International Journal of Urban Sustainable Development, 2014
http://dx.doi.org/10.1080/19463138.2014.953536

Taylor & Francis
Taylor & Francis Group

Enhancing city resilience to climate change by means of ecosystem services improvement: a SWOT analysis for the city of Faro, Portugal

Elena Berte[a] and Thomas Panagopoulos[b]*

[a]*Department of Civil and Environmental Engineering, University of Trento, Trento, Italy;* [b]*Department of Sea, Earth and Environment, Research Centre for Spatial and Organisational Dynamics (CIEO), University of Algarve, Faro, Portugal*

(*Received 11 December 2013; accepted 4 August 2014*)

Green Infrastructure has recently gained importance as a planning tool at the regional and local levels. While it provides a range of ecosystem services, greater attention is needed on integrating the economic, environmental and social benefits produced, particularly in the context of climate change adaptation and mitigation. This paper maps out the urban green infrastructure as a delivery mechanism of ecosystem services and identifies a number of measures for ecosystem services improvement using the strengths, weaknesses, opportunities and threats approach for the city of Faro within the context of the Algarve region. The absence of an integrated strategy for the urban built and green areas and the low connectivity with the hinterland green areas were the main weaknesses of the city. The solutions, identified by means of ecosystem services regulation functions, address the related measures, anticipate the climate change challenges and enhance the city's resilience. Social, economic, health and visual-aesthetic benefits have been particularly emphasised for each measure identified.

Keywords: urban threats and vulnerabilities; ecosystem services; green infrastructure; strategic decision-making; SWOT

1. Introduction

Green infrastructure is the network of green spaces in rural and urban areas that, together, enhance ecosystem resilience, contribute to biodiversity conservation and benefit people through the maintenance and enhancement of ecosystem services. Green infrastructure addresses the connectivity of ecosystems, their protection and the provision of ecosystem services, while also addressing mitigation and adaptation to climate change. It promotes integrated spatial planning by identifying multifunctional zones and by incorporating habitat restoration measures and other connectivity elements into various land use policies (European Environment Agency 2011). Urban green infrastructure is the sum of all parks, public green space, allotments, green corridors, street trees, urban forests, roof and vertical greening and private gardens (Cameron *et al.* 2012). Green infrastructure can be strengthened through strategic initiatives that focus on maintaining, restoring, improving and connecting existing green areas as well as creating new areas and features.

The Millennium Ecosystem Assessment has divided ecosystem services into four ecosystem function groups relevant to well-being (Milleniun Ecosystem Assessment 2005): regulation function related to regulating services (e.g. urban temperature regulation, air purification, noise mitigation, run-off mitigation), information function related to cultural services (e.g. educational and recreational opportunities), habitat function related to supportive services (e.g. refugee function) and production

*Corresponding author. Email: tpanago@ualg.pt

function related to provisioning services (e.g. water and food provision).

Spatial and urban planning have a determinant role in affecting the distribution, quality and use of a wide range of ecosystem services and 'disservices' (Escobedo *et al*. 2011) delivered by urban green infrastructure, and they form the basis of their conservation and enhancement (The Economics of Ecosystems and Biodiversity 2011). Furthermore, urban green infrastructure can contribute to mitigating a number of urban threats and weaknesses by informing the design of environmental quality management alternatives and addressing a number of environmental/urban planning strategies. Understanding urban ecosystems and urban green infrastructure can improve urban planning, vegetation management, urban sustainability, allocation of financial resources and, most importantly, human well-being in cities (Dobbs *et al.* 2011). However, the concept of ecosystem services has been slow to affect actual land management and economic and policy decisions (Logsdon & Chaubey 2013).

A SWOT (strengths, weaknesses, opportunities, threats) analysis has been structured in order to understand the state of urban green areas in relation to the built areas, as well as the relationship of these areas with the challenges of climate change. A SWOT analysis is an assessment of internal strengths, weaknesses, external opportunities and threats used in the preliminary stage of strategic decision-making (Johnson *et al.* 1989). In relation to city planning, internal strengths and weaknesses are within the control of the city administration, whereas opportunities and threats are external dynamics that are not controllable by the city administration.

The SWOT model was originally used in business management literature, where such an analysis has a strategic goal intended to clarify outside opportunities and threats that can affect the future of a business. Analogous to business strategy, public institutions and administrations may use a similar method to identify internal and external factors relevant to planning strategies (Tsenkova 2002). The SWOT instrument is intended to highlight those determinant factors, which may produce relevant strategic guidelines by linking the project strategy to its environment (European Commission 1999). According to this research, the analytical structure of SWOT is used as a decision support system to generate strategies with the aim of increasing the level of information and reducing uncertainty (Karppi *et al.* 2001).

The aim of the present study is to focus attention on urban green infrastructure as a delivery mechanism of ecosystem services and identify a number of measures for ecosystem services improvement for the city of Faro (the capital of the Algarve region, Portugal). The analytical structure of SWOT was used as an instrument to generate urban planning strategies. Such outcomes will help to provide evidence for the enhancement of the city's resilience, address the related measures and anticipate the climate change challenges.

2. Urban adaptation to climate change: building resilient cities

Environmental changes in general, and those associated with climate change, in particular, are increasingly recognised as growing challenges across the world, necessitating drastic adjustment in city and regional management. Because of the unavoidability of these impacts, mitigation alone will not be sufficient to fight climate change; it needs to be complemented by adaptation measures. Adaptation seeks to alleviate the impacts of climate change by increasing the resilience of people and regions to these impacts. Providing more room for waterways and establishing strong spatial planning that stops placing homes, businesses and infrastructure into future risk-prone areas can be effective and sustainable ways to deal with risks. Keeping public space and buildings cool by using green roofs and providing more shade saves energy and makes cities more attractive. Adaptation to climate change offers the opportunity for developing new jobs, promoting innovation and implementing the profound changes needed in managing cities and regions (European Environment Agency 2012).

Climate change affects cities around the world, which are increasingly recognising the need to prepare for the impacts on their operations, assets and residents. It is important for the stakeholders to know what to expect so that the necessary structures can be developed in the phase of preparation and organisation (Karanikola *et al.* 2014). Some have seen notable changes in relation to the frequency and intensity of extreme weather events; others have experienced changes in temperatures; others have experienced coastal erosions, disappearance of wetlands and storm surges (Carmin *et al.* 2012).

Many cities are working on mainstreaming adaptation and planning strategies. To this extent, ecosystem services provide a number of mitigation functions that contribute to providing solutions. The current challenge at the European level is to include ecosystem services in policies and practices in order to ensure the continuous provision of their benefits to humans. The European Union has adopted an EU Biodiversity Strategy for 2020 in which the target of safeguarding ecosystem services is explicitly included (Egoh *et al.* 2012).

The concept of ecosystem services can provide a useful instrument for more integrated and sustainable planning for investing more in restoration of degraded ecosystems. Despite the growing knowledge base and increased awareness of the political and socio-economic relevance of ecosystem services, actual implementation of ecosystem services in practical planning and decision-making is still in its early stages (Fisher *et al.* 2009).

2.1. *Climate change challenges and response options*

A number of response options to climate change challenges have started to be provided in this last decade. In particular, three main urban threats have been identified as the basis of urban climate adaptation planning: heatwaves, flooding and water scarcity/droughts (European Environment Agency 2012).

Heatwaves are related to the increasing intensity of changes in temperatures. To this extent, according to the World Meteorological Organization (WMO 2014), 13 of the 14 warmest years on record have all occurred in the twenty-first century, and each of the last 3 decades has been warmer than the previous one, while 2013 was the seventh hottest year since records began in 1850. Heatwaves in cities can lead to health impacts (with increased mortality rates) and, more generally, to other ecological impacts such as loss of livestock, wilted crops and loss of forest cover caused by wildfire activity (Trigo *et al.* 2009). Ecosystem services regulation functions that are related to planning strategies can help to mitigate urban temperature by providing shadow to streets, sidewalks and buildings through plantation of trees and green walls, for example (Qiu *et al.* 2013).

Flooding in cities can lead to social impacts related to risks to life and health. Additionally, flooding can have economic impacts such as damage to public and private buildings; loss of earning in industry and trade; loss of revenue due to road, railway and transportation interruption; and high prices for essential commodities (Merz *et al.* 2010). Ecosystem services regulation functions that are related to planning strategies can help to mitigate run-off by incentivising the presence of permeable soils supporting green soils in parking areas, squares, flower bed, rooftops, backyards, allotment gardens and bioswales, for example (Shuster *et al.* 2008).

Water scarcity and droughts in cities can lead to extensive socio-economic and environmental impacts. High demands for water frequently coincide with areas of low supply, leading to water stress. This occurs particularly in Southern Europe, though not exclusively. Farmer *et al.* (2008) report that around one-fifth of the EU's population lives in countries that are water stressed. Ecosystem provisioning services provide cities with fresh water by securing storage. The contribution of ecosystem services regulation functions that are related to planning strategies can help cities with water purification. Furthermore, vegetation cover and forests in the city catchment influence the quantity of available water (Gómez-Baggethun *et al.* 2013).

3. Urban and green areas: a SWOT analysis for the city of Faro

In order to start up a process of management and improvement of urban green infrastructure, it is important to identify the correct scale of analysis, proceed with an analysis of the context to define both human and ecological community structures and find contextualised environmental goals and the role of ecosystem services. Decision-makers should not assume that certain ecosystem services are equally important to all urbanities since ecosystem services are location specific (Escobedo *et al.* 2011). To this extent, a SWOT analysis can be helpful to find which ecosystem services need to be improved in the identified context. The outcomes of the SWOT analysis will help to set a number of measures for strategy generation that can form the basis of urban planning strategies based on ecosystem services improvement.

The scale of analysis is urban and includes the more consolidated area of the city of Faro and the related urban ecosystem (Figure 1). Faro is the southernmost city in continental Portugal. It is located in the Faro Municipality in southern Portugal. The city proper has 50,000 inhabitants, and the entire municipality has 65,000 (census of 2011). Faro has a moderate Mediterranean climate (Köppen climate classification: Csa). Summers are warm to hot and sunny with average daytime temperatures of 35°C. The annual average temperature is around 17°C, and the annual rainfall is around 350 mm. It is the capital of the Algarve region. Both the city and the region base their economy on tourism. Faro hosts the international airport (Algarve airport) that serves the south part of Portugal.

Figure 1. The consolidated area of the city of Faro and its urban green infrastructure. 1: Alameda Park, 2: Lyceum, 3: Avenue 5 October, 4: Avenue Calouste Gulbenkian, 5: Quinta Santo Antonio do Alto, 6: The historical centre on the edge of Ria Formosa National Park. (Source: Aerodata International Surveys, Cnes/Spot Image, Digital Globe, IGP/DGRF, Google 2014).

The city is surrounded to the north, east and west by an agricultural countryside and to the south by the Atlantic Ocean, where the wetland Ria Formosa National Park is located. Ria Formosa is a protected nature reserve with different and sometimes antagonistic uses. Part of the system is a wetland and the other part is sand dune islands, and it plays an important role in the region's economy. In addition to its use by tourists and residents for leisure, the system also supports other economic activities such as seafood farms and the port of Faro.

Figure 2 presents a SWOT analysis for applying an ecosystem services, maintenance and enhancement approach for the city of Faro within the context of the Algarve region. The SWOT analysis has been divided into two parts: the analysis of the endogenous/internal factors that are within the control of the city administration, where strengths and weaknesses are in evidence, and the analysis of the exogenous factors that are not controllable by the city administration, where opportunities and threats have been examined. The outcomes of the SWOT analysis can be used to set a number of measures for strategy generation that can form the basis of urban planning strategies for ecosystem services improvement.

The integrated information to structure the SWOT analysis have been collected through on-site surveys, former studies concerning the green areas of Faro (Gabriel 2007; Duque & Panagopoulos 2013) and data collected from the Civil Protection of Portugal (2013). On-site surveys, together with the existing studies and researches on the green areas of Faro, permitted

Strengths

- As a consequence of increasing tourism, some areas of the city centre are less degraded and investing in more urban green facilities.
- ‘Parque Natural da Ria Formosa’. The natural park is an important wildlife site designated as a wetlands reserve of worldwide significance. The presence of the wetland helps furthermore regulating the urban microclimate and the barrier sand islands protect from waves.
- The two smaller but important green areas of the city: Alameda Public Park, the green area that surrounds the Lyceum of the city.
- Remnants of an agricultural area close to the city centre.

Threats

- Flooding in urban areas: monthly average rainfall varies with notable seasonality in Portugal, and are stronger in the southern half of the peninsula.
- Heatwaves: according to the climate change scenarios (IPCC), the Mediterranean basin will be drier and more prone to heatwaves in the following decades.
- Water scarcity and droughts in the urban area of Faro. Golf courses in the peri-urban area of Faro and in general in the Algarve region increase the problem.
- Coastal erosion due to ocean rise and tsunamis due to high risk of earthquakes.

Weaknesses

- The historical city centre characterised by a certain amount of abandoned buildings and degradation in particular in the areas out of the paths of tourists.
- The majority of streets, buildings and open areas do not benefit from green facilities.
- The city suffers of low connectivity with the hinterland green areas.
- The absence of an integrated strategy for an urban green plan is noticeable.
- Lack of free space in the compact urban fabric

Opportunities

- Urban rehabilitation policy that emphasises the importance of sustainability and the use of green walls and green roofs.
- The regulation services provided by urban green areas and green areas in general can help to mitigate flooding.
- The regulation services provided by urban green areas and green areas in general can help to mitigate heatwaves.
- The regulation services provided by urban green areas can enhance water quality and supply.
- Urban agriculture for more resilient urban food systems.

Figure 2. SWOT analysis for applying an ecosystem services approach for the city of Faro within the context of Algarve region.

the analysis of the state of the green areas in particular, as well as some main characteristics of the city in general. This provided evidence of a number of endogenous factors based on strengths and weaknesses. Data collected from the civil protection permitted the highlighting of a number of threats such as risks and vulnerabilities. These unfavourable external factors are a potential source of damage for the city and its dwellers and are not controllable by the city administration. On the basis of this data, the city administration can structure a strategic planning process for urban green areas with the aim of improving ecosystem services, which will contribute to the mitigation of threats and to help solve weaknesses.

3.1. Endogenous strengths and weaknesses within the control of the city administration

A number of strengths that are within the control of the city administration have been identified. Tourism is the main economic driver of the city. As a consequence of tourism, some areas of the city centre are less degraded and provide more facilities. An important environmental strength for the city is the Natural Park of Ria Formosa that surrounds Faro to the south. Located along the Algarve centre–east coast, the park is an important wildlife site designated as a wetlands reserve of worldwide significance (Natura 2000 site). Furthermore, the presence of water helps regulate the urban microclimate (Bolund & Hunhammar 1999), and the barrier sand dune islands offer protection from the rising ocean waves and may also decrease the risk of tsunamis in this region that has a high risk of earthquakes.

There are two green areas of importance in relation to a rich variety of species and size of plants. Although their dimensions are small, the Alameda public park provides some recreational facilities (Figure 1, 1), and there is a green area surrounding the Lyceum of the city (Figure 1, 2); both are located in the south-eastern part of Faro. Two main urban axes are characterised by a certain number of green structures (trees, shrubs and pervious soils): the Avenida 5 de Outubro that starts from the Lyceum and goes towards the historical centre (Figure 1, 3) and the Avenida Calouste de Gulbenkian that surrounds the city centre (Figure 1, 4). The agricultural area in Quinta do Santo Antonio do Alto (Figure 1, 5) is at risk of becoming a new residential expansion due to its strategic urban position. This area includes the Palace Fialho, which was built in 1925 and considered as a national interest heritage building. This agricultural area is strategic for the green infrastructure of the city, and it links the urban ecosystem with the rural. According to Gómez-Baggethun *et al.* (2013), the urban green structure should be as close as possible to that of the hinterlands in order to benefit the most from the potential of the near-city source areas of ecosystem services. As a matter of fact, green infrastructure is about bringing together the natural and built environments using the landscape as infrastructure.

A number of weaknesses within the control of the city administration were considered. The centre of the city is inhabited mostly by elderly and low-income population. It is characterised by a large number of abandoned buildings and degradation, in particular in the areas away from the tourist paths which are mainly located in the historical city centre surrounded by the ancient

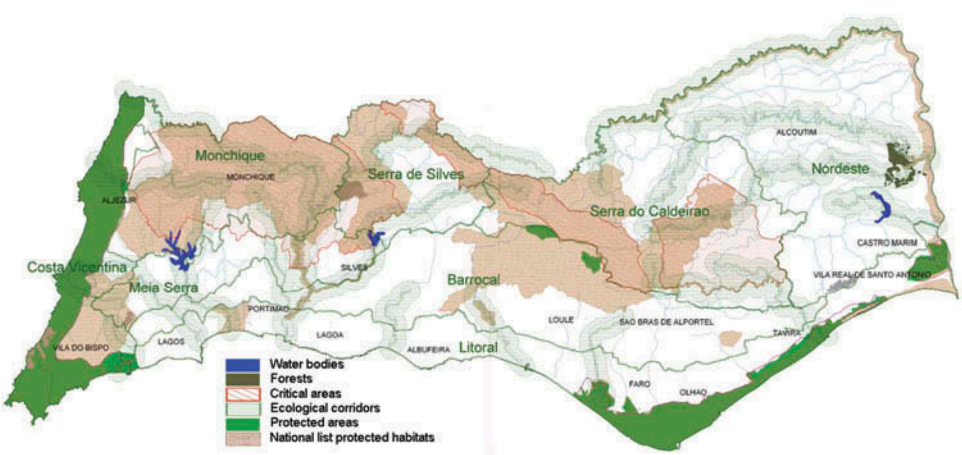

Figure 3. The green infrastructure of Algarve according to the Regional Plan for Forest Management. The city of Faro at the southern part of the region demonstrates low connectivity with the hinterland green areas. (Source: Adapted from ICNF (2006)).

walls and nearby (Figure 1, 6). As a consequence of tourism, these areas are less degraded and provide more facilities.

The green structure of the city presents a high fragmentation discontinuity and site-related situation: majority of streets, buildings and open areas do not benefit from green areas. There is a lack of free space in the compact urban fabric. Only a few parking areas, streets and squares take advantage of trees and permeable soils with limited results. The structure and composition of green areas as well as the size and typology of plants vary according to the place. The absence of an integrated strategy for an urban green plan is noticeable. The city of Faro, as well as other cities along the coast, suffers from low connectivity in terms of urban–rural green structure as visible in the Regional Plan for Forest Management. The plan identifies a number of potential corridors to link the coast with the hinterland green areas (Figure 3).

3.2. *Exogenous threats and opportunities not controllable by the city administration*

A number of threats not controllable by the city administration have been identified and described. The main risks are flooding in downtown urban areas, heatwaves, wildfires, dryness, mass movements, earthquakes and tsunamis. The main vulnerabilities of the city are the historical centre, airport, road infrastructure and high urban pressure. An overview of the main threats of the city of Faro follows.

3.2.1. *Flooding in the urban area of Faro*

Monthly average rainfall varies with notable seasonality in Portugal, and it is stronger in the southern half of the peninsula. The number of days with precipitation presents higher values in winter and the lowest, with a marked difference, in summer (Ninyerola *et al*. 2005). Faro experienced two serious flooding episodes in recent years. In September 2008, a storm caused flooding in some public streets of the city centre. In May 2011, a storm caused the closure of the Faro airport for 2 hours (16 flights delayed/changed destination); a number of houses, shops and garages were damaged; and streets were closed in the city centre, on the university campus and in the Montenegro district.

3.2.2. *Heatwaves in the urban area of Faro*

According to climate change scenarios (IPCC 2007), the Mediterranean basin will be drier and more prone to heatwaves in the upcoming decades (Trigo *et al.* 2009). The Iberian Climate Atlas notes that the Portuguese climate is characterised by dry and hot summers with average temperature above 22°C during the hottest months. The average temperature in the coldest months is in the range of 0–18°C. The number of days in the year with a maximum temperature above or equal to 25°C is greater than 110 days for a large portion of the southern peninsula. In the Algarve, the average annual values for minimum air temperature are higher than 15°C; the highest values occur in the months of July and August. Portugal has a relatively high level of exposure to heatwave events, with great impacts on health. Research concerning heatwaves and health has been conducted by the University of Lisbon in order to identify the relationships between the 2003 heatwave and excessive mortality in Portugal (Trigo *et al.* 2009).

3.2.3. *Water scarcity and droughts in the urban area of Faro*

Seasonal and annual variability in rainfall and, consequently, in water availability contributes to a geographical and temporal mismatch between water availability and water demand. This is particularly accentuated in the south of the country, notably the Algarve region, which is characterised by a dry Mediterranean climate. This irregularity is responsible for a significant number of water stress situations and complicates water resources management (European Commission 2009). The presence of golf courses that require large quantities of irrigation water (10,950 m^3/ha/year, according to Videira *et al.*

2006) in the peri-urban area of Faro and, more generally, in the Algarve coastal area further increase the problem. In 2007, the Portuguese Presidency of the European Union Council placed ‘Water scarcity and drought’ as one of its main priorities. The presidency provided evidence that the problems with relevant socio-economic and environmental impacts in the European Union were no longer exclusive to southern European countries (Kraemer 2007).

The city of Faro can find some solutions (opportunities) related to the analysed weaknesses and threats with ecosystem services improvement. The services provided by urban green infrastructure can help to mitigate flooding, heatwaves and water scarcity in cities, in particular, through their regulation function. Regulation function is related to the capacity of ecosystems to regulate essential ecological processes and life support systems that have direct and indirect benefits to humans (run-off mitigation, urban temperature regulation, water supply).

4. Solutions provided by means of ecosystem services improvement

The improvement of climatic conditions in the urban environment is related to both shading and evapotranspiration, decreasing temperatures and mitigating the ‘heat island effect’ in the city during the summer. Moreover, a reduction of heat dispersion from buildings during the winter, due to sheltering and windbreak effects, can be observed. By lowering air temperatures in the summer, indirect CO_2 savings are made through the reduction of energy consumption for air conditioning, especially in warm climates. In addition to this indirect saving, plants are also responsible for direct CO_2 savings through sequestration. Increasing vegetation is one strategy for moderating regional climate changes in urban areas and simultaneously providing multiple ecosystem services (Jenerette *et al.* 2011). The services provided by urban ecosystem and urban green infrastructure can help to mitigate flooding, heatwaves and water scarcity in cities, in relation to their regulation function. A well-structured urban forest mitigates temperature; decreases acoustic pollution, water run-off and soil erosion; and absorbs air, soil and water pollutants (COST 2012).

A brief analysis of storm water, microclimate and water treatment related to ecosystem services is beneficial in this context. Each one has been analysed according to a number of measures for its implementation and in relation to the benefits (or ecosystem services) it provides. Based on a collection of studies on urban trees, conducted by Roy *et al.* (2012), the benefits have been considered according to social, economic, health and visual-aesthetic aspects. Although some of them have been listed, there are many other direct and indirect benefits that could be added. For each ecosystem service, a number of related state indicators have been provided. State indicators can help the local administration to collect data about the state of run-off mitigation, temperature regulation and water supply in relation to the characteristics of urban green areas.

4.1. Run-off mitigation

Measures: Providing incentives for permeable soils such as green in parking areas, squares, flower bed, rooftops, backyards, allotment gardens and bioswales (Bolund & Hunhammar 1999).

Services: Reducing rate/volume of storm water run-off, reducing flooding damages, reducing water quality problems; recharging ground water (Gómez-Baggethun *et al.* 2013). Urban areas composed of 50–90% impermeable soils can lose 40–83% of rainfall to surface run-off, compared to 13% in forested landscapes (Bonan 2002). The interception of rainfall by tree canopies slows down flooding effects, and green soft lanes reduce the pressure on urban drainage systems by percolating water and delaying the timing of peak run-off. Green roofs are an example of this (Oberndorfer *et al.* 2007).

Social benefits: Improving the sense of urban security; making the urban environment a more pleasant place to live, work and spend leisure time; enhancing social cohesion (Carpenter *et al.* 2006; Roy *et al.* 2012).

Economic benefits: Reducing expenditure on urban restoration, reducing expenditure on new storm water infrastructure due to climate change, providing annual return on municipal investments, increasing municipal tax receipts due to added value on property transactions (Tyrväinen 2001; De Groot *et al.* 2002).

Health benefits: Preventing injuries/accidents, reducing stress (Nielsen & Nilsson 2007).

Visual/aesthetic benefits: Improving scenic quality; improving sense of place and identity (Panagopoulos 2009).

State Indicators: Soil infiltration capacity, percentage sealed relative to permeable surfaces (De Groot *et al.* 2010).

4.2. Urban temperature regulation

Measures: Provide shadow to streets, sidewalks and buildings through trees plantation and green walls (Soares *et al.* 2011).

Services: Reducing solar radiation, humidity, air temperature, reflection; controlling wind; decreasing the heat loading of the city/mitigating the heat island effect (Jankovska *et al.* 2010). During summer, providing the cooling effect of evapotranspiration. Urban forests could also regulate microclimate by modifying incoming solar radiation and outgoing terrestrial radiation, shading, humidity, and wind direction and velocity (Jim & Chen 2009).

Vegetation reduces temperatures in the hottest months through shading, and it absorbs heat from the air through the evapotranspiration process. Trees reflect solar radiation and provide shade to surfaces (Gómez *et al.* 2001).

Social benefits: Making the urban environment a more pleasant place to live, work and spend leisure time; providing comfortable places to meet for leisure and recreation; improving social interaction and increasing environmental awareness; enhancing social cohesion (Duque & Panagopoulos 2010).

Economic benefits: Saving on energy expenditure, avoiding investment in new power supplies, increasing property value, increasing tourism revenue (Jim & Chen 2009).

Health benefits: Reducing diseases/sickness in the population (in particular, the elderly and children), fewer complications and faster recoveries at the hospital, reducing stress, reducing death rates during heatwaves that are expected to increase in frequency due to climate change (Gómez *et al.* 2001; Tzoulas *et al.* 2007).

Visual/aesthetic benefits: Improving scenic quality, improving sense of place and identity (Tyrväinen 2001).

State indicators: Leaf Area Index, temperature decrease by tree cover × m^2 of plot trees cover (Bolund & Hunhammar 1999).

4.3. Water supply

Measures: Providing incentives for permeable soils (green in parking areas, squares, flower bed, rooftops, backyards, allotment gardens and bioswales); supporting proper planning that considers impacts on waterways as part of all urban, industrial and agricultural development (Ewel 1997).

Services: Urban vegetation provides water regulation services. Water purification is one of the many services provided by ecosystems. Pollutants such as metals, viruses, oils, excess nutrients and sediment are processed and filtered out as water moves through permeable soils. This purification process provides clean drinking water and water suitable for industrial uses, recreation and wildlife habitat (Daily 1997; Bennet *et al.* 2009). Another ecosystem function is related to the storage and retention of water through provisioning of water; watersheds are one example of this (Costanza *et al.* 1997).

Social benefits: Providing comfortable places to meet for leisure and recreation (Grahn & Stigsdotter 2010).

Economic benefits: saving on water regulation services; decreasing the demand of construction of additional, costly water purification technologies (Daily & Ellison 2003; Hubacek & Kronenberg 2013).

Health benefits: once in water, pathogens that are harmful to humans can be difficult to remove – natural purification processes can often keep them from reaching source water (Daily 1997).

Visual/aesthetic benefits: improving scenic quality, improving sense of place and identity (Roy *et al.* 2012).

State indicators: Water supply from untreated spring and ground water in millions m^3, percentage of untreated spring and ground water in the whole water process and water supply system (Staub *et al.* 2011).

5. Discussion and conclusions

The present study has been developed within the COST action FP1204 'Green infrastructure approach: linking environmental with social aspects in studying and managing urban forests'. The action aims to develop the scientific knowledge base on the role of urban forests and green spaces in the implementation of green infrastructure and provision of ecosystem services in urban areas (COST 2012). This study has been conducted with consideration for the perspective of urban ecosystem services in urban areas. It contributes to provide information and tools for local administration in order to strengthen the green areas in the city of Faro and mitigate its urban threats. This was accomplished by means of a SWOT analysis used as a decision support system to generate strategies. The analysis led to a selection of critical problems, narrowing the range of objectives for strategic city planning based on urban ecosystem services improvement in order to fight climate change.

The absence of an integrated strategy for an urban green plan and the low connectivity with the hinterland green areas are the main weakness of the city. One of the reasons of the recent shrinking of many Portuguese cities is the sense of insufficient contact with nature and deterioration of the city microclimatic conditions (Panagopoulos & Barreira 2012). The output of the present study helped to highlight how a well-structured, urban green infrastructure can contribute to ameliorate the quality of the city of Faro by delivering a number of ecosystem services with direct benefits for citizens and tourists. Such services can contribute to the mitigation of some ecosystem threats that affect the city such as flooding, heating and water supply. There are additional, general benefits delivered in health, economic, social and visual/aesthetic areas.

To this extent, it could be significant to consider the application of state indicators to measure the condition of the urban green areas in Faro, in order to elaborate on the weak and strong elements of the current situation. The measures related to run-off mitigation, urban temperature regulation and water supply are useful to improve the existing planning tools and provide a number of practical solutions. Moreover, it is important to identify strategic areas of connection through the urban and peri-urban areas into the rural in order to structure a connected urban–peri-urban–rural green infrastructure and thereby improve the resilience of the related ecosystem services (Kennedy *et al.* 2011).

Furthermore, this work provides an overview of appropriate measures for the improvement and management of the urban green infrastructure of Faro in order to help city planners and administrators in decision-making. When considering the problems that Faro is facing due to climate change, city planners should take a more in-depth look at the issues and enhance city resilience with investments in green infrastructure. Using the results of the SWOT analysis, the public administration of Faro could inform citizens in relation to run-off mitigation, urban temperature regulation and water supply, as well as provide a number of measures in order to improve ecosystem services.

Considering that we are living in times of limited resources and uncertainty, planners and decision-makers should address a common rather than individual approach (Healey 2010), based on the exercise of a collective action to reshape urban (private and public) green and open areas. The measures should be easily applicable to private green areas by citizens, with the role of public administration limited to supervising the participatory processes.

Notes on contributors

Elena Berte graduated in Architecture from the University of Ferrara in 2002 and in 2009 gained a PhD in Environmental Engineering from the University of Trento, Italy. She was a researcher for the COST FP1204 project 'Green Infrastructure approach: linking environmental with social aspects in studying and managing urban forests'. Her research interests include landscape and environmental planning, cultural landscapes, and sustainable infrastructure.

Thomas Panagopoulos is a member of the Faculty of Science and Technology at the University of Algarve. He gained his Forestry and Natural Environment PhD in 1995 from Aristotle University (Greece). He is the Director of Landscape Architecture and Executive Board member of UNISCAPE (Network of Universities for the Implementation of the European Landscape Convention).

References

Bennet EM, Peterson GD, Gordon LJ. 2009. Understanding relationships among multiple ecosystem services. Ecol Lett. 12:1394–1404.
Bolund P, Hunhammar S. 1999. Ecosystem services in urban areas. Ecol Econ. 29:293–301.
Bonan GB. 2002. Ecological climatology: concepts and applications. Cambridge: Cambridge University Press.
Cameron RWF, Blanusa T, Taylor JE, Salisbury A, Halstead AJ, Henricot B, Thompson K. 2012. The domestic garden – its contribution to urban green infrastructure. Urban For Urban Gree. 11:129–137.
Carmin J, Nadkarni N, Rhie C. 2012. Progress and challenges in urban climate adaptation planning: results from a global survey. Cambridge (MA): MIT Press.
Carpenter SR, Bennet EM, Peterson GD. 2006. Scenarios for ecosystem services: an overview. Ecol Soc. [Internet]. [cited 2013 Sept 12]; 11:29. Available from: http://www.ecologyandsociety.org/vol11/iss1/art29/
CII and Birdlife International. 2011. Measuring and monitoring ecosystem services at the site scale. Cambridge: Cambridge Conservation Initiative and Bird Life International.
Civil Protection of Portugal. 2013 [Internet]. [cited 2013 Jun 27]. Available from: http://www.proteccaocivil.pt/
COST. 2012. COST action FP1204 Green infrastructure approach: linking environmental with social aspects in studying and managing urban forests [Internet]. [cited 2014 Jun 20]. Available from: http://www.greeninurbs.com/
Costanza R, d'Arge R, De Groot R, Farberk S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, *et al*. 1997. The value of the world's ecosystem services and natural capital. Nature. 387:253–260.
Daily G, Ellison K. 2003. The new economy of nature: the quest to make conservation profitable. Washington (DC): Island Press.
Daily GC. 1997. Nature's services: societal dependence on natural ecosystems. Washington (DC): Island Press.
De Groot RS, Alkemade R, Braat L, Hein L, Willemen L. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecol Complex. 7:260–272.
De Groot RS, Wilson MA, Boumans RMJ. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecol Econ. 41:393–408.
Dobbs C, Escobedo FJ, Zipperer WC. 2011. A framework for developing urban forest ecosystem services and goods indicators. Landscape Urban Plan. 99:196–206.
Duque JAG, Panagopoulos T. 2010. Urban planning throughout environmental quality and human well-being. Spat Organ Dyn- Discuss Pap. 4:7–20.
Duque JAG, Panagopoulos T. 2013. Evaluation of the urban green infrastructure using landscape modules, GIS and a population survey. Spat Organ Dyn. 13:82–95.
Egoh B, Drakou EG, Dunbar MB, Maes J, Willemen L. 2012. Indicators for mapping ecosystem services: a review. European Commission, EUR 25456 – Joint Research Centre – Institute for Environment and Sustainability [Internet]. [cited 2013 Nov 4]. Available from: http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/26749/1/lbna25456enn.pdf
Escobedo FJ, Kroeger T, Wagner JE. 2011. Urban forests and pollution mitigation: analyzing ecosystem services and disservices. Environ Pollut. 159:2078–2087.
European Commission. 1999. Evaluating socio-economic programmes. Principal evaluation techniques

and tools. MEANS-collection, Vol. 3. Luxembourg: European Communities.

European Commission. 2009. The economics of climate change adaptation in EU coastal areas [Internet]. [cited 2013 Jul 12]. Available from: http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/portugal_climate_change_en.pdf

European Environment Agency. 2011. Green infrastructure and territorial cohesion. The concept of green infrastructure and its integration into policies using monitoring systems. Luxembourg: Publications Office of the European Union.

European Environment Agency. 2012. Urban adaptation to climate change in Europe. Luxembourg: Office for Official Publications of the European Union.

Ewel KC. 1997. Water Quality Improvement by Wetlands. In: Daily GC, editor. Natures services: societal dependence on natural ecosystems. Washington (DC): Island Press; p. 329–344.

Farmer A, Bassi F, Fergusson M. 2008. Water scarcity and droughts. Policy Department Economic and Scientific Policy. IP/A/ENVI/ST/2007-17

Fisher B, Turner RK, Morling P. 2009. Defining and classifying ecosystem services for decision making. Ecol Econ. 68:643–653.

Gabriel M. 2007. Os Sistemas de Informacao geografica na gestao do espaco verde publico. Caso de Cidade de Faro [Master Thesis]. Faro: University of Algarve.

Gómez F, Tamarit N, Jabaloyes J. 2001. Green zones, bioclimatics studies and human comfort in the future development of urban planning. Landscape Urban Plan. 55:151–161.

Gómez-Baggethun E, Gren A, Barton DN, Langemeyer J, McPhearson T, O'Farrell P, Andersson E, Hamstead Z, Kremer P. 2013. Urban ecosystem services. In: Elmqvist T, Fragkias M, Goodness J, Güneralp B, Marcotullio PJ, McDonald RI, Parnell S, Schewenius M, Sendstad M, Seto KC, Wilkinson C, editors. Urbanization, biodiversity and ecosystem services, challenges and opportunities. New York (NY): Springer.

Grahn P, Stigsdotter UK. 2010. The relation between perceived sensory dimensions of urban green space and stress restoration. Landscape Urban Plan. 94:264–275.

Healey P. 2010. Making better places: the planning project in the twenty-first century. Basingstoke: Palgrave-Macmillan.

Hubacek K, Kronenberg J. 2013. Synthesizing different perspectives on the value of urban ecosystem services. Landscape Urban Plan. 109:1–6.

ICNF – Instituto de Conservação da Naturesa e Florestas. 2006. Plano Regional de Ordenamento Florestal do Algarve [Internet]. [cited 2013 Jul 26]. Available from: http://www.icnf.pt/portal/florestas/profs/algarv

IPCC, 2007. Summary for policymakers. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE, editors. Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Jankovska I, Straupe I, Panagopoulos T. 2010. Professional's awareness in promotion of conservation and management of urban forests as green infrastructure of Riga, Latvia. WSEAS Trans Environ Dev. 6:614–623.

Jenerette GD, Harlan SL, Stefanov WL, Martin CA. 2011. Ecosystem services and urban heat riskscape moderation: water, green spaces, and social inequality in Phoenix, USA. Ecol Appl. 21:2637–2651.

Jim CY, Chen WY. 2009. Ecosystem services and valuation of urban forests in China. Cities. 26:187–194.

Johnson G, Scholes GK, Sexty RW. 1989. Exploring strategic management. Scarborough (ON): Prentice Hall.

Karanikola P, Panagopoulos T, Tampakis S, Karantoni MI, Tsantopoulos G. 2014. Facing and managing natural disasters in the Sporades Islands, Greece. Nat Hazards Earth Syst Sci. 14:995–1005.

Karppi I, Kokonen M, Latheenmaki-Smith K. 2001. SWOT analysis as a basis for regional strategies. Stockholm: Nordregio.

Kennedy AW, Van Wassenaer PJE, Satel LA. 2011. Criteria and indicators for strategic urban forest planning and management. Arboriculture and Urban Forestry. 37:108–117.

Kraemer RA. 2007. Economic impact of droughts: challenges for water & environmental policies. Water Scarcity and Drought – a Priority of the Portuguese Presidency, Jg. 1:61–88.

Logsdon R, Chaubey I. 2013. A quantitative approach to evaluating ecosystem services. Ecol Modell. 257:57–65.

[MEA] Millenniun Ecosystem Assessment. 2005. Ecosystems and human well-being: current state and trends. Washington (DC): Island Press.

Merz B, Kreibich H, Schwarze R, Thieken A. 2010. Assessment of economic flood damage. Nat Hazards Earth Syst Sci. 10:1697–1724.

Nielsen AB, Nilsson K. 2007. Urban forestry for human health and wellbeing. Urban For Urban Gree. 6:195–197.

Ninyerola M, Pons X, Roure JM. 2005. Atlas Climático Digital de la Península Ibérica. Metodología y aplicaciones en bioclimatología y geobotánica. Bellaterra: Autonomous University of Bellaterra.

Oberndorfer E, Lundholm J, Bass B, Coffman RR, Doshi H, Dunnett N, Gaffin S, Kohler M, Liu KKY, Rowe B. 2007. Green roofs as urban

ecosystems: ecological structures, functions, and services. Bioscience. 57:823–833.
Panagopoulos T. 2009. Linking forestry, sustainability and aesthetics. Ecol Econ. 68:2485–2489.
Panagopoulos T, Barreira AP. 2012. Shrinkage perceptions and smart growth strategies for the municipalities of Portugal. Built Environ. 38:276–292.
Qiu G, Li H, Zhang Q, Chen W, Liang X, Li X. 2013. Effects of evapotranspiration on mitigation of urban temperature by vegetation and urban agriculture. J Integr Agric. 12:1307–1315.
Roy S, Byrne J, Pickering C. 2012. A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. Urban For Urban Gree. 11:351–363.
Shuster WD, Morrison MA, Webb R. 2008. Front-loading urban storm water management for success – a perspective incorporating current studies on the implementation of retrofit low-impact development. Cities Environ. 1:1–15.
Soares AL, Rego FC, McPherson EG, Simpson JR, Peper PJ, Xiao Q. 2011. Benefits and costs of street trees in Lisbon, Portugal. Urban For Urban Gree. 10:69–78.
Staub C, Ott W, Heusi F, Klingler G, Jenny A, Häcki M, Hauser A. 2011. Indicators for ecosystem goods and services: framework, methodology and recommendations for a welfare-related environmental reporting. Bern: Federal Office for the Environment. Environmental studies no. 1102: 17 S.
The Economics of Ecosystems and Biodiversity. 2011. TEEB manual for cities: ecosystem services in urban management [Internet]. [cited 2013 Oct 1]. Available from: www.teebweb.org
Trigo RM, Ramos AM, Nogueira PJ, Santos FD, Garcia-Herrera R, Gouveia C, Santo FE. 2009. Evaluating the impact of extreme temperature based indices in the 2003 heatwave excessive mortality in Portugal. Environ Sci Policy. 12:844–854.
Tsenkova S. 2002. SWOT analysis of Sofia's economy, infrastructure and spatial planning issues. Washington (DC): World Bank, Infrastructure Sector Unit, Europe and Central Asia Region.
Tyrväinen L. 2001. Economic valuation of urban forest benefits in Finland. J Environ Manage. 62:75–92.
Tzoulas K, Korpela K, Venn S, Yli-Pelkonen V, Kazmierczak A, Niemela J, James P. 2007. Promoting ecosystem and human health in urban areas using green infrastructure: a literature review. Landscape Urban Plan. 81:167–178.
Videira N, Correia A, Alves I, Ramires C, Subtil R, Martins V. 2006. Environmental and economic tools to support sustainable golf tourism: the Algarve experience, Portugal. Tourism and Hosp Res. 6:204–217.
WMO. 2014. WMO statement on the status of the global climate in 2013. Geneva: World Meteorological Organization.