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NORDISK ARKITEKTURFORSKNING
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THE ROLE OF NON-URBANIZED AREAS FOR DESIGNING AN URBAN GREEN INFRASTRUCTURE

RICCARDO PRIVITERA, FRANCESCO MARTINICO, DANIELE LA ROSA AND VIVIANA PAPPALARDO

Abstract

This paper presents an Urban Green Infrastructure (UGI) design approach aimed at re-defining the role of green area network as part of the Land Use Masterplan of the city of Catania (Italy), a southern Mediterranean city. It is a particularly relevant and challenging case considering the substantial lack of green spaces, which characterizes the urban environment of this city. The proposed approach is intended as a tool for implementing planning actions that aim to include existing Non Urbanized Areas (NUAs) into the construction of a Green Infrastructure. Actions are proposed to define and build different design scenarios including longitudinal, radial and urban core connections through specific Design Elements (Green Lines, Green Wedges and Green Hooks). As a result, UGI would provide an increase of green spaces up to 2250 % compared to the current amount of public green areas. Integrating rural landscapes into leisure areas, through protection and promotion of urban and peri-urban agriculture, would substantially increase the total amount of usable and accessible green space within the municipal boundary.

Key words:
Non Urbanized Areas, urban green infrastructure, peri-urban agriculture integration, sub-urban and urban green spaces

Introduction

The concept of Green Infrastructure (GI) has been introduced to upgrade urban green space systems, thus forming a coherent planning structure (Sandström, 2002). GI includes different kinds of green spaces, connected as networks of multifunctional ecological systems within, around and between urban areas, and at different spatial scales. GI should be designed and managed as a multi-functional resource, able to provide landscape, ecological services and quality of life required by affected communities. The concept of GI emphasizes quality as well as quantity of urban and peri-urban green spaces (Turner, 1996; Rudlin and Falk, 1999); their multifunctional role (Sandström, 2002) and the importance of interconnections between habitats (van der Ryn and Cowan, 1996). Its design and management should also enhance the character and distinctiveness of an area with regard to existing habitats and landscape types. GI comprises inter-connected natural areas instead of separate parks and recreation sites. It requires responsible intervention to safeguard critical land and actively practice conservation, regeneration and/or stewardship (van der Ryn and Cowan, 1996).

Numerous reasons exist for considering GI as an implementation tool for planning actions. From an ecological perspective, GI maintains the integrity of habitat systems and provides the physical basis for ecological networks, which has been advocated as a way for alleviating the ecological impacts of habitat fragmentation, even in urban context (Bierwagen, 2007). This makes biodiversity conservation an integral part of sustainable landscapes (Opdam, Steingrover and van Rooij, 2006). GI also plays a key role in climate change adaptation and mitigation by improving the city's capacity to cope with rising temperatures and extreme weather events associated with climate change (Gill, et al., 2008). Furthermore, the connection of urban green spaces increases the overall accessibility of these areas through the creation of cycling and walking paths.

The term «infrastructure» implies a system that is vital to the functioning of a city, whereas «green space» may be regarded something merely nice to have. Like other infrastructure typologies, such as transport, food/-energy supplies and water/waste management systems, GI can contribute significantly to the delivery of other forms of services to communities (MEA, 2005). For all these reasons, GI should be seen as a primary consideration in planning, developing and maintaining an eco-town. If GI is proactively planned, developed and maintained, it has the potential to guide the urban development by providing a framework for economic growth and nature conservation (Walmsley, 2006; Schrijnen, 2000; van der Ryn and Cowan, 1996). Such a planned approach would offer many opportunities for integrating urban development, nature conservation and public health promotion (Tzoulas, et al., 2007).

The present paper explores the possibilities of efficiently connecting the various open spaces in order to create a green infrastructure. It presents a design approach for the Urban Green Infrastructure (UGI), aimed at re-defining the role of a green area network within the land-use Masterplan of the city of Catania, in Italy. The creation of an UGI is particularly relevant and challenging considering the substantial lack of green spaces that characterizes the urban environment of this city.

The various types of green space are extremely different and complex; therefore, specific strategies are required for dealing with each sub-group. The implementation of UGI will be based on the following strategies, which address: (1) environmental protection and integration of peri-urban agriculture, (2) development of sub-urban green areas, and (3) enhancement of current urban green spaces (see section Action Strategies).

Materials

As one of the main cities in southern Italy, Catania ranks second in economic and political importance in Sicily and has the tenth highest population in Italy overall. The city's municipal area is 180 km² with a population count of 295,591 in December 2010. The city's favorable location along the coast; its well-connected motorway and railway systems, and the presence of a commercial port and busy airport afford the city a strategic role in the region. Today, Catania is the most important commercial, industrial, administrative, cultural and educational centre of eastern Sicily, extending its influence well beyond the municipal borders of its province. The existing settlement has developed around the historical center and has grown beyond the city's administrative borders, incorporating existing agricultural and fishing villages into a large metropolitan area. The result is a rather heterogeneous aggregate of settlements, where rich and vital urban fragments are intertwined with poor and marginal ones, the latter often corresponding to social housing schemes or illegal settlements.

Catania is the centre of a large conurbation that represents the largest metropolitan area in Sicily (figure 1), a settlement system characterized by extensive urban sprawl. In the course of forty years (1961–2001), the total population of 27 municipalities included in the metropolitan area grew more than 27 % (La Greca, et al., 2011a). In 2008, approx. 60 % of its total population lived outside the main city, indicating progressive population expansion beyond the city center.

The amount of current public green space is less than the minimum amount stated by national legislation (D.M. 1444/68) that imposes to Local land use master plans to stipulate a minimum of 9 m² of public green space per inhabitant. To date Catania encompasses a total amount of

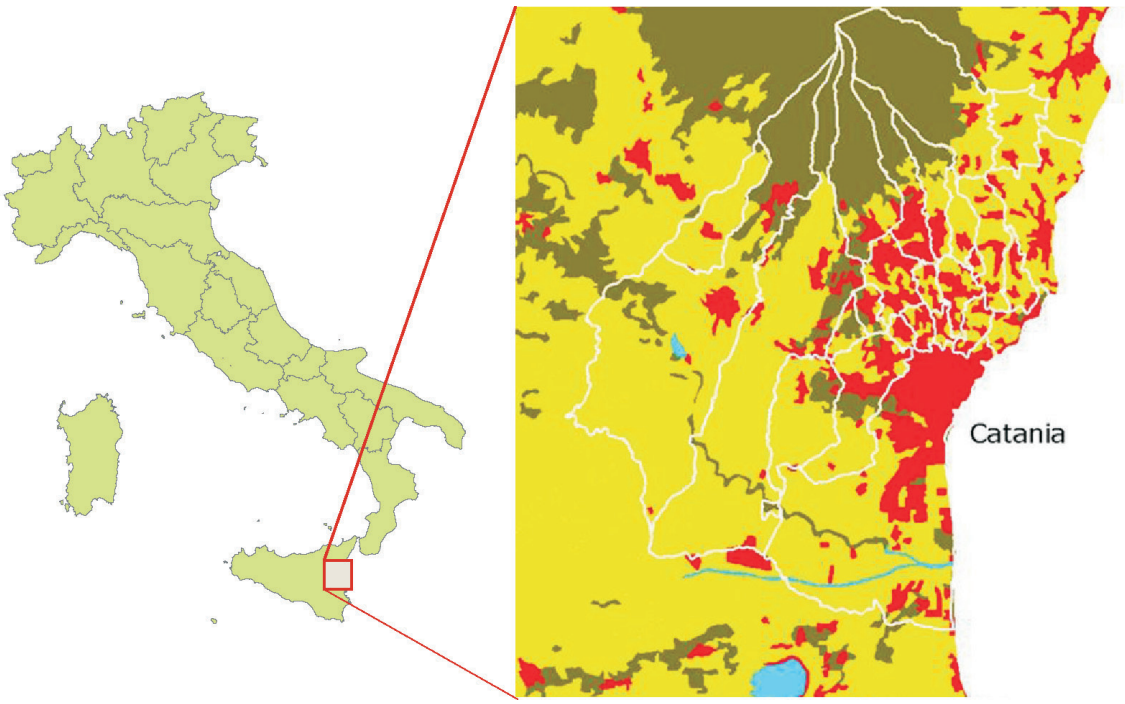


Figure 1
Catania municipal study area (Italy).

856,000 m² of public green space, which is far below the required total area (1,670,000 m²) according to population size. Public green spaces account for 3 m²/inhabitant; consequently approx. 814,000 m² are lacking in order to comply with the minimum amount required by law (Catania Master Plan, 2012).

Approx. 702,000 m² of the existing green spaces can be categorized into three groups: (a) 'Public green spaces', including few historical gardens and other small public parks, (b) 'Public open spaces', including squares planted with trees and flower beds and furnished with benches, and other small open spaces beside roads and public facilities, (c) 'Street trees' mostly composed of tree-rows, abandoned grass and roadside planting. These categories are mapped in figure 2 and summarized in table 1.

A natural reserve along the main river (*Riserva Naturale Orientata Oasi del Simeto*) is also included into the city's municipal boundaries, located along the south-eastern border (figure 2). This protected area covers 1,859 ha and includes the river mouth area, wetlands, sand dunes and river banks.

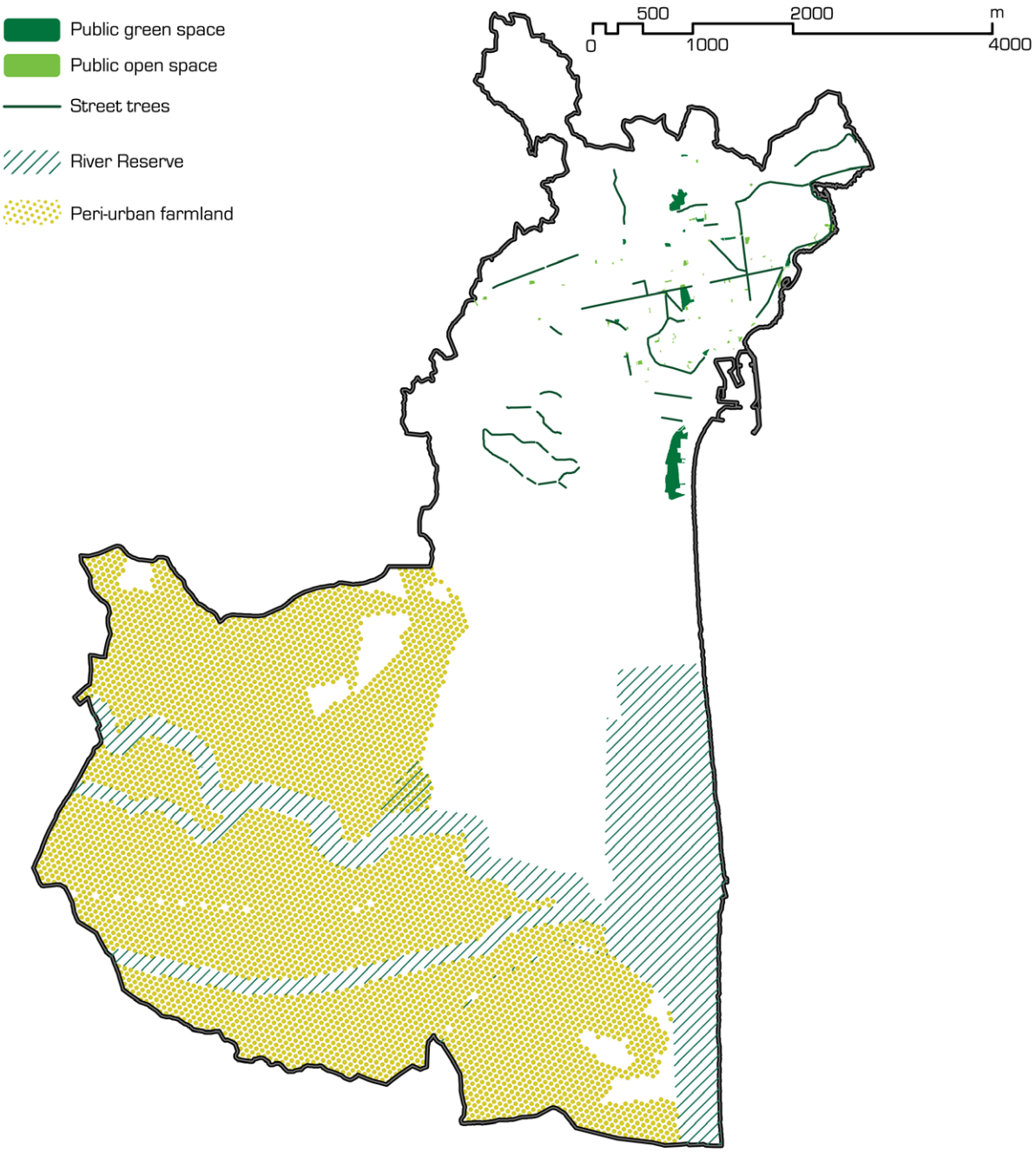
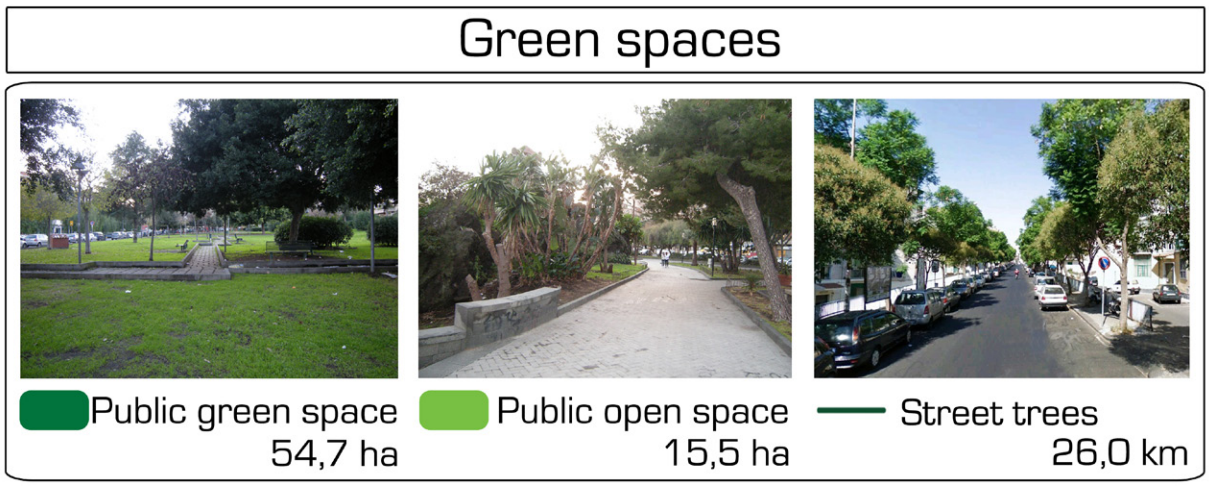


Figure 2
Map of current greenspaces in Catania municipal area.

Table 1
Categories of current green spaces.



Non-Urbanized Areas

Apart from public green spaces introduced in the previous paragraph, a significant number of other open spaces, currently unmanaged, are present in Catania. These Non-Urbanized Areas (NUAs) are outdoor places with significant amounts of vegetation, mainly semi-natural areas that represent the last remnants of nature within the built up area, able to produce ecosystem services (La Greca, et al., 2011a). These areas are quite heterogeneous in shape, size, land-use type, function, bio-physical features, and ecological and landscape value.

NUAs play a multi-various role in urban ecosystems, including preservation and enhancement of biodiversity (McHale, McPherson and Burke, 2007; Romano, 2005), production of oxygen (Jo, 2002), reduction of air pollution (Yang, et al., 2005), noise (Fang and Ling, 2003) and the heat island effect (Shin and Lee, 2005), regulation of microclimates, as well as the achievement of crucial health, well-being and social safety objectives (Groenewegen, et al., 2006).

To date, NUAs in the Catania area, in spite of their strategic role, have not been studied systematically. This lack of rigorous data collection and analysis may be directly attributed to an existing weakness of the region's planning policy. Nevertheless, NUAs are the elements suitable for use in an urban GI, considering that they can be converted into a multifunctional green network. Uncontrolled urban sprawl over the past thirty years has undermined the grid of natural ecosystems, which good planning policy attempts to restore by applying an UGI approach.

NUAs Land-Use Analysis

The initial step in designing the UGI was the construction of a land-use map for the Catania municipal area. The map was based on vector cartography (at scale of 1:10,000), municipal vector cartography (at a scale of 1:2000), field surveys and 2008 high resolution (0.25 m) ortho photos.

NUAs have been classified into two categories of land-use types: 'Farmlands' and 'Woods/Shrubs', both located in the northern part of the municipal area (figure 3). Peri-urban farmlands and the River Reserve, located in the southern part of Catania, have not been included in the proposal of the UGI, since these areas already have an important role in productive agriculture and environmental protection and thus are not suitable to be converted into different land uses.

The 'Farmlands' category includes: orchards, arable lands and vegetable groves. The 'Woods/Shrubs' category includes: woods, shrubs and lava fields (figure 4).

Figure 3
Map of Non-Urbanized Areas Land-use types.

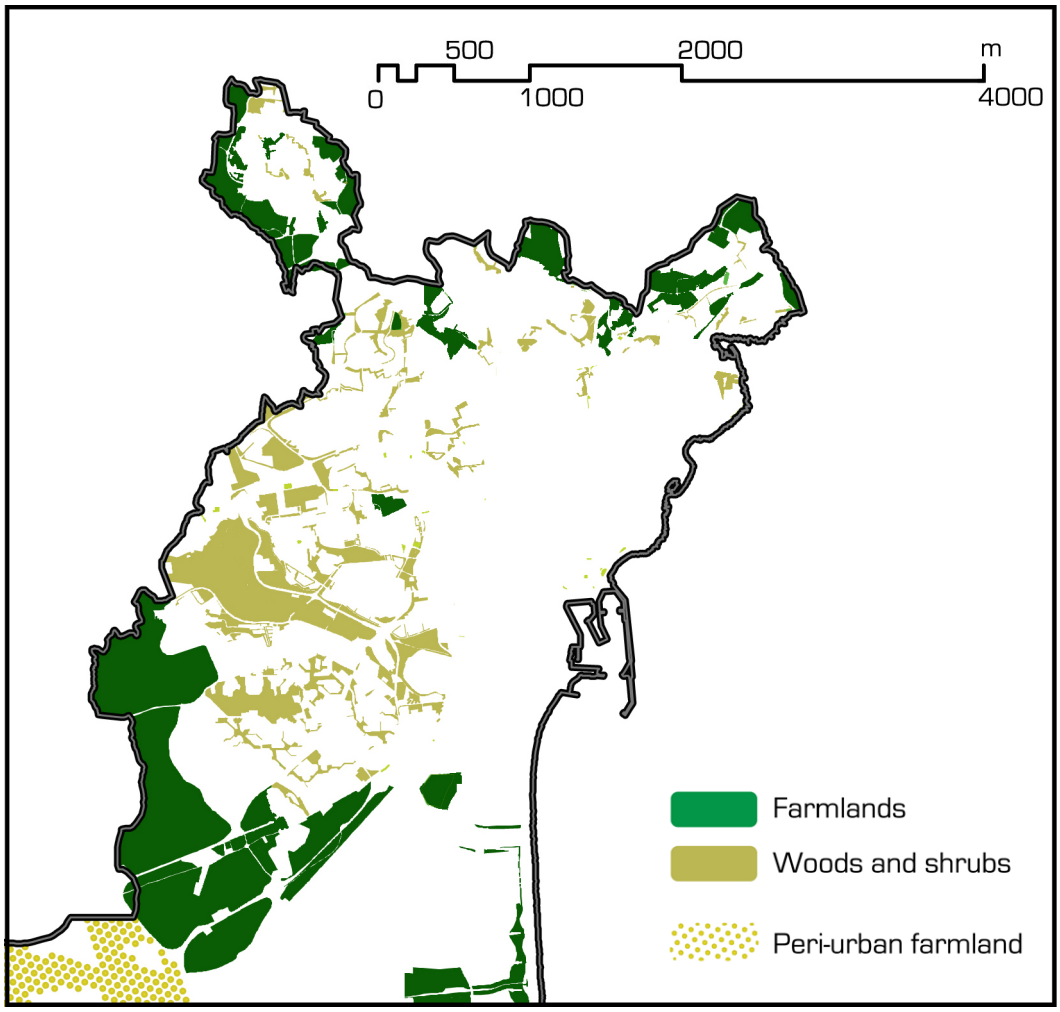


Figure 4
Non-Urbanized Areas land-use categories.

Orchards include vineyards, orange groves, lemon groves, olive groves and other orchards (figure 5) and they are mostly located in the southern part of the municipality, next to *Simeto* River. In the northern part, most of the farmlands are abandoned as a result of urban sprawl and fragmentation, resulting in the loss of biodiversity and ecological integrity (Franklin, Noon and Luke George, 2002; Romano, 2005).

Arable lands, located in the southern part of the municipality include grasslands and pasture lands, which represent an important habitat for many bird species. Vegetable groves are scattered throughout the municipal area and represent the most economically relevant farmlands. Shrubs are usually located beside the urban fringe, which are characterized by annual and perennial vegetation typical of the *maquis* (Mediterranean flora). Lava fields represent the most peculiar habitat and are characterized by lava flows, colonized by pioneer vegetation beginning a chain of ecological succession (Doelle, et al., 2008). Woods are mainly characterized by fragments of the *maquis* located beside the coast of Ionian Sea and fragments of the so called *bosco etneo* in the northern part of the municipality. They represent the last remnants of wider natural systems, once present in the area of the *Mt. Etna* slopes, typically populated by oak woods (*Quercus virgiliana, Quercus dalechampii, Quercus congesta*). In the last decades some plots of woodlands have been reforested for preserving dunes and orange groves.

Examples of orchards, arable lands, vegetable groves, shrubs, lava fields and woods are shown in figure 5.

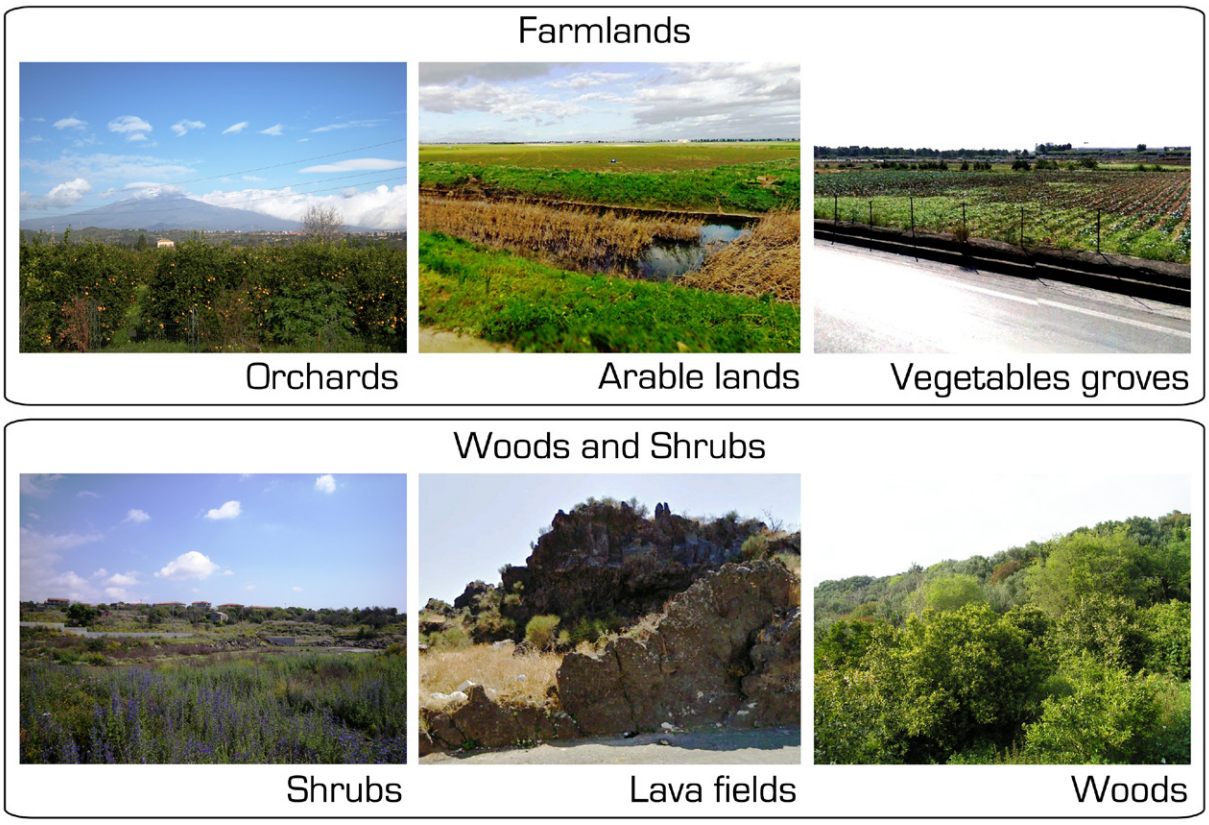


Figure 5
Non-Urbanized Areas land-use detailed categories.

Design Approach

The design of an UGI for Catania is based on the main concept of creating a network of green areas (OCS, 2007), involving both, existing urban green spaces and currently unmanaged NUAs. Ecological connections need a robust and defensible green network, especially when they are embodied within cities (Beier and Noss, 1998). Within urban context the ecological functions of the GI are generally weak (OCS, 2007) and in need of improvement. In the municipality of Catania the natural character of some peripheral NUAs can contribute to improve the ecological functions of an UGI. The design proposal presented here follows a multifunctional approach of GI in urban contexts (Benedict and McMahon, 2002; Hostetler, Allen and Meurk, 2011; Walmsley, 2006). It not only takes into account the ecological functions, but also highlights the importance of agriculture in an urban context (Thornton, 2008) and the issues of accessibility and equitable distribution of urban parks, garden and playgrounds (Smoyer-Tomic, Hewko and Hodgson, 2004) as well as stating the need for an alternative mode of transport next to car traffic (La Greca, et al., 2011b). These issues are particularly relevant within the given context, in which heavy traffic and lack of public transportation are common.

Thus, the proposed UGI aims at following action strategies:

a. environmental protection and integration of peri-urban agriculture into urban context, providing specific new urban agricultural land-use types such as agricultural parks, community supported agriculture and allotment gardens (La Rosa and Privitera, 2013). These land uses can provide various improvements, such as increasing local food production in the city (Granvik, 2012), becoming areas for leisure and supporting the integration of socially deprived population groups (Rubino, 2007);
b. development of sub-urban green areas in order to provide a new distribution of public parks and gardens;
c. enhancement of current urban green spaces by improving quality, usability and accessibility.

Moreover, the UGI provides the basis for establishing *connections for leisure,* a network of green spaces consisting of pedestrian and bicycle pathways among NUAs, which are characterized by different functions and land-use types (Jongman and Pungetti, 2004).

Land-use Analysis, described in section Land-Use Analysis, identifies NUAs that can be used as elements in the UGI. Figure 6 shows the conceptual model of the Design Approach proposed for the UGI implementation. It is based on Connecting Scenarios, Action Strategies and Design Elements, as introduced in the next sections.

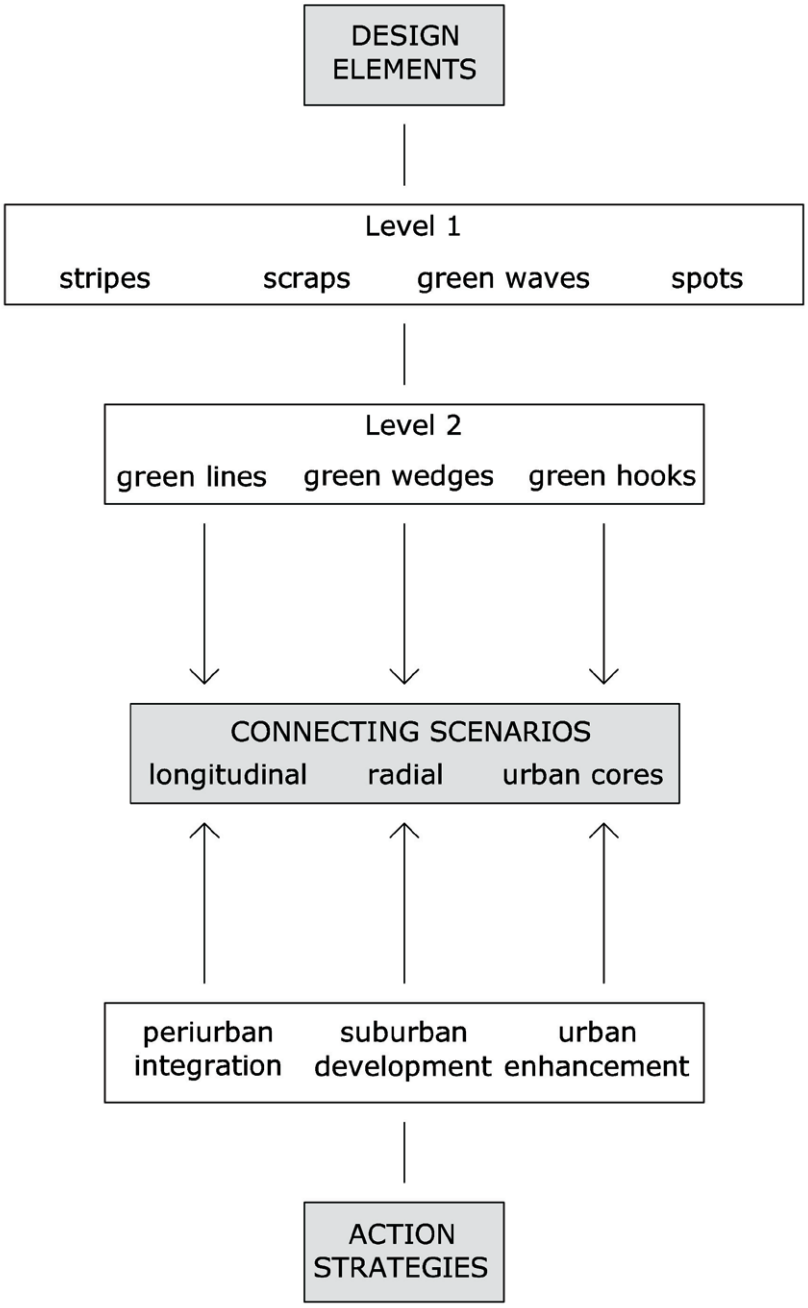


Figure 6
Conceptual Model of Design Approach.

Connecting Scenarios

Connecting Scenarios represent different new spatial configurations that can be assumed by the UGI and are defined according to different connection purposes and types of connected NUAs. Position, land-use, land cover features, shapes and sizes are also taken into account when defining the proposed scenarios. Three categories of NUAs have been identified to specify the relationship between *Connecting Scenarios* and NUAs, which are: (a) '*NUAs at the city edge', (b) 'NUAs in the city periphery', and (c) 'NUAs in the city core',* as shown on map in figure 7.

'NUAs at the city edge' (991.4 ha) are larger areas with high ecological value. They include farmlands and represent the most important green hubs of the municipality. '*NUAs in the city periphery*' (570.8 ha) are smaller non-urbanized areas scattered between the city's surroundings. '*NUAs in the city core*' (85.5 ha) are very small green areas including Public green spaces, Public open spaces, and other unmanaged areas within the urban fabric (see section Materials).

Figure 7
Map of types of Non-Urbanized Areas.

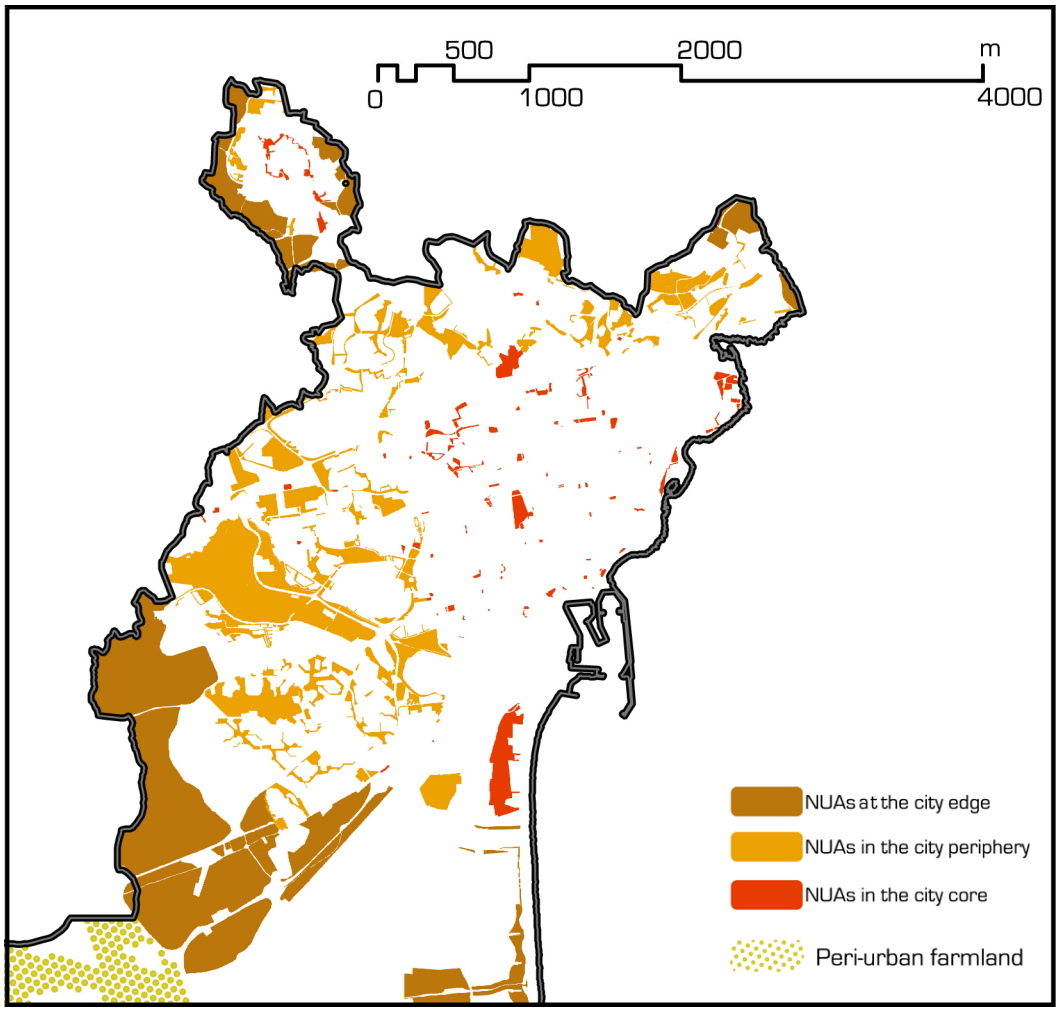
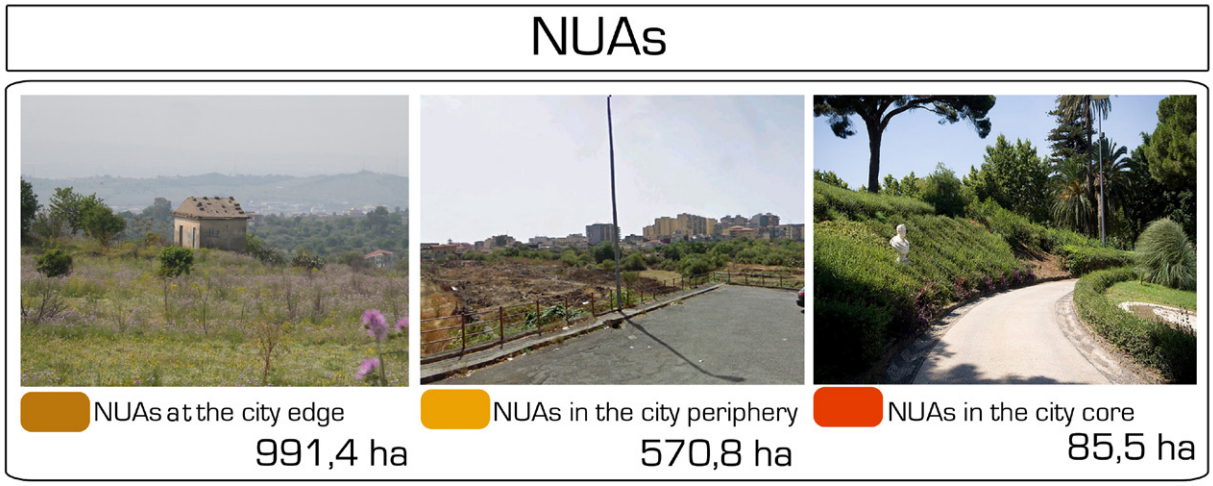


Table 2
Categories of Non-Urbanized Areas.



Taking into account these different NUAs categories, *Connecting Scenarios* have been divided into: *(a) Longitudinal Connecting Scenario* that links *'NUAs at the city edge'; (b) Radial Connecting Scenario* that links '*NUAs at the city edge'* to the widest *'NUAs in the city core', and (c) Urban-cores Connecting Scenario* linking *NUAs in the city periphery* and *NUAs in the city core*.

Action Strategies

Action Strategies are a set of actions created for achieving the aims listed in section Design Approach. From this perspective, strategies include objectives, design scenarios and actions relating to different types of NUAs, indicating functions and new land uses for each NUA. *Action Strategies* have been divided into three categories: *Peri-urban Integration Strategy, Sub-urban Development Strategy* and *Urban Enhancement Strategy*.

Peri-urban Integration Strategy is aimed at integrating agricultural land uses and leisure by promoting urban and peri-urban agriculture and the conservation of traditional rural landscapes (Valentini, 2007; Fanfani, 2009). Actions include the conservation and improvement of NUAs, which account for larger patches of the following two land-use categories: 'Woods/Shrubs' and 'Abandoned Farmlands'. Land pertaining to the category 'Woods/Shrubs' could be converted into *countryside parks* (Donadieu and Mininni, 2006), thereby offering different opportunities, such as the formation of a boundary for anticipated urban growth and an opportunity for enjoying the rural landscape. The second category, 'Abandoned Farmlands' could be zoned as *agricultural parks*. Setting aside these large patches of farmland for agriculture (preferably based on organic farming) would give them stringent rural landscape protection according to law (La Rosa and Privitera, 2013). This strategy leads

to the *Longitudinal Connecting Scenario* for the *NUAs at the city edge*, which was introduced as the first scenario in the previous section.

Sub-urban Development Strategy is aimed at converting current NUAs into new public parks and gardens for leisure. Actions include the design of urban parks, urban gardens, allotment gardens, re-forestation and a network of pedestrian and bicycle pathways connecting these individual areas. This strategy leads to the second scenario: *Radial Connecting Scenario* for the *NUAs in the city periphery*.

Urban Enhancement Strategy is aimed at improving the quality, usability and accessibility of urban green spaces. Actions include the conservation, improvement and promotion of green features, such as tree-planting, recreational equipment and facilities for playing informal games and for encouraging social encounters. Finally, this strategy leads to the third scenario, which is *Urban-cores Connecting Scenario* for the *NUAs in the city core*.

Design Elements

Design Elements are the components of the UGI network that are used to implement *Action Strategies* and *Connecting Scenarios*. They represent the design configurations of NUAs and are divided into *First* and *Second Level Elements*.

First Level Elements are the basic components of the network, such as nodes and linkages, and include the following categories: (a) *Stripes*, *(b) Green Waves*, (c) *Scraps* and *Spots*.

Stripes are mostly characterized by a linear shape and a width ranging from 10 m to 20 m. They include 'Woods/Shrubs' and 'Abandoned Farmlands', into which pedestrian and bicycle pathways are designed. The two main purposes are to preserve existing green areas and to increase the permeability of paths.

Green Waves are located along existing or planned urban roads. They include existing and new 'Street Trees', new cycle paths and enlarged sidewalks, which together provide an overall improvement of road quality. The improvement of soil permeability is achieved by using specific surface materials. The shape of *Green Waves* strictly depends on the size of the adjacent road.

Scraps are elements of the network that include urban parks, local parks, countryside parks, agricultural parks, areas for Community Supported Agriculture (van En, 1995), allotment gardens and sport facilities. They mostly correspond to '*NUAs in the city periphery*' and are characterized by a significant amount of vegetation.

Spots are small areas including existing '*Public green spaces*', '*Public open spaces*' (figure 2) as well as '*NUAs in the city core*' (figure 7), which are suitable for new resting areas for pedestrians. The design features here may include tree-planting and minimal facilities for playing informal games and social encounters.

In the UGI network *Stripes* and *Green Waves* represent linking elements, while *Scraps* and *Spots* represent node elements. Particularly, *Stripes* are designed to link *Scraps,* while *Green Waves* are designed to connect *Spots* (figure 8).

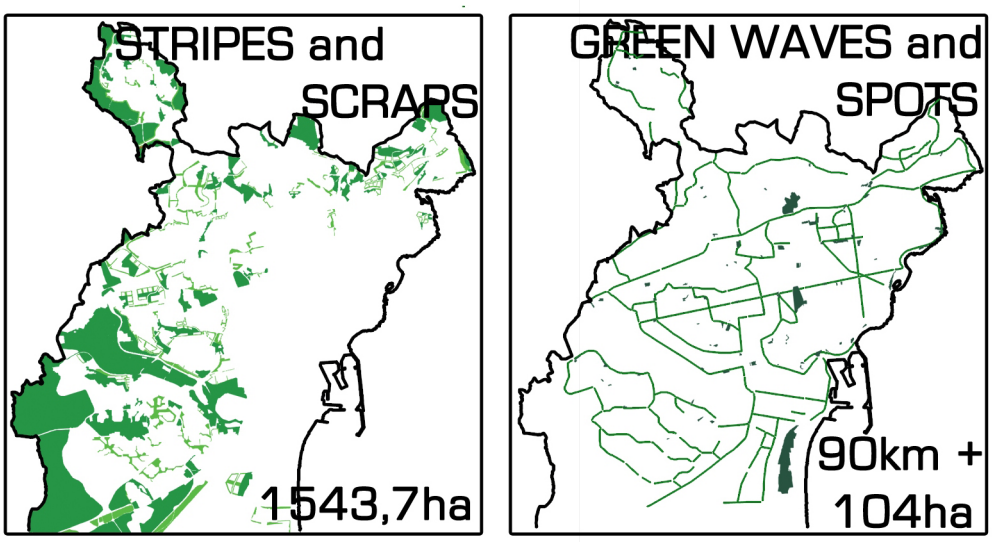


Figure 8
Map of First Level Design Elements (Stripes, Scraps, Green Waves and Spots).

Second Level Elements are elements, which connect areal (Scraps and Spots) with linear ones (Stripes and Green Waves). They represent the design configuration of the three proposed *Connecting Scenarios* and are divided into: *Green Lines*, *Green Wedges* and *Green Hooks*.

Green Lines connect northern rural landscapes of 'Abandoned Farmlands' with southern productive 'Farmlands' (figure 9, left). They are located in the western part of the municipality and along the seaside in the East and represent the design configurations of the *Longitudinal Connecting Scenario*. Particularly, Green Lines new land-uses, such as countryside parks, agricultural parks and allotment gardens are prospected for Scraps.

Green Wedges are aggregations of the largest natural or semi-natural areas, mainly in *'NUAs at the city edge'*. They are targeted toward environmental protection, leisure and new forms of agriculture. Particularly, Scraps within *Green Wedges* are intended for urban parks mixed with Community Supported Agriculture and allotment gardens. The three proposed Green Wedges (figure 9, middle) are the design configurations of the *Radial Connecting Scenario*.

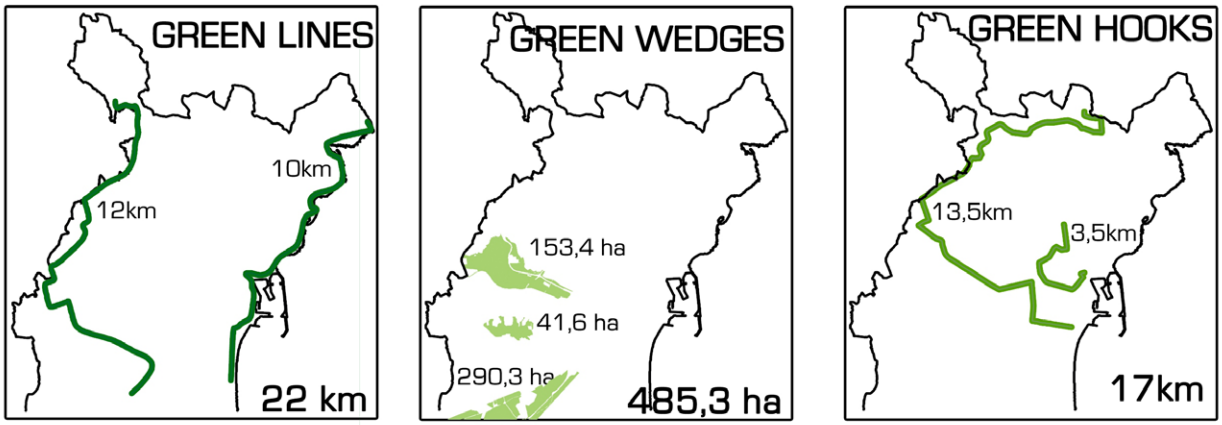


Figure 9
Maps of Second Level Design Elements (Green Lines, Green Wedges and Green Hooks).

Green Hooks are connections of *Green Waves* and *Spots*. They are intended to create green links inside the urban fabric allowing connections between 'NUAs in the city periphery' and in the 'NUAs in the city core'. Green Hooks are designed on the existing main urban ring roads. The two proposed Green Hooks (figure 9, right) represent the design configurations of the *Urban-cores Connecting Scenario*.

Results

Figure 10 shows the final configuration of Catania's UGI as a network of Scraps and Spots connected through Stripes and Green Waves. Stripes and Scraps amount to 1543.7 ha, Spots cover 104 ha and Green Waves have a total length of 90 km (figure 8). Within the category of Second Level Design Elements (figure 9), Green Lines and Green Hooks have a total length of 22 km and 17 km respectively, while the Green Wedges cover an area of 485.3 ha.

The comparison between existing public green spaces (table 1) and the proposed UGI of new public open spaces (figure 8) shows a remarkable increase in surface area of about 2250 % and an increase of 246 % in terms of length of roads planted with 'Street trees' (table 3).

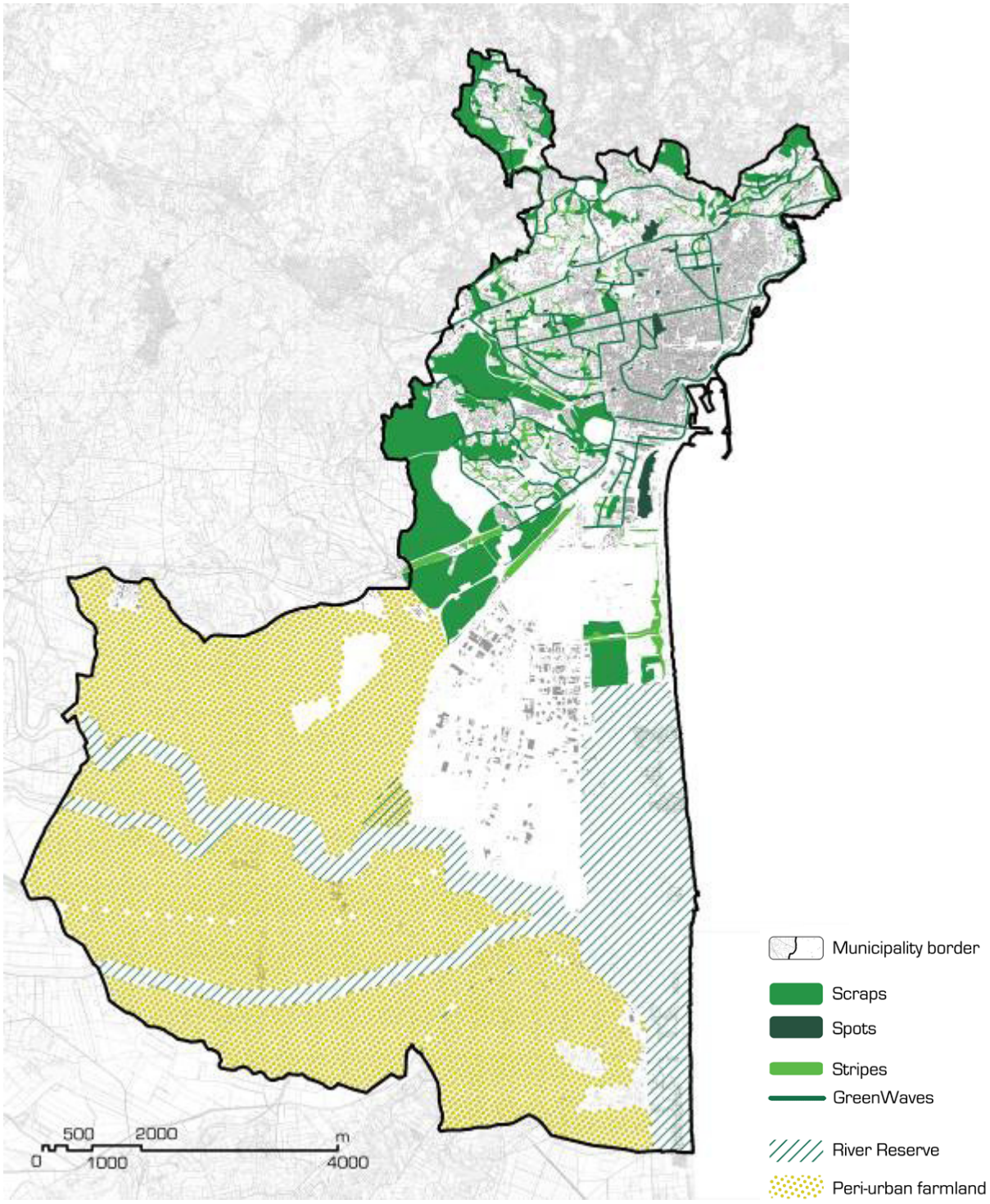


Figure 10
Map of Catania Urban Green Infrastructure.

Table 3
Percentage of green areas and street trees increases.

	Green areas (Ha)	Street trees (Km)
Existing	70.2	26
Urban Green Infrastructure scenario	1647.7	90
% of increase	+2247	+246

Interestingly, the Peri-urban Integration Strategy, involving 100 % of 'NUAs in the city edge', provides the most important contribution to new green areas (more than 60 %) (see table 4). Sub-urban Development Strategy, deals with 35.6 % of UGI green areas and involves 100 % of 'NUAs in the city periphery' and 17.9 % of 'NUAs in the city core'. Finally, Urban Enhancement Strategy concerns 4.2 % of UGI green areas and involves more than 82 % of the 'NUAs in the city core', representing the categories of *Public greenspaces, Public open spaces* and *Street trees (section Materials)*.

Table 4
Contribution (%) of the three Strategies for implementing Urban Green Infrastructure.

Strategies	Green areas (Ha)	involved NUAs %	UGI %
Peri-urban Intergration	991.4	100 'NUAs at the city edge'	60.2
Sub-urban Development	586.1	100 'NUAs in the city pheriphery'	
		17.9 'NUAs in the city core'	35.6
Urban Enhancement	70.2	82.1 'NUAs in the city core'	4.2

Sub-urban and peri-urban green areas, even if non-urbanized, are mostly not accessible to people. Thus, the relevance of developing an UGI is mainly related to increasing the total amount of public green spaces and improving their connectedness and accessibility. Some of the proposed solutions for the Design Elements of the Catania UGI (Stripes and Green Waves as First Level Elements and Green Wedges as Second Level Elements) are presented here in order to highlight their specific contribution in providing new green areas. Figure 11 and figure 12 show two types of proposed Stripes. Type A is beside an existing or new urban road, while Type B is within a NUA. Their widths vary from 14 m to 20 m, with a total percentage of green cover varying from 70 % to 75 % and permeable surface of 92 % and 100 % cover respectively. They are composed of a bed of arboreal species with a width between 6.8 m and 7.8 m. The trees' maximum height ranges between 5 m and 12 m and their canopy

spread between 3 m and 6 m. Following species are proposed for the Stripes*: Ligustrum japonicum, Phillyrea agustifolia, Magnolia grandiflora, Celtis australis*. These exotic species are widely used in the Catania municipal area. Experience, so far, has shown these species not to be aggressive or negatively affect local urban biodiversity.

One-way cycle paths (1.5 m wide) are included in the Stripes and can be paved with a bituminous layer. Pedestrian paths have a width varying from 2.1 m to 2.5 m. Pedestrian and bicycle pathways are always paved with natural permeable materials. *Zoysia japonica* species can be used for lawns, as it is a very robust species suitable for the Mediterranean climate. The result is a configuration of public green spaces where usability, thermal comfort and safe mobility are the main objectives.

Figure 13 and figure 14 show two types of Green Waves (Type A and Type B). The first represents a Green Wave situated between different built-up areas, which include a total road section of 12 m. The second is a Green Wave beside an Urban Park with a total road section of 32 m. These examples show that the green component (green area) can vary from a mini-

Figure 11
Stripe Type A (First Level Design Element).

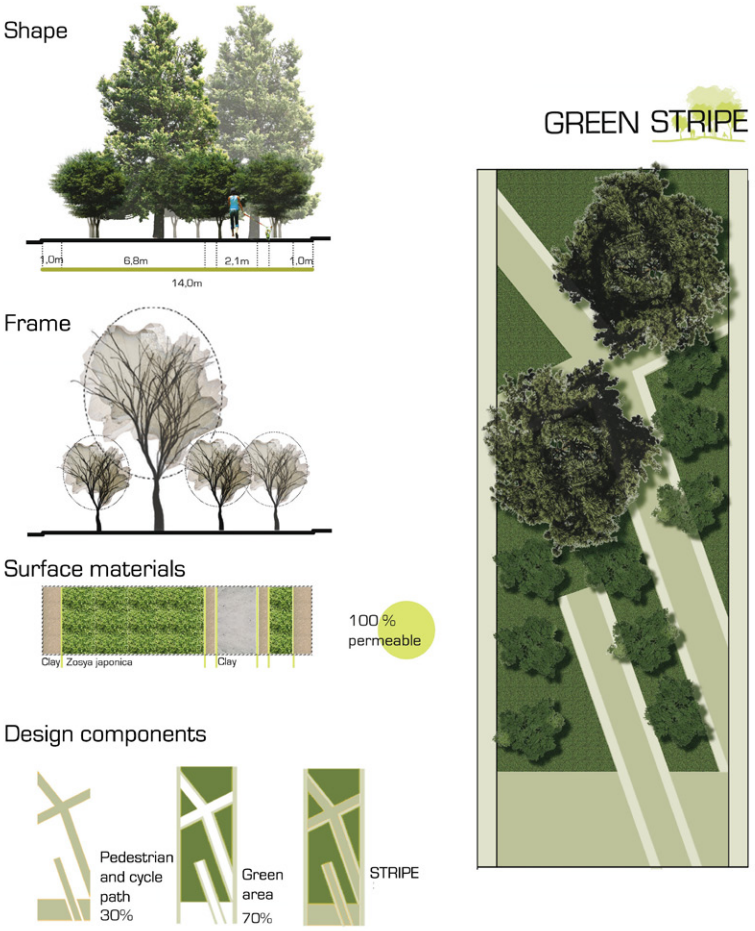


Figure 12
Stripe Type B (First Level Design Element).

mum value of 1.5 m width (Type A) to a maximum width of 10 m (Type B) in road sections with bicycle paths, pedestrian paths and bus lanes. These values represent approx. 12.5 % and 31 % of the total width of the road section.

The Green Wedge (figure 15) covers an area of approx. 153.4 ha and represents a Second Level Design Element. It is to be allocated to major parks providing leisure and sport facilities, or for urban agricultural purposes. This Wedge is mainly composed of two different types of Scraps. The first one is a large urban park aimed at protecting current woods and shrubs as well as providing spaces for sporting and recreational activities. The second Scrap is a smaller area, containing abandoned farmlands, where community supported agriculture and allotment gardens have been proposed. Next to the northern part of the Green Wedge boundary, a Stripe is designed along a stream to restore its vegetation. In the southern part, a Green Wave (Type B) has been proposed to sit next to a newly designed urban road.

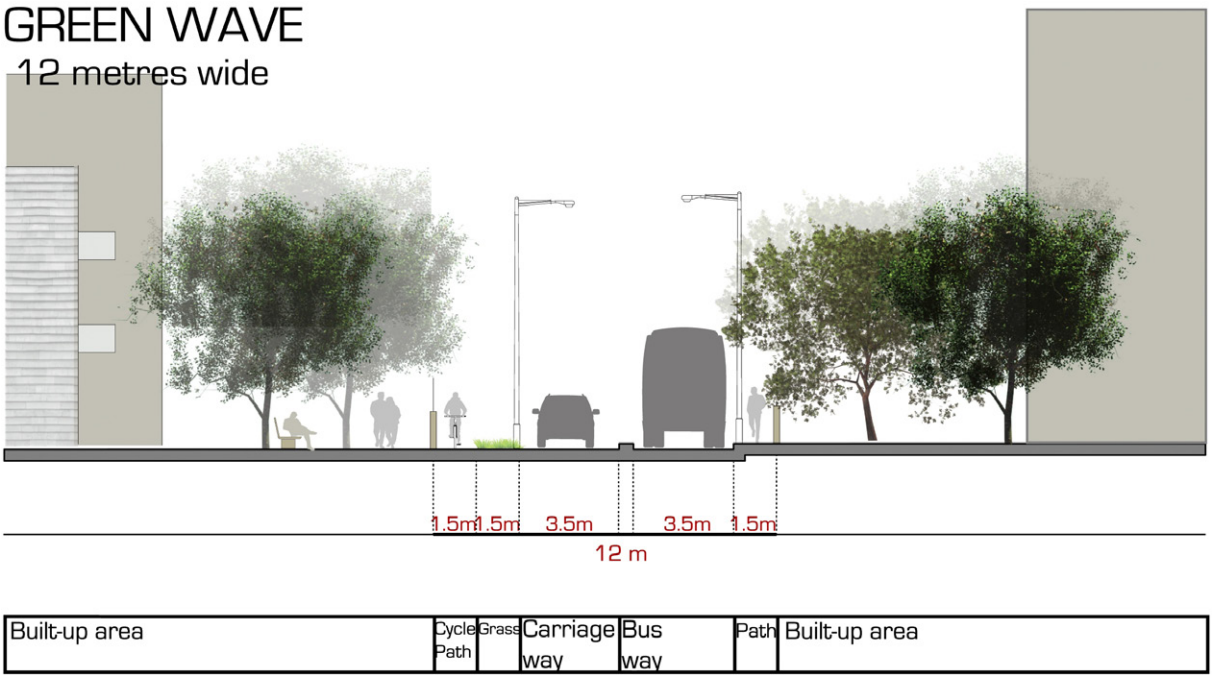


Figure 13
Green Wave Type A (First Level Design Element).

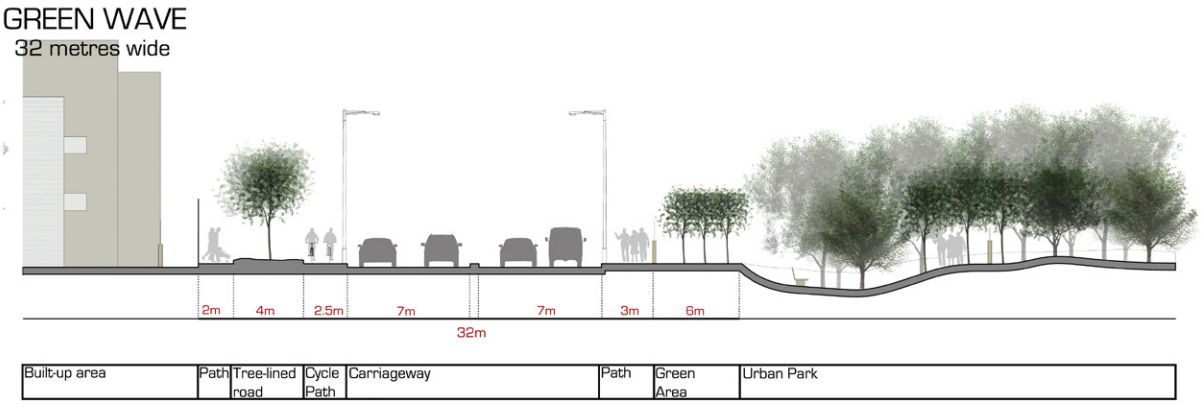


Figure 14
Green Wave Type B (First Level Design Element).

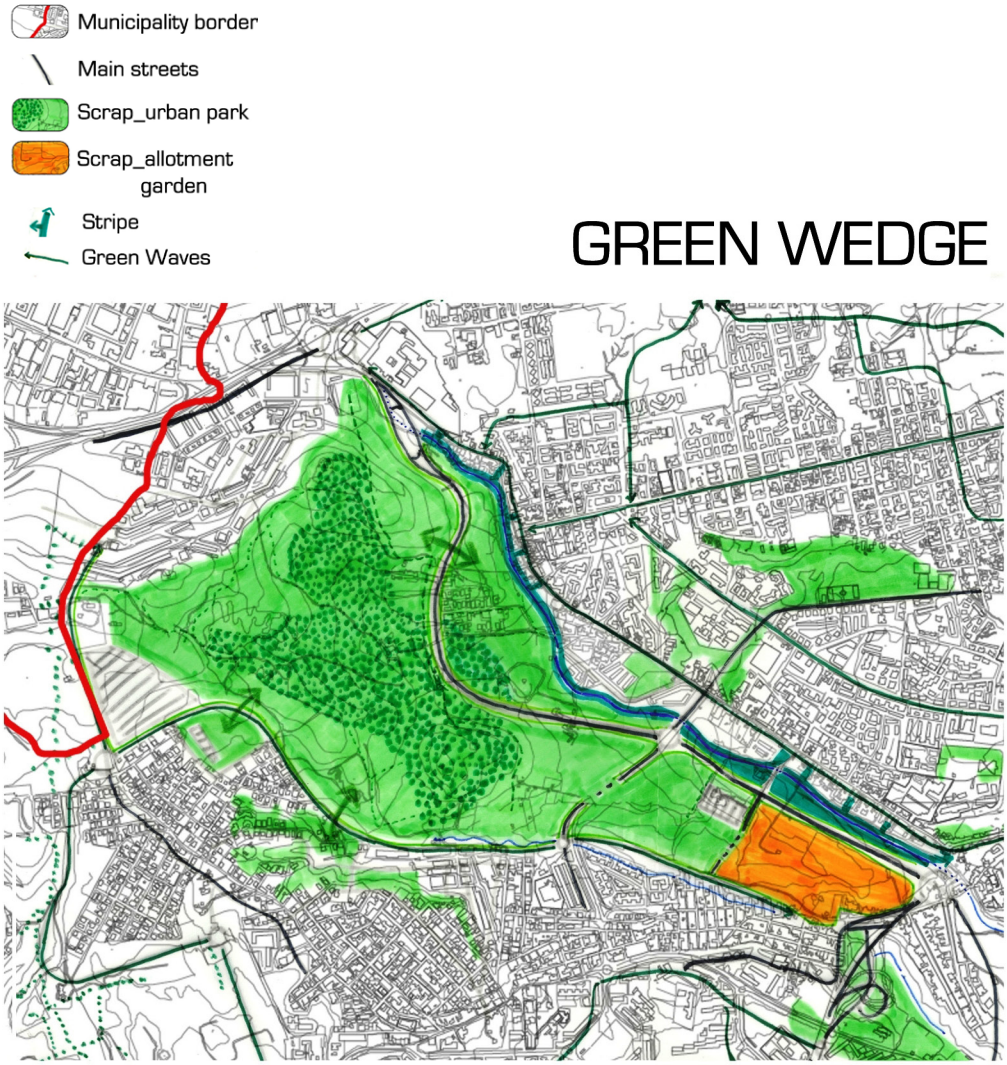


Figure 15
Green Wedge (Second Level Design Element).

Discussion and conclusion

In the Catania municipal area, urban land-use plans have always considered NUAs as generic farmlands or undefined green spaces without any particular importance or role (La Rosa and Privitera, 2013). Despite their appearance of being abandoned and neglected areas, NUAs could play a strategic role in the construction of UGI, especially within urban contexts where the lack of green spaces is particularly relevant. Environmental, social, economic and cultural benefits can be derived from integrating NUAs into the urban fabric; therefore, they need to be given careful consideration.

The importance of this paper is that it represents a design approach aimed at enhancing the current land-uses of NUAs through the implementation of an UGI. Classification of NUAs into three main categories ('NUAs at the city edge, in the city periphery and in the city core) has been a fundamental step for re-thinking and expanding NUAs' value in terms

of UGI components. *Action Strategies (Peri-urban Strategy, Development Areas Strategy* and *Urban-core Strategy)* are proposed in order to define and build different Connecting Scenarios (longitudinal, radial and urban core) through specific Design Elements (Green Lines, Green Wedges and Green Hooks). As results show, Peri-urban Integration Strategy would provide the largest amount of total green area for the implementation of UGI. Thus, integrating rural landscapes and leisure, through the protection and promotion of urban and peri-urban agriculture, would allow for a major increase in the total amount of usable and accessible green spaces within municipal context.

Moreover, the results show that UGI would provide an increase of green spaces up to 2250 % compared to the current scope of public green areas. This significant gain of new green spaces triggers issues of economic feasibility for local government and resistance from private landowners. These issues could be addressed through incentive-based approaches for managing urban growth and protecting open spaces (Stoms, McDonald and Davis, 2002). From this perspective, Transfer of Development Rights programs can be used to design NUAs in order to promote the economic benefits of UGI components for different stakeholders, incluing landowners of land parcels to be included into UGI, developers of land parcels to be developed and local administrators, who may implement land-use allocation decisions with non-financial efforts (Brabec and Smith, 2002; Kaplowitz, Machemer and Pruetz, 2008). In particular, *Urban-core Strategies* related to NUAs in the city core could provide a stage for testing the approach of Transfer of Development Rights programs.

Finally, UGI can provide municipalities or other public decision making agencies with a strategic tool for the implementation of planning policy relating to NUAs aimed at the construction of a Green Infrastructure. Such a tool would be extremely relevant in the context of Catania, where the presented UGI has been developed within the on-going Catania Master Plan process. It represents a proposal for creating a Green Infrastructure in an urban area where previous master plans have always neglected NUAs.

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Biographical information

Riccardo Privitera
Address: Università di Catania Dipartimento di Architettura, Viale Andrea Doria 6, 95125 Catania (Italia)
Phone: +39 095 738 2528
E-mail:
riccardo.privitera@virgilio.it

Riccardo Privitera got a master degree in Civil Engineering and a PhD in Urban and Regional Planning at the University of Catania (Italy). He has been working on different urban master plans for public bodies, including Municipal Authorities and University. His scientific interests are: urban-planning, non-urbanised areas planning, ecosystem services, land cover analysis, land suitability analysis, urban and peri-urban agriculture studies. He is recently working with energy-related issues and their relations to urban and spatial planning.

Biographical information

Francesco Martinico
Associate Professor
Address: Università di Catania Dipartimento di Architettura, Viale Andrea Doria 6, 95125 Catania (Italia)
Phone: +39 095 738 2528
E-mail: fmartinico@dau.unict.it

Francesco Martinico is Associate Professor in Town and Regional Planning at the University of Catania (Italy) and Deputy President of the School of Architecture. His main fields of interests are: regional and landscape planning, management issues related to land use, and the use of GIS in planning. He is author of books and papers and member of local and national research groups on regional planning themes. He has been consultant for several land use and landscape protection plans, including the master plan for Catania. He is a member of The International Society of City and Regional Planners (ISoCaRP).

Biographical information

Daniele La Rosa
Address: Università di Catania Dipartimento di Architettura, Viale Andrea Doria 6, 95125 Catania (Italia)
Phone: +39 095 738 2528
E-mail:
dlarosa@darc.unict.it

After a master degree in Environmental Engineering, Daniele La Rosa got a Master in Soil and Water Engineering and a PhD in Urban and Regional Planning at University of Catania (Italy). He has been previously working as research assistant in landscape and regional planning projects. Among his scientific interests are: GIS applications for urban and landscape planning, environmental indicators, Environmental Strategic Assessment, landscape studies, landscape ecology, spatial analysis.

Biographical information

Viviana Pappalardo
Address:Università di Catania Dipartimento di Architettura, Viale Andrea Doria 6, 95125 Catania (Italia)
Phone: +39 095 738 2528
E-mail:
pappalardo.viviana@gmail.com

Viviana Pappalardo is a graduated construction engineer and PhD student in Evaluation and Mitigation of Urban and Land Risks at the Department of Architecture of University of Catania. Her graduation thesis focuses on themes such as ecosystem services, green infrastructure and peri-urban settlements. She is starting to do research for her doctoral thesis concerning topics of smart green cities, green infrastructure and the implications of resilience theory in urban contexts for urban planning.