AND "infrastructure/s" AND "thermodynamic/s" AND "urban" AND "planning" | 0 | 0 |
| **Total occurrences** | **59** | **18** |

Tab.1 Results from queries on SCOPUS and ISI Web of Knowledge (ISI WoK) (period: up to 25/01/2017)

| Concept | References | Field of application |
|---|---|---|
| Exergy | (Stremke and Koh 2011); (Stremke and Van den Dobbelsteen 2013) | Renewable resources and sustainable energy landscapes. Several study cases of exergetic optimization in The Netherlands |
| | (Leduc and Van Kann 2013) | Sustainable urban energy planning. Kerkrade-West neighbourhood, The Netherlands |
| | (Balocco et al. 2004) | Sustainability of built up areas. Castelnuovo Berardenga, Italy. |
| Entropy | (Balocco and Grazzini 2000) | Sustainability of urban areas in terms of energy. Florence, Italy. |
| | (Fistola and La Rocca 2014) | Urban entropy assessment. Benevento, Italy. |
| Urban metabolism | (Chrysoulakis et al. 2013) | Sustainability of urban planning interventions. Helsinki, Athens, London, Florence and Gliwice. |
| | (Codoban and Kennedy 2008) | Design of sustainable neighbourhoods. Toronto, Canada |
| | (Voskamp et al. 2016) | Urban planning and design. Amsterdam, The Netherlands |
| | (Pincetl et al. 2014) | Urban environmental sustainability. Los Angeles, California |

Tab.2 Spatial planning and second law of Thermodynamics: relevant applications of SLT concepts and study cases from scoping review.

systems, from compacted to sprawled, with a stronger nature integration, able to use local and renewable resources, to reuse wastes and to institute closed productive cycles. These new urban socio-ecological systems, by maximizing cyclic, non-dissipative flows while minimizing dissipative flows, would release less entropy out of the system and, like a complex living organism that tends to minimum entropy production (e.g. the more healthy, mature forests at later stages of succession), they would persist and even grow in an even more sustainable manner (Pelorosso, Gobattoni, and Leone 2017).

The objective of this article is to present the background review, carried out to aid the development of the recently proposed strategy by providing information about state of art UGI planning and SLT applications. It aims therefore to support the improvement/development of UGI planning strategies based on thermodynamics concepts. To this aim, a coupled systemic and scoping review is presented, highlighting the main applications and gaps present in urban planning with particular reference to SLT related concepts and UGI. In particular, we sought for explicit spatial UGI analyses with real study cases, which could facilitate the task of applying the research results to guide practical decision-support within planning processes. Indeed, explicit evidence of spatial anisotropies of land uses and indicators allow scenarios and urban projects to be designed considering the complex relationships among UGI components and urban systems (Pelorosso, Gobattoni, Geri, et al. 2017).

## Material and methods

To point out the links between SLT and UGI planning, a preliminary systemic review based on peer-reviewed papers or book chapters on the Scopus (http://scopus.com) and ISI Web of Knowledge (WoK) databases (https://webofknowledge.com) has been performed. A combination of terms was used to capture all the possible scientific products with ongoing research within the title, keyword and abstract fields. In particular, the search engines were used to explore the use of the terms thermodynamics, green, infrastructure, urban and planning (see the queries reported in Table 1). We then verified the relevance of the selected dataset with thermodynamics and real study cases of spatial UGI planning. Additionally, a second review framework, concentrated efforts on the concepts of exergy, entropy and urban metabolism even though UGI were not considered directly. Since the scientific literature on these three research fields is abundant and diversified, a scoping review (Arksey and O'Malley 2005) was carried out to build a knowledge synthesis regarding the following research question: what are the main applications of, and gaps in, SLT related concepts (exergy, entropy and urban metabolism) within spatial planning with particular reference to urban systems and UGI? Google Scholar was used to search for published papers and books following the individual terms exergy, entropy and urban metabolism in an iterative process engaging with each stage in a reflexive way, repeating search steps in order to ensure a comprehensive coverage of the literature (Arksey & O'Malley, 2005). References reported in the papers identified were also checked following the same search engine. We focused in particular on the most recent literature in order to report significant update information. The majority of the publications found were thus filtered out, taking into account only the most recent scientific products reporting spatially explicit quantifications, prioritizing works with practical applicability for urban planning.

## Results and discussion

The systemic review on UGI planning and SLT has brought to light few occurrences within scientific products for significant terms. In particular, no result was found considering UGI planning in urban contexts related to Thermodynamics (see queries 6 and 7, Table 1). Considering combinations of terms, the search provided a total number of 77 papers. Then, excluding overlaps between the two dataset we kept 66 papers. Amongst the 66 works selected, only one paper presented an interesting application for spatial urban planning, though it does not explicitly consider SLT (He et al. 2015). The work deals with the urban climate of Beijing and proposes to use the synergy between the urban-induced heat island circulation and green-wedge planning to deliver cool/fresh air from the suburbs to downtown Beijing (He et al. 2015). Explicit references to ecosystem services are not present in the paper. On the other hand, many urban ecology and design studies are founded on physically-based methods and models that rely on physical laws such as Thermodynamics (e.g. climate or energy modelling studies), even if this is not explicitly declared in the papers (e.g. Ambrosini et al. 2014).

The scoping review on the exergy, entropy and urban metabolism concepts is reported below. Table 2 reports a summary of the selected papers on SLT concepts and their field of application within spatial planning. The selected planning examples of Table 2 thus represent the state-of-art for further research developments and their applications in real case study are instances of SLT spatial planning.

The exergy assessment and SLT planning approach have been presented in the context of renewable resources and sustainable energy landscapes (Stremke and Van den Dobbelsteen 2013; Stremke, Van den Dobbelsteen, and Koh 2011; Stremke and Koh 2011). The SLT planning approach aims to increase the exergy component of any process and, consequently, to reduce the production of pollutants (entropy) responsible for the alteration of ecosystem ecological functionality (e.g. climate change, freshwater degradation etc.). Exergy analysis is also proposed to evaluate the sustainability of urban areas (Balocco et al., 2004) and guide spatial planning (Leduc and Van Kann 2013). Exergy studies analyse mainly the energy aspect of cities and landscapes without specific interest in UGI spatial planning.

Despite numerous studies, only a limited number of papers present useful methods based on urban entropy aimed at supporting practical urban planning (Pelorosso, Gobattoni, and Leone 2017). Indeed, entropy is a complex task that needs to be studied at different scales of analysis taking into consideration various urban system components such as energy, water, social aspects, waste cycles, etc. Few applications of the entropy concept have been presented in a context of spatial urban planning. Balocco and Grazzini (2000) propose GIS and entropy indicators to study the sustainability of urban areas in terms of energy. Fistola and La Rocca (2014) propose a different approach to urban entropy assessment within system theory and urban planning, by applying reversed sustainability indices as proxies of urban entropy. The work of Fistola and La Rocca (2014) is more operative in an urban planning context, but needs further research to develop a stronger theoretical foundation.

Two main schools of UM exist: one describes metabolism through energy equivalents (emergy), while the second studies the flows of water, materials and nutrients in terms of mass fluxes (Kennedy, Pincetl, and Bunje 2011)disappearance in the 1980s, and reemergence in the 1990s, a chronological review shows that the past decade has witnessed increasing interest in the study of urban metabolism. The review finds that there are two related, non-conflicting, schools of urban metabolism: one following Odum describes metabolism in terms of energy equivalents; while the second more broadly expresses a city's flows of water, materials and nutrients in terms of mass fluxes. Four example applications of urban metabolism studies are discussed: urban sustainability indicators; inputs to urban greenhouse gas emissions calculation; mathematical models of urban metabolism for policy analysis; and as a basis for sustainable urban design. Future directions include fuller integration of social, health and economic indicators into the urban metabolism framework, while tackling the great sustainability challenge of reconstructing cities. (Kennedy, Pincetl, and Bunje 2011. Most UM studies use a top-down approach and coarse or highly aggregated data which cannot be correlated with specific locations, activities, or people (Chrysoulakis et al. 2013)water, carbon and pollutant fluxes. However, good communication is required to provide this new knowledge and its implications to endusers (such as urban planners, architects and engineers. Indeed, obtaining and managing huge amounts of data at a sufficiently downscaled level for planning purposes is often difficult (Pincetl et al. 2014). Only a few studies have presented UM as the baseline for effective designing and planning aimed at optimizing urban flows (Chrysoulakis et al. 2013; Codoban and Kennedy 2008; Voskamp et al. 2016). Moreover, human regulating and governing mechanisms play a critical role in urban ecosystems where policy, planning, and management decisions influence both anthropogenic and ecological processes within and beyond the city (Bai 2016). A systemic understanding of urban resource flows must be reached in order to provide insight both into the social and ecological processes affecting resource flows and into the interlinkages between processes and resource flows (Voskamp et al. 2016).

## Conclusions

Although several scholars have investigated the role of Nature and SLT in making cities more sustainable, UGI planning based on SLT is a relatively new field of research with few real applications to urban systems. From the literature review, some general indications can be derived for the development of spatial UGI planning strategies based on SLT. Practical UGI planning requires operative and integrated exergy, entropy and UM assessments with accurate descriptions of the urban system complexity at the temporal and spatial scale at which practitioners work. Moreover, governing mechanisms and social evaluations should be essential components of SLT planning strategies to allow UGI interventions being actually sustainable and effective in increasing the quality of urban systems.

The knowledge synthesis on SLT and urban planning then confirms the innovative character of the seminal adaptive UGI planning strategy of low-entropy urban systems (Pelorosso, Gobattoni, and Leone 2017). The proposed low-entropy strategy then represents a promising cross-boundary tool that

proposes a flexible integration of assessment methods considering ecosystem services framework, urban metabolism, social impacts and SLT-based planning. The paper represents a first contribute to the development of a new systemic planning paradigm of UGI in which nature of, for and in the city converges together under a thermodynamics vision. Further research should aim to build and translate systemic planning strategies into real UGI study cases in order to support a SLT-conscious green transition of cities.

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# From urban standards to ecosystem services. An essential semantic change

Marialuce Stanganelli, Carlo Gerundo

## Introduction

The implementation of techniques and criteria to provide cities with spaces able to introduce natural elements within urban tissues represents a challenge which modern urban planning has always been faced. In Italy, the scientific and cultural debate on the improvement of the National Law on Urban Planning (1150/1942), which no attention focused on these spaces at all, led to the approval of Law 765/1967 and Interministerial Decree 1444/1968. This legislation introduced into Italian law the concept of "urban standards", meant as public spaces to be provided in every municipal area, according to a merely quantitative criterion (per capita m² of space) provided by the law itself, to be calculated during the drafting of Land Use Municipal Plans. Fifty years after these laws came into effect, there is an urgent need for a radical semantic change that allows the transition from the urban standards exclusively quantitative approach to the systemic, transcalar and contextualized one required by Ecosystem Services, a new vision of natural spaces introduced by Millennium Ecosystem Assessment in 2005. The paper will outline the evolution of urban standards from their legislative genesis to the present days, highlighting the reasons why it is essential to promote an upgrade of urban planning legislation, methods and tools, in order to valorize ecosystem services performances, mainly taking into account their location, quality and multiple utility. Finally, a case study will be presented, exemplifying the use of ecosystem services at the urban scale (Fuorigrotta District, Naples).

## Urban standards theoretical and legislative genesis

In Italy Urban Planning was born, as a technically structured discipline, between XIX and XX centuries. At the beginning, it was characterized by a health-oriented approach and shaped around the need to interpret cities layout by measuring and assessing geometrical dimensions and proportions, as well as functional issues. The methods and techniques, commonly privileged in that period, were based on numerical relations and quantities, expressed by math functions and land use and protection rules respectively, in order to homogenize and codify urban planning practices and procedures.

During the 30s, urban planners used to focus their attention on traffic and road network aspects, as witnessed by Cesare Chiodi in his volume *La Città Moderna* (1935). In the description of modern city main elements, the author offered a remarkable dissertation concerning urban green areas system, to be arranged in terms of not only quantity and quality, but also of proper distribution. Moreover, Chiodi set a minimum amount of green areas, parks and sports fields, equal to 15% of the total urbanized area or to 6 m² per-capita.

Gustavo Giovannoni, one of the founding father of Urban Planning in Italy, in 1931, in his volume *Vecchie città ed edilizia nuova*, suggested a set of solution to new cities expansion, to urban traffic and, in particular, to old and modern city contrast with regard to new socio-economic demands. According to Giovannoni, since the system of modern city elements – such as road networks, built areas, public spaces – had been complexifying increasingly, it had to perform three main tasks: to be a *social*, *cinematic* and *aesthetic* organism. As a *social* organism, the modern city should have guaranteed better and healthier dwellings, a rational distribution of functions and facilities, balanced building densities and a provision of open spaces at least equal to 40 m² per-capita. Giovannoni stated that the Land Use Plan should have dealt with all these aspects – distribution of building, public spaces, gardens, roads – in a coherent and homogeneous program preceded by analysis made using data and statistics. Giovannoni introduced another relevant theoretical innovation since he considered urban planning as a hierarchical process: land use plans should have been contextualized within a wider (regional) framework, where main roads, urban development areas, regional parks are planned in order to harmoniously coordinate city and its surrounding villages growth.

Despite the most important scholars at that time theorized how modern city could not work without an appropriate system of open and green spaces, those aspects were not taken into account into the drafting of law 1150 (urban planning Italian regulation), approved in 1942, during the Second Wold War, and still in force today. Anyway, after the end of the conflict, an enhancement of technical and scientific knowledge production was achieved in urban planning, albeit a more organic approach was adopted. As a matter of fact, the role of analyses become even more important and a more sophisticated formalization of indexes and parameter to investigate urban morphology and to fix per-capita public spaces quantities to be created.

These trends are evident in Luigi Dodi's handbook, *Elementi di Urbanistica* (1946): urban planner should have knowledges and tools too coordinates the multiple parts of urban organism. In this book, Dodi proposed a set of per-capita minimum surface to be created within urban expansions, where the values identified for green spaces was equal to the one proposed by Chiodi, 6 m².

Similarly, Luigi Piccinato considered cities as living organisms that need to be planned as an organic whole through the zoning, an essential tool to structurally and organically arrange the territory. In his volume *Urbanistica*, Piccinato identified an upper limit for building density in new extensive residential areas equal to 250 inhabitants per hectare, where a minimum provision of urban structure essential components should be ensured, expressed in percentage terms with regards to the total area: 65% for buildings; 21% for roads, 7% for sport fields, 0,5% for playgrounds; 5,5% for parking areas, 1,25% for walking routes. In terms of quantity, he proposed 30 m² per capita made available for green spaces, organized in 4 m² per capita for playground; 15 for parks, grasslands, woods, parade grounds; 4 for graveyards; 1 for walking paths.

In the *Architects' Handbook* (1962), edited by the Italian Research Council, Cesare Valle identified minimum thresholds for per capita public spaces: 20 m² for *neighborhood services* (10 for green spaces and 10 for other facilities like schools, markets, libraries, parking areas), 15 m² for *parks*, 10 m² for general infrastructures (hospitals, cemeteries, highways).

In 1964, the Research Centre of the Workers' Housing Management Italian Agency (Gescal), coordinated by Federico Gorio, publi-

shed a research on urban standards edited by Edoardo Salzano. In this study, urban standards are defined as the qualitative and quantitative formalization of the relations between those physical elements which are essential to satisfy, within a given historical period, some people needs, that can be organized using urban planning methods and tools. It's useful to observe that, according to the research, the above mentioned formalization had to be achieved through the formulation of optimum parameters. This research started with a theoretical clarification concerning the distinction between *public service* and *community facility*: while the former represents the organized activity, the latter is the building or urban envelope where this activity takes place. Therefore, Service and facility should be intended as two complementary and mutually connected aspects of the same attempt to satisfy an urban need, and their public and community character is not linked with their property or management but with their use that could not be individualistic. Moreover, according to the research, urban standards should be defined with regards to social life needs and could not be identified in a general and abstract way. On the contrary, social needs materialize in a certain historical situation, so it is essential to identify them in an open and dynamic way, with regards not to present demands but to the future ones. To do that the research choose the quantitative approach as the most appropriate one. They classified community facilities and public services in functional categories: 9 for the first group and 3 for the second one.

Community facilities were categorized as *cultural and spiritual life*, *educational and childhood institute*, *healthcare facilities*, *performing arts centers*, *commercial facilities*, *facilities to exercise democratic rights*, *touristic facilities*, *household facilities* and *sports and recreational facilities*. In this last category, the study included the facilities able to satisfy needs related to sport, game and recreation and subdivided it in 7 typologies of green and sport areas, identifying for each of them a minimum per-capita threshold[1]: *elementary green unit*, 3 m²; *playgrounds for kids* (3-6 years old), 0,4 m²; *playgrounds for kids* (6-11 years old), 0,6 m²; *sports and playgrounds for kids* (11-14 years old), 1 m²; *sports and playgrounds for adults*, 5 m²; *neighborhood parks*, 3 m²; *urban parks*, 12 m². On the other hand, public services were categorized as *services having their sits in a building*, *having their sits in a building on a surface* and *networks*. Among the second category were included all the green areas (parks, gardens, vegetable gardens, tree rows) able to satisfy needs related to health and hygiene: *urban public green areas*; *neighborhood green areas*; *private green areas*.

We can observe how it was already clear, at the beginning of the sixties, the double role green areas, classified as urban standards, should have played within cities: to be a meeting and gathering space and to enhance the ecological quality.

On the basis of the results of Gescal Research Centre study, the Ministry of Public Works issued a Circulaire (n. 425, 29th January 1967) to ensure a minimum provision of public spaces and facility in new social housing settlements. The creation of these spaces should have been assessed with regards to families and people feature, like age or gender. Moreover, as regard spaces localization, they should have been positioned, not only respecting maximum radius of influence, but also considering users' characteristics. For instance, *elementary green unit* and *playground for kids* should have been deployed adjacent to dwellings and focusing mainly on sunshine and protection from dominant winds, while sports and recreational facilities in such a way as to create a green continuum.

However, while scholars and urban planners were involved in ever more thorough discussion concerning how properly calculate the provision of spaces and functions in the cities, population growth in Italy was spiraling and the law 1150/1952 was proving to be unable to ensure a harmonious development for urban areas. Cities tended to expand out of all proportion without land use plans and peripheries grew lacking any sorts of facility. Nevertheless, in 1967, after the dramatic landslide happened in Agrigento in 1966, ad emergency regulation was enacted, the so-called *legge ponte* (law 765/1967), that introduced the obligation to respect, in new municipal land use plans, maximum ratios between areas for residential and production settlements and public spaces for community facilities, green and parking areas. Those ratios, technically called *urban standards*, were quantitatively defined by Interministerial Decree 1444/1968, with regards to six *homogeneous zones* introduced by the Decree itself, and were set equal to 18 m² for each inhabitants in residential settlements (4,5 m² for compulsory education institutes, 2,5 m² for parking areas, 2 m² for community facilities and 9 m² for green areas with sport fields and playgrounds). In addition, the Decree fixed the obligation to provide at least 15 m² per-capita of urban parks, to be created in a designated homogeneous zone.

The Decree 1444/1968 were no more modified and is still in force, even though regional laws have innovated over time urban standard identification and quantification. Probably, the bravest attempt to reform this issue was made by Lombardia Region that enacted the last urban planning regional regulation in 2005 (law 12/2005). This law disapplies the Decree 1444/1968 since it no longer subdivides the territory into homogeneous zones and empowers Municipalities to identify minimum thresholds for public services or community facilities through the *Plan of Services*[2]. This plan should ensure the provision and functional distribution, among others, of green spaces, wildlife corridors, green connection between rural and built areas and between road networks and urbanized areas, considering quality, usability and accessibility criteria, as well as the costs to realize and maintain them.

## New perspectives and approaches for urban standards

The Decree 1444/1968 allowed Municipalities to increase the provision of public spaces and community facilities within cities even if it have not always translated into an enhancement of life quality of urban areas, revealing all the limits of the urban standards quantitative approach.

Anyway, urban standards are a social and cultural conquest that need to be safeguarded and improved, adapting them to a new perspective and considering more performing approaches able to take into account the multiple benefits they can generate within cities.

During the 29th Congress of *Istituto Nazionale di Urbanistica* (2016) it was agreed that in Italy can no longer be put off an effort to shift from urban standard, as they were conceived for growing cities, to *territorial provisions* conformed to different urban forms quality.

With regards to green areas, they should be

no more provided to merely ensure a per-capita quantity of space but to create wellness and life quality. That's the reason why it is essential to internalize the concept of *Ecosystem Services* into urban planning process. Ecosystem Services, as defined by Millennium Ecosystem Assessment (MEA, 2005), are the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems (MEA, 2005). The ecosystems that provide the services are usually referred to *natural capital*, where capital has to be interpreted as a stock that yields a flow of services over time (Costanza and Daly, 1992; Costanza 1999). If combined with other forms of capital that do require human agency (built or manufactured, human, social or cultural capital) it can produce any human benefits. Ecosystem services thus refer to the relative contribution of natural capital to the production of various human benefits, through crucial interaction with the other forms of capital. Therefore, understanding, modelling, measuring, and managing ecosystem services requires a very transdisciplinary approach (Costanza et al., 2017).

The definition of Ecosystem Services is strongly inclusive and their valorization depends on the elaboration of new knowledges, paradigms and tools. One of the tool that deserves increasing attention worldwide is *green infrastructures*, defined by the European Commission as networks of natural and semi-natural areas, strategically planned together with other natural elements, designed and managed to provide a wide range of ecosystem services.

A properly designed green infrastructure penetrates into landscape and urban areas creating continuity and functionality and removing barriers. In this way, nature is no more a consumer product or something simply enjoyed from an aesthetic point of view, and becomes a provider of vital resources, a stability and global sustainability balancer.

A green infrastructure is a category of products, technologies and practices that use natural systems (or artificial ones, simulating natural processes) aiming at the improvement of the environmental quality and the provision of public utilities services. As a rule, green infrastructures use soil and vegetation to foster first flush seepage, evapotranspiration or recycle. If used as a component of rainwater and run-off management systems, green infrastructures, as green roofs, permeable surfaces, rain gardens – also known as Nature Based Solution (Nbs) – can produce several environmental benefits. As a matter of fact, they can simultaneously contribute to air pollutant reduction, energy demand decrease, urban heat island mitigation, and, at the same time, they offer aesthetic benefits to community concerning landscape quality and place-based identity.

Green infrastructures are multi-objective space networks and, therefore, turn out to be the proper way to shift from urban standard to ecosystem services approach. By their very nature, they need to be designed using an interdisciplinary approach, able to take into account social, urban and environmental issues.

Later on, an interdisciplinary methodology to design a green infrastructure for urban run-off control is described and the results of the case study of a residential district in Naples, Italy, are presented.

## Ecosystem Services for urban runoff control. The case study of Fuorigrotta District

Climate change and its effects on urban areas is an extremely relevant issue. The intensity of Climate change-linked events as floods, droughts and heat waves is progressively increasing. For instance, floods can cause serious damages to urban settlements, destroying roads, waterworks and vegetation, inundating buildings, as well as endangering people safety.

Moreover, uncontrolled soil sealing and inadequate urban drainage systems contribute to increase the risk to suffer serious damages. In detail, soil permeability reduction is the main source of problem caused by heavy rainfalls because it produces a substantial decrease of water evapotranspiration and, consequently, the enhancement of water to be drained by the sewage system.

For these reasons, it is essential to develop integrated and multidisciplinary approaches for urban planning in order to resume in the same project all the aspects concerning infrastructures, risk prevention and mitigation, as well as quality of urban spaces.

In the new course of management of urban water drainage systems, an important role can be played by innovative design approaches, the Low Impact Development (LID) technologies of Best Management Practices (BMPs) related to the control of urban runoff. The main goal of these strategies is to increase urban resilience to risk of flooding and this aim can be successfully achieved integrating urban design, land use planning and mixed rainwater draining systems, which can include both underground sewerages and above-ground draining elements and surfaces, into a network of green infrastructures.

The methodology implemented to create this green infrastructure is structured on three parallel and interlinked segments aiming at urban space physical renovation (*space*), social and gathering spaces creation (*sociality*), environmental resources re-activation (*runoff*). It was applied to the case study of Fuorigrotta, a residential district located in the western part of Naples, which is particularly vulnerable to the phenomenon of *pluvial floods*. For instance, during the night of 14 to 15 September 2001, the district of was seriously damaged by a violent cloudburst that caused chasms in the road pavement, sediment of debris and mud, uprooted trees, flooding of the underground parking of San Paolo stadium.

The methodology is made of five subsequent steps: Input; Tool, Knowledge; Diagnosis; Project (Figure 1).

*Input*

This phase regards the identification of the *inputs*, seen as the urban sub-systems afflicted by relevant problems the green infrastructure aim to solve. In the case study, as previously said, three project input were selected.

A first project input are urban open spaces since most of them are merely non-built empty spaces and need to become physically safe and attractive for inhabitants and city users, triggering a social-driven regeneration process.

Therefore, the second input is sociality, given that the regeneration process need to be activated starting from users' needs.

The third and last input concerns the urban run-off system that turned to be inefficient over time and needs to be renovated using LID-BMPs techniques.

*Tool*

The second phase concerns the recognition of the *tools* to be used to perform the following analysis. For the case study, all

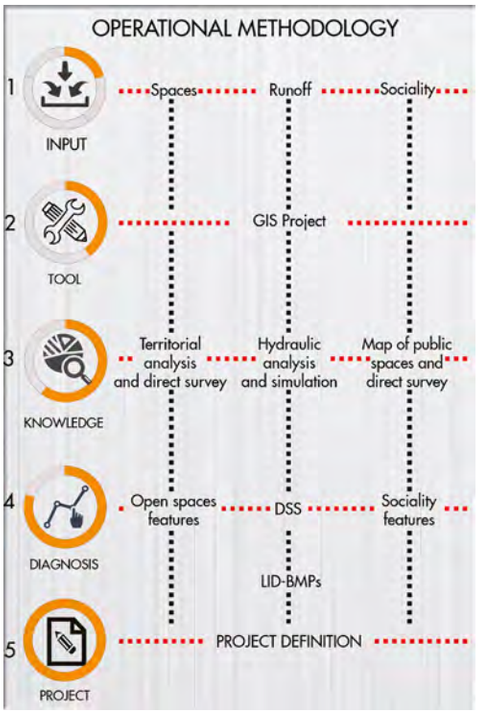


Figure 1– Conceptual scheme of the methodology implemented

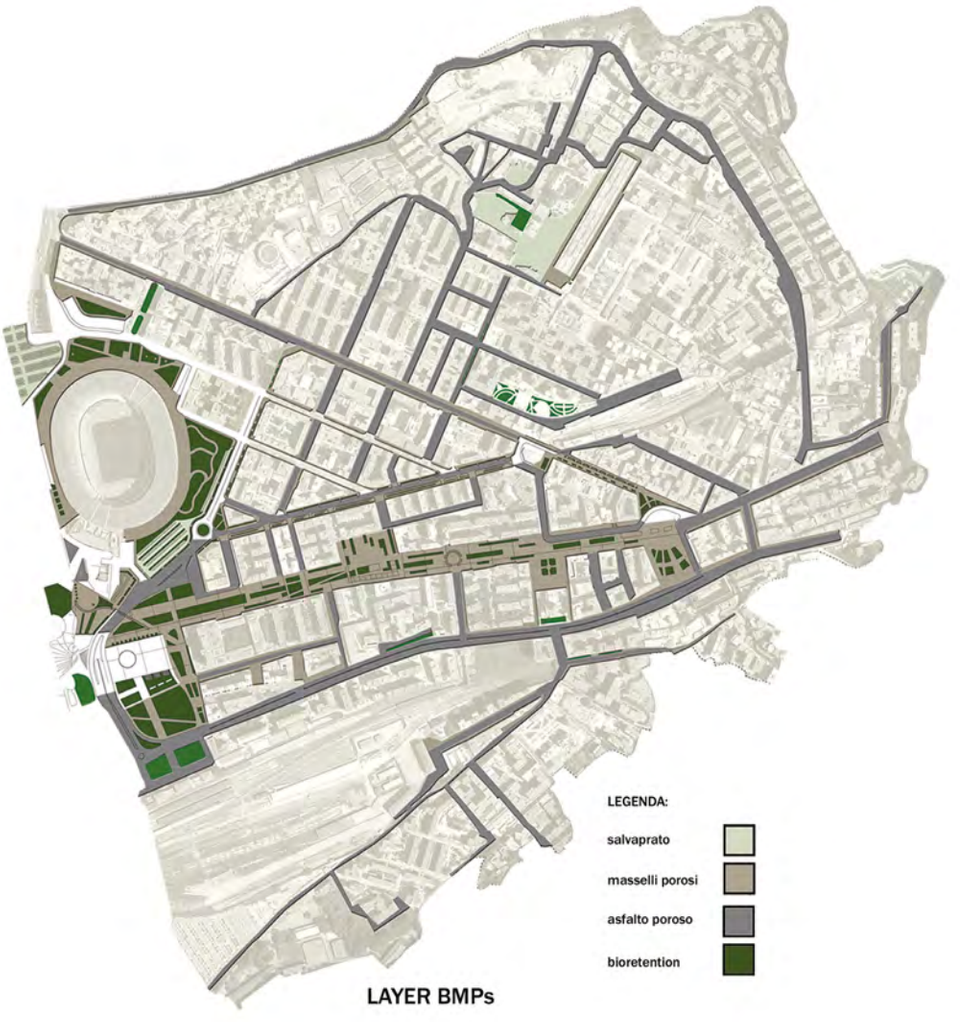


Figure 2– Masterplan of the open spaces.

the analysis were carried out in a GIS environment.

*Knowledge*

As regard urban space, the socio-economic and urban morphology features of the district were analyzed.

Socio-economic features were investigated not only with regards to residents but also to city users since within the district many upper level facilities, as University, the Fair site, the Stadium, are located. This analysis revealed how, when some events take place, city users are more than double people living in the district, emphasizing the sense of space usability deprivation. Moreover, a census of commercial activities was elaborated since they represent an attraction and can revitalize urban open spaces.

Urban morphology features analysis was performed with regards to land use and road network. This latter were analyzed in depth, given that roads are usually the most suitable location for BMPs technology. Therefore, for each road the width was calculated performing a GIS routine and the intensity of use was assessed considering two parameters, the traffic flows, deduced from Naples Urban Traffic Plan, and the vehicular load, evaluated considering the bus lines travelling through a roads and the density of commercial activities along the road itself.

As far as *sociality* concerns, an analysis of open spaces livability was carried out through direct observation and following compilation of a template survey sheet created by *Project for Public Spaces* (PPS), a no-profit organization dedicated to public spaces sustainability. For each open space a score was assigned (from 1 to 4), considering four different indicators (comfort and appearance, accessibility and relations, uses and activities, social context).

Some of the analyses described below were used to perform the urban runoff system analysis, recreating its mode of operation and then using a Decision Support System (DSS) for the identification of the useful BMPs, among the usual ones in the technical literature (in the case study porous pavements, bioretentions and roof gardens were used), as described by De Paola et al. (2017). This System interfaces a simulation model (SWMM5.1) with an optimization module (Harmony Search) able to identify the best combination of BMPs to properly reduce flood peak discharges and volumes.

*Diagnosis*

The DSS, setting a maximum budget in the range 50-55 millions € and a maximum volume rate $V/V_0$ equal to 70%, identified an optimal solution that contemplate converting 56 hectares of road from asphalt to porous pavement.

Nevertheless, this solution did not take into account that part of the area to be converted into porous pavement is private. Therefore, another solution able to respect the property constraint was chosen. This solution allows a 22% volume reduction and a consequent money saving (-6 millions €). It contemplate realizing 36 hectares of porous pavement on public roads, 5 hectares of bioretentions and 160 m² of green roofs.

These BMPs, in the last phase, should be positioned allowing to solve not only the floods- linked inconvenience, but also the

open space and sociality problems. Actually, *open space* and *sociality* analysis revealed how public and gathering spaces are perceived as empty, unsafe and functionless. It can be ascribed to the distance from main roads and the lacking of neighboring commercial activities, able to generate flows of people. At the same time, the diagnosis phase highlighted the massive presence of physical and visual barriers, caused by wide and scarcely crossable roads or by unduly intrusive street furniture.

Moreover, the analysis of urban functions distribution allows to confirm how the district is structured on two different mono-functional parts. The first one, in the south part of the study area, hosts upper level facilities, mainly visited only in some hours of the day or some days during the year, and it is in contrasts with the northern part of the study area, the most populated one and organized according to residents' needs.

*Project*

The project is the result of the diagnosis phase and aim at triggering an urban, social and environmental regeneration process through the creation of a green infrastructure. The project proposal is based on the re-connection of the two mono-functional parts of the district, through the reshaping of the main road, Viale Augusto, and the creation of a pedestrian linear urban park, able to link all the principal open spaces. The surface of all the public roads will be converted from asphalt to porous pavement, while all the pedestrian areas will be covered with porous block and bioretention stripes (Figure 2).

The methodology described in the paper represents a valid proposal to transform the urban standards quantitative approach to a place-based and social-driven one, allowing to relive and actualize the principles that underlay Dm 1444/1968 conceptual genesis.

1. The main bibliographic source used to identify the minimum per-capita thresholds was the handbook *Verde per la città* (1961), by Mario Ghio and Vittoria Calzolari.
2. The Plan of Service must anyway ensure a minimum per-capita provision of public services and community facilities equal to 18 $m^{2.}$

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# Regenerating standards through ecosystem services


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## Introduction

The introduction in 1968 of urban standards in Italian planning and design framework (Falco, 1993) has constituted a great social achievement for the construction of public city. Nevertheless, new incoming challenges and the awareness of urban growth limits require planning policies to change their perspective and paradigm – from a quantitative to a qualitative approach in urban design. Current urban plans must be designed with the aim of overcoming previous oversized territorial previsions and zoning actions in order to favor regeneration processes through the integration of different public services and equipment and of nature and green infrastructures into cities. In this perspective, urban standards have to be made functional for cities which no longer need to expand outwards but to be requalified in the inner historical boundary. Regeneration processes do not require new developable quantities of land but they consist of specific and punctual operations in the consolidated city. An integration of quantitative values with qualitative parameters could therefore foster an environmental and eco-systemic functionality of the built environment.

New urban standards, in order to be functional for the urban project in all its aspects (Steiner, 2004), can be represented by green infrastructures (Lovell, Taylor, 2013; Hansen, Pauleit, 2014), which allow, for example, the conservation of biodiversity, the improvement of climate change, the sequestration of carbon, etc. Additionally, they continue pursuing their original purpose of supplying public facilities to urban dwellers. In this perspective, new urban standards can become evaluation tools for the realization of projects, as it happens in the American approach, and for the feasibility of objectives of environmental, ecological and landscape quality. The American approach, by referring to performative criteria, allows to evaluate a new project intervention before its realization.

## Origins and evolution of Italian urban standards

Before being defined by law, the matter of urban standards in Italy was vague and mainly referred to green facilities (Falco, 1993). First attempts to systematize the quantification of urban growth through specific quantitative values date back to 1947; indeed, various Italian handbooks proposed technical solutions updated on the current debate but they didn't have founding ambitions with respect to the issues they dealt with. Italian handbooks of early '50s showed a moderate technical growth which nonetheless did not paid attention to emerging social and environmental necessities. Differently from other European countries, where post-war reconstruction was more careful to social needs, Italy adopted as a legal measure for reconstruction and control of development the compulsoriness to respect a defined quantitative value (Talia, 1999). Indeed, Italian urban standards, as they were conceived in 1968 by the national ministerial decree 1444, can be considered as the first tool for a balanced quantification of urban growth (*dimensionamento del piano*). Their main purpose was the homogeneous distribution of public spaces, measured in quantitative terms, and they were imposed as a prescription for individuals in charge for territorial transformations. In citing Tutino's report, Campos Venuti (1967) recalls the importance that urban standards are not to be intended as a measure established once for all which is equally effective today as in 10 years; they have instead to be continuously renovated so that they maintain their significance.

Many Regions specified urban standards in their own laws and in particular Piedmont region, with the promulgation of the regional law on urban planning (LUR) n. 56 of 1977 and further modifications[1], strengthened the role and the importance of urban standards established by the national ministerial decree, by increasing their quantitative value.

Until 20 years ago, it was proper to distinguish between different urban contexts: the ones in which it was still evident the need (even if limited) to build new houses and the ones where the real increasing issue was the requalification of the existing heritage. Already in the '90s, the debate shifted toward a general reconsideration of urban standards; indeed, some Italian urban planning experimentations (Oliva, 1999) based their choices on the concepts of environmental compensation and ecological-environmental potential, by connecting urban transformations to concrete interventions of qualitative improvement. Nowadays, in this perspective, INU, in the last two years, has emphasized a "renovated declension of urban standards" (Viviani, 2015) in order to favor the ecosystemic functionality of cities. A possible element of this renovation, toward a project standard, is represented by green infrastructures (GI) as they can be considered as the principal reference for environmental, social and economic development (Benedict, McMahon, 2006). The concept of green infrastructures recalls to a systemic vision able to gather different punctual interventions of ecosystem services' valorization.

## Environmental compensation plan: an opportunity to change project approach

As a main reference toward a project standard, a remarkable experience is the one led by some American counties and states (Steiner, 2004) which connected zoning ordinances to performative criteria. By referring to performative criteria as tools for controlling all the aspects of the project, the American model represents a good reference of what urban standards should address to. The State Environmental Policy Act (SEPA) is one of the most relevant legal tool used for the protection of the environment; the one of Washington (Steiner, 2004), as an example, states the protection of the environmentally sensitive areas through the preventive control and the review of potentially damaging interventions. In order to protect biodiversity, American local governments can adopt Habitat Conservation Plans (HCP) which are based on the analysis of the areas to be enhanced.

Even if there is not a systemic and strategic approach between the different tools, the American model shows how it is possible to connect zoning actions with performative criteria in order to preserve biodiversity.

In Italy, an example is represented by a pilot experience led in Piedmont region, the Environmental Compensation Plan. Defined in 2004 in the setting of the River Contract of the Stura di Lanzo river, this tool aims at setting up an ecological network based on the identification of areas which could play a strategic role for territorial development. The selected areas are fundamental elements of a much complex landscape and environmental system for the mitigation and compensation of big interventions with major impacts. These areas are indeed intended to connect the Regional Nature Park of La Mandria with the Nature Park of Po river, by linking the rivers of Stura and Po. Result of a participative process between different stakeholders of the territory of Stura river, this tool claims itself to overcome the character of urgent remedy of current compensation projects.

With the aim of integrating the entire process of ecological compensation in territorial development plans, this Environmental Compensation Plan takes the cue from German experience of Öko*konto*, literally ecological account (Voghera, 2016). This tool is a kind of bank account made up of eco-credits that can be managed and used by municipalities in order to counteract damages caused by territorial transformations. Once the areas are ecologically compensated, they become structural elements of an ecological network. The method followed by the Environmental Compensation Plan of Stura river includes different stages: "acknowledgment and evaluation of the ecological relevance of the areas eligible for environmental compensation; identification of the measures for improvement or protection of ecological and landscape value; selection of the compensation areas; selection of the compensation measures; definition of related priority of actions; update of the naturalistic value of the areas subject to compensation" (Voghera, Negrini, 2016: 81).

With reference to this method, the first selected areas eligible for environmental compensation are located in the municipalities of Venaria Reale, Robassomero and Nole Torinese. Peri-fluvial margins have been chosen as key areas for the restoration of the river environment following critical interventions of allotments' removal. The second area, the Regional Nature Park of La Mandria, constitutes more than half of the territorial surface of Venaria Reale municipality and it represents a fundamental node for the Provincial Ecological Network; in a perspective of a reinforcement of it, compensation actions include reforestation, re-naturalization

through the prevention of invasion of exotic species. A third type of areas has been selected starting from the local system of canals (*bealere*) in the peri-urban environment which are basic elements able to promote the multi-functionality of the local ecological network. Actions in these areas include environmental restoration and realization of recreational equipment.

## Final considerations

The experience of the Environmental Compensation Plan, even though it is not a formally recognized tool of Italian planning system, can be considered a good starting point for the integration of environmentally qualitative elements in urban and local plans, aimed at developing ecosystem services in the territory through naturalization interventions. Given as a fact that the identification of areas suitable for environmental compensation actions does not suffice to realize a high eco-systemic quality in the ordinary landscape, it is clear that there is a general need of systematizing different criteria and methods able to overcome the quantitative approach of urban standards.

This strict dependence on urban qualitative standards has indeed led to an unintegrated growth of green urban areas. In a perspective of sustainable development, this process lacks a strategic and systemic vision needed for a high well-being. This systemic vision could be improved and enhanced by a strategy based on green infrastructures. GI, if properly integrated in the planning tools, can indeed provide to urban contexts the necessary strategic approach which allow a wide vision on different issues. The concept of GI, due to its multi-functionality (Lovell, Taylor, 2013; Hansen, Pauleit, 2014), can provide the benefits of ecosystems, both in the urban and in the territorial context.

In a perspective of a transversal reticular paradigm (Gambino, 2009), the concept of GI recalls to an open system of relationships and they help overcoming the matter of Italian urban plans' boundaries which often represent an obstacle for suitable planning decisions.

Nowadays, the construction of GI in Italy is only based and supported by the definition of methods of evaluation and, in the case of the Environmental Compensation Plan, the selection of areas eligible for compensation. The overall construction of GI should nevertheless be implemented and included in the decision-making processes of local plans, coordinated with supra-local levels; the integration itself in urban plans anyway is not enough to confer to GI the necessary planning and design actions which could lead to a qualitative approach.

Assigning a project value to GI, as it happens in French planning system within the experience of *Trames vertes et bleues* (Clergeau, Blanc, 2013), can be the cornerstone to overcome the quantitative approach of Italian urban standards, to include qualitative elements and to reinforce ecosystem services. GI indeed guarantee in a long-term period the maintenance of ecological connections between urban and peri-urban areas and the provision of ecosystem services. They can also support local and regional decisions in urban plans by acquiring a strategic and operative role; the strategic character can be recognized in the ecological and landscape scale while the operational character can be achieved through the direct change of territorial land uses.

1. The last significant modification is the regional law n. 3/2013.

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