



Identifying Spatial Opportunities for Nature-Based Solutions Planning in Cities: A Case Study in the Area of Valletta, Malta

Davide Longato¹, Chiara Cortinovis², Mario Balzan³, and Davide Geneletti¹ (✉)

¹ Department of Civil, Environmental and Mechanical Engineering, University of Trento,
Trento, Italy

davide.geneletti@unitn.it

² Department of Geography, Humboldt-Universität Zu Berlin, Berlin, Germany

³ Institute of Applied Sciences, Malta College of Arts, Science and Technology, Paola, Malta

Abstract. Nature-based solutions (NbS) in cities are actions that utilize ecosystem processes of green-blue infrastructure to safeguard or enhance the delivery of ecosystem services and contribute to address urban challenges. The identification of spatial opportunities for NbS can support the development of concrete options of NbS planning and implementation. This research presents an approach to identify spatial opportunities to implement NbS within the urban agglomeration around Valletta, Malta. Spatial opportunities for NbS are identified through spatial analysis of available open spaces and content analysis of the spatial policies promoting NbS interventions. Overall spatial opportunities cover the 14% of the case study area. They include open spaces that are potentially available for the creation of new ecosystems, built-up areas where it is possible to integrate green elements, and existing ecosystems to conserve and/or enhance. The identification and mapping of spatial opportunities can support the NbS planning and implementation on the ground, while highlighting in which city areas there is the need to integrate alternative solutions because of the lack of space.

1 Introduction

Over the past years, an increasing number of perspectives have reflected an anthropocentric view of the management of nature and natural resources, including biodiversity and the environment, focusing on the benefits that humans gain from nature [1]. Although sharing a similar root with more consolidated concepts such as ecosystem services (ES) and green and blue infrastructure, the emergence of the notion of Nature-based Solutions (NbS) denotes the recent expansion of the scope to particularly encompass the use of nature for addressing (i.e., resolving or mitigating) multiple environmental, socio-economic, and ecological challenges [2]. For this reason, it is directly relevant and enforceable to several policy areas such as land use and spatial planning [3]. NbS can be described as actions that utilize ecosystem processes of green and blue infrastructure to safeguard or enhance the delivery of ES [4]. The promotion of NbS in urban areas builds on the increasing evidence and experiences showing that natural resources can

play an important and cost-effective role in addressing the challenges of cities, such as climate mitigation and adaptation, air pollution, and human well-being.

The availability and distribution of green and blue infrastructure elements in cities are directly linked to urban planning decisions, together with the spatial distribution and vulnerability profile of population and physical assets [5]. The relationship between urban planning and NbS therefore stems from the fact that planning practices can influence the existence, spatial extent and allocation, and even the management of green and blue infrastructure, while controlling and influencing the distribution of population and physical assets that in turn create the demand for ES to address the existing challenges. To act as an effective solution, NbS must then be carefully planned and distributed to target - in space and time - the issues and challenges affecting a city, a neighbourhood, or a specific site, while providing benefits to as many beneficiaries as possible. However, the urban form of the city represents a strong limitation, with dense urban form itself, many competing uses for land, and land ownership being important factors potentially hindering NbS mainstreaming in planning [6], especially concerning NbS that require space on the ground. To increase the uptake of NbS in urban planning practices, there is a need to know where and how much space exists for their implementation. Spatial opportunities for NbS represent possible locations where proper conditions exist for their implementation on the ground [7]. The identification of spatial opportunities for NbS is a key step towards identifying, planning, and actually implementing NbS, and can support the development of concrete options of NbS [8].

This research presents an approach to identify spatial opportunities for NbS in cities based on a case study application, and it discusses possible implementation options in the different available spaces. The case study is represented by the dense urban area around Valletta, in the small island state of Malta. Besides the identification of physically available open space for NbS through spatial analysis, spatial policies adopted in the urban plans covering the study area are analysed to identify further opportunities and options for implementing NbS that cannot be identified through simple spatial analysis of open spaces (e.g., integration of NbS into the existing built-up spaces, public spaces and infrastructure, etc.).

2 Study Site

The study site includes the capital city of Malta, Valletta, and the surrounding compact urban agglomeration constituted by numerous urban localities that form a unique urbanised continuum. The case study area is defined by the boundaries of the North Harbour and Grand Harbour Local Plan areas, covering a total surface of 2363 ha. Urban land uses cover a significant proportion of the study area, with almost 80% of artificial surfaces, while agricultural and natural/seminatural areas cover respectively 7% and 12% (Fig. 1). It includes one of the major areas for tourism along the coastal belt from Sliema to Paceville, densely populated residential areas, heavy industrial uses together with maritime-related activities, and several areas with significant natural elements (i.e., valley areas) and urban greenery (i.e., urban open spaces and green areas).

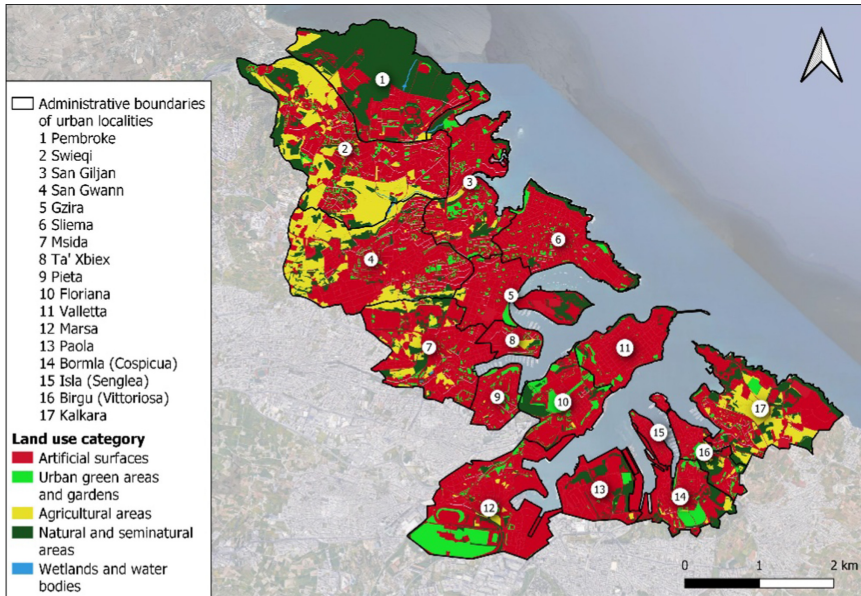


Fig. 1. Administrative boundaries of the case study area and main land uses.

3 Methodology for Identifying Spatial Opportunities for NbS

The approach used to identify spatial opportunities for NbS is based on two steps.

First, we identified open spaces (of undeveloped land) potentially suitable for the implementation of NbS on the ground. These are called physical opportunities. In order to avoid over-estimating the amount of space for effective urban green [9], as well as the land take of areas that are not intended for urban uses such as farmland and natural spaces, only open spaces located within the urban footprint were considered. The urban footprint is represented by the area located within the development boundaries and/or urban conservation areas. Development boundaries enclose the area within which it is possible to apply for building permits and, thus, where land use change to urban uses is allowed. Urban conservation areas cover already urbanised areas where special attention is paid for the historical and landscape character of the built environment. The map of open spaces with green infrastructure categories developed for the case study area in 2017 during the EnRoute project (<https://oppla.eu/casestudy/19309>) – further updated through photo interpretation to account for land use changes during the 2017–2020 period – was used as baseline for the identification of the physical opportunities by excluding open spaces outside the urban footprint or characterised by land cover categories that are unsuitable for land transformation (i.e., cliffs, beaches, wetlands, watercourses, garden areas, and open spaces within major government institutions). Consequently, physical opportunities mainly cover peri-urban zones potentially destined to city expansion, infill development sites, decommissioned sites, and urban open spaces that are preserved from development.

Second, we mapped the areas and sites identified by the local plans' spatial policies and regulations as target spaces for NbS interventions, namely for the conservation, enhancement, or restoration of existing, and creation of new ecosystems [10]. These are called opportunities related to planning regulations. We carried out a qualitative content analysis of the local plans to identify the spatial policies promoting NbS interventions (i.e., policies involving planning actions that explicitly include green elements, such as trees, green spaces, urban parks and playgrounds, and any kind of greenery associated with specific sites) and the related target areas and sites. They include development areas where developers are required to include green elements, green/open spaces to preserve from development, and public spaces (e.g., streets, plazas, pedestrian zones) and other sites (e.g., industrial activities, office complexes) to enhance through environmental improvements (e.g., street greenery, planting and landscaping measures for aesthetics or mitigation purposes). Once mapped, they were added to the physical opportunities to set up the final map of spatial opportunities for NbS.

4 Spatial Opportunities for NbS

A total of 332 ha of spatial opportunities for NbS were identified, corresponding to the 14% of the case study area. 207 ha are covered by physical opportunities and 188 ha by opportunities related to planning regulations, with 63 ha covered by both typologies. When overlapping, the two typologies cover open spaces designated by the spatial policies to future development schemes or to ecosystem conservation and/or improvement actions. Opportunities related to planning regulations that do not overlap the physical opportunities instead cover elements of the built environment that are not identifiable through open space analysis, such as streets and other public and private built-up sites. Table 1 shows the different land use and cover categories characterising the areas mapped as spatial opportunities for NbS.

As shown in Fig. 2, significant physical opportunities are located in the northern part of the study area, namely in the urban localities of Pembroke and Swieqi, in the western part of Msida, in Manoel Island, in Floriana and the southern part of Cospicua and Birgu. The central part with the touristic coastal belt has the lowest presence of spatial opportunities for NbS, especially in the localities of Sliema, San Julian, Gzira, San Gwann, and Pieta, together with Valletta and Senglea, the two historical and most compact cities.

The distribution of the opportunities related to planning regulations is quite scattered. Floriana, Marsa, and Cospicua show significant opportunities, contrary to the capital city of Valletta and, to a lesser extent, the towns of Senglea, Sliema, San Gwann, and Pieta. Figure 3 shows the spatial distribution of the opportunities related to planning regulations classified in four main typologies of NbS interventions based on the scope and target area of the intervention: conservation of open and green spaces, sites for urban transformation and/or development that require the integration of green elements, environmental improvement of public spaces, and environmental improvement of existing urban sites. Respectively, they cover 106 ha, 42 ha, 28 ha, and 31 ha. However, except the areas for open and green space conservation that fully correspond to the available space for NbS implementation (like the physical opportunities), the areas corresponding to the

Table 1. Land use and cover categories of the areas mapped as spatial opportunities for NbS.

Typology of spatial opportunities	Land use and cover category	Notes
Physical opportunities, including opportunities related to planning regulations that overlap them	Brownfield land, or land within urban zones which was not developed and is not used for agriculture	Typically disturbed through human action
	Abandoned agricultural areas	Land use change to urban used allowed
	Agricultural areas (arable, permanent crops)	
	Natural grassland	Land use change to urban used allowed, except for conservation areas
	Shrubland	
Woodland		
Opportunities related to planning regulations that do not overlap physical opportunities	Residential areas	-
	Commercial areas	-
	Industrial areas	-
	Roads and associated land	-
	Other public spaces	Squares and pedestrian areas, waterfront areas

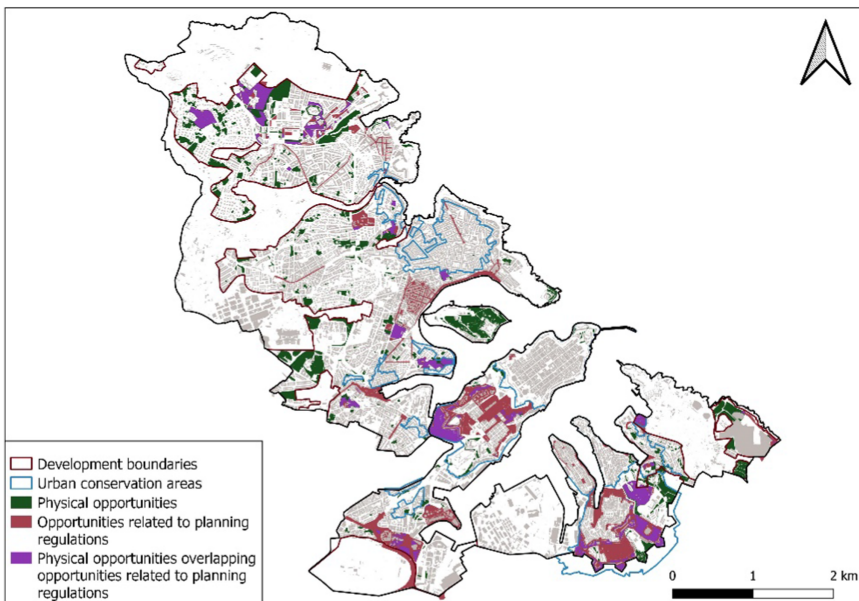


Fig. 2. Spatial distribution of the spatial opportunities for NbS.

other categories do not correspond to the available space for NbS, which are expected to be implemented only in a portion of the mapped space. For example, in the case of a street or public space identified for environmental improvement the space available for the greening intervention (e.g., street trees, public greenery) will be a portion of and not the whole street/public space area mapped.

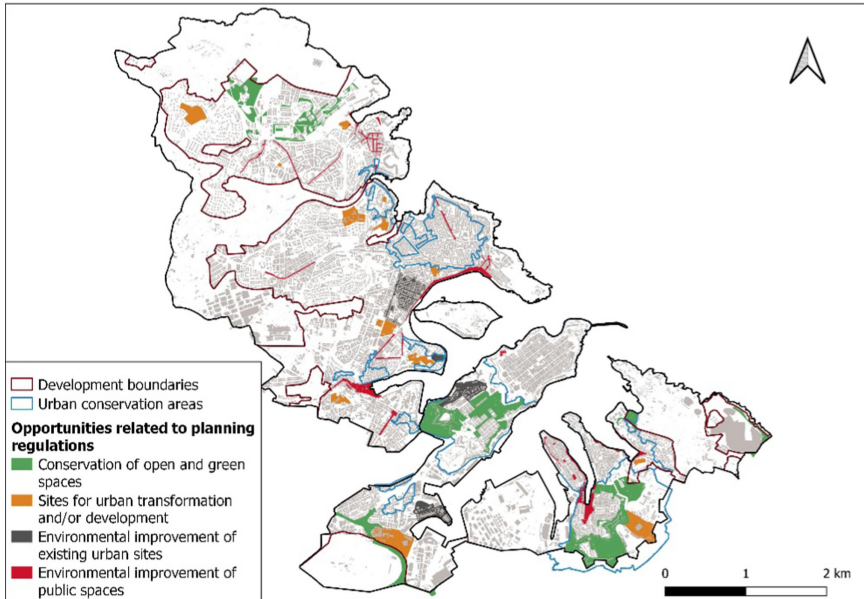


Fig. 3. Spatial distribution of the different typologies of opportunities related to planning regulations.

5 Discussion and Conclusions

Our research identified spatial opportunities for NbS on the ground in the urban agglomeration around Valletta, the capital city of Malta. We detected and mapped available open spaces through spatial analysis (called physical opportunities) and the areas and sites identified by the urban planning instruments as target spaces for NbS interventions through content analysis of the local plans' spatial policies (called opportunities related to planning regulations). Some of the areas mapped as opportunities related to planning regulations overlap the physical opportunities, namely those targeting open space areas. The others are targeted to built-up spaces (e.g., streets and other public spaces, existing built-up sites, etc.), thus allowing the identification of further potential for implementing NbS that otherwise is not possible to capture solely on the basis of the spatial analysis. The two typologies of spatial opportunities can therefore be considered complementary in providing a more comprehensive picture of the space that is potentially available for implementing NbS, which could include: the creation of new ecosystems within the

available open spaces through medium- and large-scale NbS projects (e.g., urban forests and parks); the integration of small-scale NbS interventions into the built environment (e.g., trees, playgrounds, and sustainable urban drainage systems), also through restoration interventions (e.g., de-paving public spaces); the conservation and/or enhancement of existing urban ecosystems (e.g., formal and informal green spaces). Moreover, the identification of the opportunities related to planning regulations revealed possible NbS implementation options that can be promoted through specific policies and instruments and potentially scaled up within the rest of open space areas identified as physical opportunities. These include the definition of standards and requirements to apply when transforming an area (e.g., from agricultural to residential land use) with the objective to integrate NbS in the project, the definition of natural conservation zones or open space areas to be preserved from development and dedicated to greening interventions, and the promotion of best practices and criteria that include NbS in the design and improvement of public and private spaces. In particular, areas for new development and transformation projects by privates could integrate greening elements early on during the planning process with the interventions paid off by private developers, while their integration into the existing private spaces requires retrofitting interventions that can be mainly promoted through economic incentives provided by the public.

Overall, the spatial opportunities identified are not equally distributed among the study area and, for this reason, there may be significant city areas that cannot benefit from their implementation. However, a fair number of (public) open spaces that were not initially included within the spatial opportunities – because of covering areas with already established uses and functions, thus not meant for generic land use transformation and development – could offer further opportunities for NbS in such city areas that lack proper spatial opportunities. For example, existing public gardens could be re-designed not only to fulfil the recreational functions but also to accommodate, where possible, specific NbS features to address urban challenges without affecting the recreational value and accessibility. Possible solutions may include floodable areas within specific portions of urban parks to reduce stormwater runoff, increased canopy cover to provide more shadow and reduce temperature and air pollution, and increased permeable soil in highly paved garden areas to improve water infiltration and carbon storage. Another opportunity is offered by the incorporation of green elements that go beyond the mere aesthetic purpose in the street and public space greenery to mitigate specific issues at the local scale, especially those requiring ES supplied by linear green infrastructures such as noise reduction and moderation of extreme events [5]. Possible NbS that may be introduced in such spaces are vegetation buffers to shield traffic noise or linear rain gardens and bioswales to reduce stormwater runoff in streets and highly impervious public areas. However, site-specific considerations are required to assess if enough space and technical feasibility exist for introducing such elements (e.g., vegetated noise barriers require a minimum width and multi-layered vegetation to perform the noise shielding function [11]).

The mapping of spatial opportunities for NbS could offer a valuable tool that can be used as an entry point for planning NbS distribution and implementation. For example, when combined with ES mapping and assessment including both the demand and supply side, it can support decision-making to identify priority sites for NbS interventions,

whether it is the conservation of existing ecosystems to secure ES provision, or the enhancement of existing and creation of new ecosystems in areas with high ES demand. In particular, the distribution of population and physical assets determines the demand for ES [12] that, together with the spatial configuration of the societal challenges and related hazards, can be used to assess and map the distribution and magnitude of the ES demanded across a city (e.g., [11]). Such knowledge is necessary to prioritize and locate the right solution, which delivers the right ES, on the right (available) place, which can be identified in the map of spatial opportunities. Finally, the identification of spatial opportunities may help to analyse what city areas may benefit from NbS implementation on the ground and where there is instead the need to design and integrate solutions that do not require space on the ground (e.g., green roofs and walls).

Funding Information. DL, MB e DG acknowledge support from the Renature project (Promoting research excellence in nature-based solutions for innovation, sustainable economic growth and human wellbeing in Malta) receiving funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 809988. CC acknowledges support from the Alexander von Humboldt Foundation.

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