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The DPSIR framework in support of green infrastructure planning: A case study in Southern Italy

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ABSTRACT

Human activities such as urban densification, soil sealing and the spread of service infrastructure are altering the quality and quantity of ecosystems. They are depleting natural capital, like water supply and air quality, on which society depends. To preserve natural capital, the European Commission is promoting new land-use policies, one of which is Green Infrastructure (GI). It has been postulated that GI planning can promote sustainable land-use by supporting a wide range of ecosystem services. Research conducted in the GREEN SURGE project (FP7-ENV.2013.6.2-5-603567) has suggested that a number of tangible benefits accrue when GI planning is implemented at different spatial scales. In support of this, GI has been conceptualized in a case study in Southern Italy using the Driving force–Pressure–State–Impact–Response (DPSIR) framework. This framework was employed to promote the GI approach with the aim of ensuring sustainable land development without compromising natural capital. In fact, the DPSIR framework used in the case study shows how GI, through the provision of ecosystem services, is a response to various critical environmental issues. Despite known limitations as reported in the literature, the DPSIR framework was selected for its simplicity in representing and reporting the interactions between the environment and society. Given the complexity of environmental issues and the presence of various stakeholders involved in decision-making processes, DPSIR provides planning professionals with a streamlined tool to develop strategic solutions for sustainable land-use and for promoting societal wellbeing.

1. Introduction

In the last decade, green infrastructure (GI) has become a prominent concept for planners and practitioners worldwide to foster sustainable land-use (Ahern 2007; Mell, 2008; Mazza et al., 2011) and enhance human wellbeing (Tzoulas et al., 2007). The GI concept offers solutions for innovative approaches that deal with nature conservation and green space planning (Padoa-Schioppa et al., 2009; Hansen and Pauleit, 2014). More recently, emphasis has been given to GI at the urban scale for the enhancement of biodiversity and ecosystem services (ESS) considering the challenges posed by climate change in densely populated areas (Lafortezza and Chen, 2016).

Examples of the application of the GI concept can be found especially in the US and UK, where GI was taken up and promoted in several land-use policies (Benedict and McMahon, 2002; Kambites and Owen, 2006); e.g., the US Environmental Protection Agency (EPA) offers technical guidance, design manuals and tools to community leaders and urban planners interested in applying GI solutions for natural resource protection and storm water management (see: https://www.epa.gov/green-infrastructure). Another example is a recent report of the European Union (EU) project 'GREEN SURGE' (FP7-ENV.2013.6.2-5-603567), which focuses on urban green infrastructure planning and implementation in 20 European cities (Davies et al., 2015).

One of the main challenges in sustainable land-use planning is to link up the GI concept with approaches and tools that have been widely accepted and used in other fields, such as landscape assessment and environmental management (Romano et al., 2015). Of singular importance is the so-called **D**riving force–**P**ressure–**S**tate–**I**mpact–**R**esponse (DPSIR) framework (EEA, 2000; Kristensen, 2004). Based on previous environmental frameworks, i.e., the Pressure-State-Response (PSR) (Organisation of

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Economic Co-operation and Development (OECD), 1993) and Driver-State-Response (DSR) (UN, 1996), the DPSIR is a conceptual framework to analyze the cause–effect relationships existing between society and the environment and to support decisions in response to environmental issues (Hammond et al., 1995; OECD, 1998, 1999, 2003; Bridges et al., 2001; Joumard and Gudmundsson, 2010; Tscherning et al., 2012). In accordance with its terminology, the DPSIR framework considers *driving forces* (D) (e.g., human activity) that exert *pressures* (P) (e.g., land-use change) on the environment, leading to changes in the *state* (S) (e.g., ecological processes) of the environment. In turn, these changes give rise to *impacts* (I) on ecological systems, human health and society that may elicit a societal *response* (R). Depending on the measure(s) taken, responses can be directed to any component of the DPSIR framework and control drivers, reduce pressures, improve the state and mitigate impacts (Smeets and Weterings, 1999; Gabrielsen and Bosch, 2003).

The causal chain of the DPSIR framework functions as a tool to integrate knowledge from diverse disciplines and has been widely adopted in environmental assessments, e.g. the State of the Environment in Europe (EEA, 1995, 2000, 2015; Kristensen, 2003), and by practitioners (Lundberg, 2005; Borja et al., 2006; Nilsson et al., 2009; Atkins et al., 2011). For example, Fassio et al. (2005) adopted the DPSIR framework for assessing alternative measures to reduce the use of nitrogen in agriculture and to protect water resources at European level. Omann et al. (2009) employed it to investigate the effects of climate change on ecosystem functions and the consequent policy responses. More recently, the US Environmental Protection Agency (EPA) used the framework to discuss the social, cultural, and economic aspects of environmental and human health (Yee et al., 2012).

Although the DPSIR framework has been broadly applied in landscape assessment and environmental management, only a few applications have explored its potential in support of land-use planning and, specifically, green infrastructure planning and implementation in urban areas (Lafortezza et al., 2013a). To this end, we investigated the applicability of the DPSIR framework to support GI planning and implementation within a local context. A case study in a district of Southern Italy has been used to demonstrate how the DPSIR framework can help local stakeholders and policy makers achieve the goal of sustainable land-use planning through green infrastructure (Smaling and Dixon, 2006; Svarstad et al., 2008).

While the simplicity of the DPSIR framework can be viewed as a shortcoming, its strength lies in its adaptability, popularity and, most of all, replicability. These characteristics allow the framework to guide decision making for implementing strategies in planning policies in response to the loss of natural resources, and at the same time, to ensure long-term sustainable land-use.

2. The green infrastructure approach for sustainable land–use planning

Green infrastructure planning began to take prominence in the late 1990's when the concept was first introduced by researchers and academics mainly in the UK, Western Europe and North America who recognized that GI allows planners to create multi-functional and sustainable places (Mell, 2008). The GI approach has been increasingly employed in land-use planning, especially in compact and rapidly expanding European cities (EEA, 2006). The reasons are that compared to some other approaches it looks at conservation values (Benedict and McMahon, 2002) and considers ecological and social aspects in combination with other land-use developments (Aegisdóttir et al., 2009) and the delivery of ESS (Elmqvist et al., 2013). Further GI benefits are related to soil erosion control in areas affected by high erosion risk (Bisantino et al., 2010), as described in the Italian Green Infrastructure project 'Infrastrutturazione Verde' (Autorità di Bacino della Puglia, 2016). In these circumstances reforestation, vegetation in streams, and riparian buffers can provide benefits in reducing soil erosion on hillslopes and sediment load at the watershed outlet (Abdelwahab et al., 2014, 2016; Momm et al., 2014). GI benefits are also related to water management issues such as water supply regulation (including drought mitigation), water quality control and the moderation of extreme events (floods and urban stormwater runoff) (Milella et al., 2012; Liu et al., 2014; UNEP, 2014; Young et al., 2014). In addition, GI contributes to lower energy demand, cost savings, increased carbon storage, and higher land values (Foster et al., 2011).

The widespread adoption of the GI approach also results from the integration of the principle of social inclusion (Benedict and McMahon, 2006; Kambites and Owen 2006; Pauleit et al., 2011). GI planning is based on the involvement, alliances and interrelationships among different stakeholders – public and private, non-profit agencies (NGOs), practitioners and researchers – with diverse backgrounds and needs because it builds a shared vision that can help drive the process and create consensus (Benedict and McMahon, 2006). Recent literature, in fact, stresses how community involvement is necessary to achieve environmental management goals (Fraser et al., 2006) and how stakeholder participation needs to be inclusive, legitimate, and informed to provide a sound base for decision making (Fish, 2011).

Connectivity, another basic principle of the GI approach, plays a key role in the implementation of strategies for sustainable land-use (EC, 2012). In fact, it is able to enhance the functionality of ecosystems precisely by developing their structural and functional linkages through ecological networks and human-based components (Lindenmayer and Fischer, 2007). For Benedict and McMahon (2002) '*linkage is key*' and the same origins of GI are to be found in the connectivity concept: (1) to link parks and other green spaces for the benefit of people, and (2) to link natural areas to benefit biodiversity and counter habitat fragmentation.

Multi-functionality is another basic tenet of the GI planning approach whereby, differently from 'gray infrastructure', GI combines ecological, social, and cultural functions and is planned to address multiple purposes (Davies et al., 2015; Lafortezza and Konijnendijk, in press). Thus, based on the multi-functional use of natural capital, GI can contribute to achieve a number of policy aims and fulfil the needs of a variety of stakeholder groups (EC, 2012). The previously cited GREEN SURGE project report suggests connecting various typologies of (natural and semi-natural) green spaces at different spatial levels to create networks of multi-functional areas supporting healthy ecosystems. In fact, the general classification proposed by the EEA (2011) breaks down GI components into three spatial groups in ascending order: (1) local, neighborhood and village scale; (2) town, city and district scale; and (3) city-region, region and national scale. Considering GI components at the local scale, such as tree-lined streets and neighborhood parks, the linkages of these creates synergies and higher level effects that have significance at a scale that is greater than the local (Konijnendijk et al., 2004; Davies et al., 2006; Lennon, 2014). In this perspective, the EC (2012) states that "*GI also promotes integrated spatial planning by identifying multifunctional zones and by incorporating habitat restoration measures into various land-use plans and policies...*".

Taking the 'multi-scale' concept a step further, Davies et al. (2006) and Kimmel et al. (2013) maintain that the GI approach occurring at multiple *nested* scales creates a connective network of features that build on each other to provide essential ESS to the community. Plan nesting is common in all forms of government where strategic approaches take priority in delivering plans at smaller scales (Lafortezza et al., 2013a). Strong evidence from the literature in support of GI planning through the connectivity of green spaces (e.g., regional and urban parks, wetlands, urban allot-