GREEN INFRASTRUCTURE IN-DEPTH CASE ANALYSIS

THEME 5: URBAN GREEN INFRASTRUCTURE

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1 Introduction

This case analysis file is concerned with Green Infrastructure policy initiatives which have the creation of urban green spaces as their primary objective together with delivering services to human populations and/or wild flora and fauna. The principal purpose of this class of Green Infrastructure initiatives is to realise a unique type of element that exists only within urban areas and provides a series of specialised services to urban environments. Green urban areas include any natural elements in towns and cities that provide an ecological or ecosystem service function. This includes urban elements such as green parks, green walls and green roofs that host biodiversity and allow ecosystems to function and deliver their services by connecting urban, peri-urban and rural areas. In particular, Green Infrastructure in proximity to urban areas is associated with a high potential in delivering multiple benefits to society. A review of the health benefits of natural areas (SDC, 2008) suggests that there are substantial gains to human health to be achieved from the increase in access to green areas (everything from parks and open countryside to gardens).

Under the 'Habitats complexes' category of the EUNIS habitat classification, green urban areas include the following habitats:

- Large parks: "large, varied green spaces within towns and cities, usually >5 ha."' These include small woods, mown lawns, water bodies (semi-natural or artificial), flower beds and shrubberies and semi-natural grassland or woodland enclaves.

- Small city-centre non-domestic gardens: usually <0.5 ha often partitioned by walls located inside city blocks and completely or almost completely surrounded by architectural structures. They may contain mown lawns, flower beds and native or ornamental trees. For the purposes of this project, it will also be understood to include green roofs.

- Large non-domestic gardens: typically 0.5–5 ha, more restricted in diversity than large parks, usually similar composition and aspect to small city-centre non-domestic gardens.

- Domestic gardens of cities and town centres: usually <0.5 ha with very mixed species-rich flora and fauna.

- Domestic gardens of villages and urban peripheries: usually <0.5 ha, with very mixed species-rich flora and fauna, in close proximity to human dwellings, agricultural land, natural or semi-natural habitats.

One of the most effective ways of building up Green Infrastructure is through spatial planning. Policies that adopt a spatial planning approach can improve spatial interactions over a large geographical area – i.e. at local and regional level. Spatial planning entails bringing together different sectors in order to decide on land-use priorities in an integrated and cooperative way. Integrated spatial planning can, for instance, guide future infrastructure developments away from sensitive sites and help minimise the risk of further habitat loss and fragmentation.

Of particular interest in urban environments will be the costs associated with creating and managing new green areas with the aim of providing biodiversity or ecosystem service functions. These may include green roofs or new small non-domestic gardens in public areas. These are elements of more modern architectural and planning design and could provide interesting insights into the potential of integrating biodiversity into existing urban areas.

The lead example selected for this analysis, which was considered among the most representative of the measures that could be reported under this theme, is the Regional Plan of Territorial Planning in the Metropolitan Area of Lisbon. It is one of the most ambitious examples of this type of Green Infrastructure in terms of creating green urban areas through the integration of a protection and environmental enhancement regional structure into regional spatial planning, minimising negative impacts and enhancing positive effects arising from the implementation of projects. Accomplishing this structure in the Lisbon metropolitan area is done through the Metropolitan Ecological Network (*Rede Ecológica Metropolitana*, REM). The REM comprises a hierarchical network of territories which are set in a number of areas and ecological corridors (primary network, secondary network and complementary network) which are linked to each other and with the urban system and the rest of the territorial units of the metropolitan area.

Two other examples have also been included in this case analysis with the same Green Infrastructure objective, namely the planning of the network of ecological corridors in the Autonomous Community of Madrid (Spain), and the green roofs of Basel (Switzerland), but using different policy instruments.

2 Overview of Initiatives

2.1. Lead Initiative: The Regional Plan of Territorial Planning in the Metropolitan Area of Lisbon

Green Infrastructure as such is not an established concept in Portugal, but consideration of ecological systems in planning has been a principle since 1999, when Decree-Law No. 380/99 defined the legal regime applicable to territorial management tools, incorporating the concept of the ecological network as a tool for land management at the national, regional and local levels. Under this decree, the ecological network aims to delineate areas, values and key or critical systems for environmental protection and for the benefit of rural and urban areas, connecting it with another tool for planning the National Ecological Reserve (*Reserva Ecologica Nacional)*. The spatial translation of this concept is at the subnational level and guides the local implementation of the local ecological network. The Decree-Law of Territorial Management Tools (Dec.-Law nº 46/2009) adjusts the basis for the policy and planning system adopted in 1999, defining the coordination system of national, regional and municipal land management system. The Regional Plan of Territorial Planning in the Metropolitan Area of Lisbon (*Plano Regional de Ordenamento do Territorio da Área Metroplitana de Lisboa*, PROT AML) applies this concept through the creation of the Metropolitan Ecological Network (*Rede Ecológica Metropolitana*, REM) to coordinate a network of green spaces and corridors between them and with the urban system. The objectives of the REM are to maintain the connectivity features and ecological continuity of the territories to which it is applied, and also to achieve other environmental goals concerning the stability and quality in the metropolitan area, such as protection of water resources, soil and landscape. The proper management of these areas is fundamental to the quality of the urban environment and to the prevention and reduction of natural risks. The PROT AML is still pending final approval.

2.2. Secondary Initiative I: the Network of Ecological Corridors in the Autonomous Community of Madrid

The Autonomous Community of Madrid planned to develop an ecological corridor network at regional level as an opportunity for integrated social welfare and natural heritage conservation (*Planificación de la red de corredores ecológicos de la Comunidad de Madrid: identificación de oportunidades para el bienestar social y la conservación del patrimonio natural*). One of the specific objectives is to create a metropolitan green ring (suburban green corridors) based on the existing urban and metropolitan parks. The initiative is now in the project phase. The benefits of the project have not yet been estimated in detail, but while the lead example is primarily concerned with delivering environmental protection, disaster prevention and enhancement of urban and rural landscapes benefits, this initiative focuses on ecosystem service provision and ecosystem resilience. In comparison with the lead example, the cost/ha ratio appears to be more favourable.

2.3. Secondary Initiative II: Green Roofs in Basel

Basel City is interested in green roofs as an energy-saving measure for buildings. An electricity tax generated funds (5% of all customers' energy bills) and an Energy Saving Fund was then used to fund energy-saving campaigns and measures. The municipality was quick to involve a variety of stakeholders, such as business associations and environmental organisations, in developing an incentive programme. Green roofs were funded for a two-year period in the mid-1990s to stimulate interest and awareness. A second programme was initiated in 2005–2006, based on the successes of the first, on the new building regulations and on the results of an investigation into the benefits of

green roofs for biodiversity, especially to protect endangered invertebrate species. This initiative focuses on climate change adaptation. The cost-benefit ratio of this initiative appears to be positive.

3 The Regional Plan of Territorial Planning in the Metropolitan Area of Lisbon

3.1. General Background Information

The PROT AML was passed on 15 May 1989 by Resolution 21/89 and had an initial duration of 18 months. which was subsequently extended a further 18 months. The decision to develop PROT AML was motivated by the existence of disorders in territorial planning resulting in large, uncoordinated occupancy areas. In order to tackle this situation, it was necessary to define a planning policy for the metropolitan territory to promote territorial planning that ensured the sustainable development of human activities, a higher quality of life for the population and the conservation of natural resources and environmental quality. Hence, from the beginning PROT AML was considered a fundamental strategic tool for effective territorial planning in the metropolitan area of Lisbon.

Aware of the strategic relevance of this plan for solving the deep structural problems of the metropolitan area of Lisbon, that had clear negative consequences in regional and national development and in the quality of life, in April 2002 the government decided to develop a more coherent and ambitious territorial planning policy and, in this way, to end a process which had been ongoing for 12 years.

However, since 2002 the PROT AML has had to be revised due to the fact that it was published under a different legal framework to the current legislation and with a set of problems and technical solutions which needed to be updated. The planning and development of new infrastructures such as the new Lisbon airport, the high-speed train and the 3rd Tejo diversion, combined with the construction of two new logistic platforms in Castanheira do Ribatejo and Poceirão, have also led to a reassessment of the original PROT AML.

The modification process of the PROT AML (November 2010) is part of Law 48/98 on Political Bases for Territorial and Urban Planning (*Ley de Bases de Política de Ordenamento do Território e de Urbanismo*) which defines the national territorial management system, assuming three levels:

1. National (PNPOT – *Programa Nacional de Política de Ordenamento do Território*);
2. Regional (PROT– *Plano Regional de Ordenamento do Território*);
3. Municipal (PDM – *Plano Director Municipal*).

The PROT AML has an implementation plan period of 2011–2020. The measure defines the guidelines for the regional structure on territorial planning, integrating the options established at national level and takes into account the municipal strategies of local development. It also constitutes the framework to elaborate municipal territorial planning.

Decree-Law No. 380/99 establishes the legal regime for territorial management tools (*Regime Jurídico dos Instrumentos de Gestao Territorial*) which consider the ecological network (*Estrutura Ecológica*) as a tool for land management at national, regional and local level. Legally, municipalities must have an ecological network mapped in their municipal development plan (*Plano Director Municipal*, PDM), but there are no established criteria on how to define and develop it. Under the same decree, the ecological network aims to define areas, values and key systems for environmental protection and enhancement of urban and rural areas (Article 14), connecting it with another planning tool, the National Ecological Reserve (*Reserva Ecológica Nacional,* REN*)*. The REN is a

biophysical structure which integrates all areas, by value and ecological sensitivity or exposure, and susceptibility to natural hazards should be given special protection. It defines a network of conservation areas, including coastal and riverine areas, aquifer recharge and steep-slope areas for erosion protection. The REN is integrated in the Fundamental Network of Nature Conservation (*Rede Fundamental de Conservação da Naturaleza*, RFCN). REN was created in 1983 under Decree-Law nº 321/83, last modified by Decree-Law nº 166/2008.

This modification of PROT-AML was subject to a strategic environmental assessment (SEA) process pursuant to Decree Law No. 316/2007 of 19 September (with the wording provided by Decree Law No. 46/2009 of February 20, and secondarily with the Decree-Law No 232/2007 of 15 June). The public consultation of this SEA process ended on 31 January 2011. The SEA influenced a significant number of plan outcomes.

In this context, the PNPOT is the reference and strategic tool of the territorial management system, assuring the integration of different spatial policies in order to carry out the national spatial planning objectives. The PNPOT provides that the guidelines to develop the territorial management tools must be developed by the regional plans (PROTs). These are territorial development tools which define the regional territorial development strategy, integrating the options established at national level and considering municipal territorial development strategies, creating a reference frameworkto elaborate municipal territorial planning plans.

A regional plan establishes the regional policy on environmental issues, the Regional Ecological Network (called Regional Structure Plan for Environmental Protection and Appreciation – *Estrutura Regional de Protecção e Valorização Ambiental*, ERPVA).

The main objective of the Regional Structure Plan for Environmental Protection and Appreciation is the sustainable use of natural resources, assuring the maintenance and appreciation of the main ecological and landscape values at regional level, of the agricultural and forest areas that integrate AML, and the articulation of the rest of the areas and territorial functions in order to guarantee the global functioning of natural systems. The Regional Structure Plan is composed of:

- The National Ecological Reserve;
- The National Agricultural Reserve (*Reserva Agrícola Nacional*, RAN);
- The Water Domain (water reservoirs and the water supply network) and all the other special plans (i.e., coast, classified areas and special protection areas), as well as water resources, coast, soil and landscapes as risk areas;
- The Metropolitan Ecological Network (*Rede Ecológica Metropolitana*, REM).

Realising the objectives of the Regional Structure Plan in the PROT AML is carried out by means of the REM, which is a hierarchical regional and inter-municipal territorial network with ecological connectivity and continuity functions, with the aim of maintaining and improving local and regional ecological biodiversity within its areas. The correct management of these areas is fundamental for urban qualification and prevention as well as for preventing and reducing environmental risks. It is a relevant tool to support and accompany the territorial planning decisions both at local and regional level. The objective of nature and biodiversity conservation is achieved through the REM, making environmental protection and assessment integrated and relevant in the territorial planning of the PROT AML. Hence, the REM is a fundamental part of the Territorial Model for the PROT AML and fundamental for the sustainable and balanced functioning and development of this metropolitan area.

The REM results in a group of areas and ecological corridors organised on three hierarchical levels according to their importance and contribution to the environmental structure of the metropolitan area (*Rede Primária, Rede Secundária e Rede Complementar*) as indicated in Figure 1, each of which has associated strategic guidelines actions and measures with different territorial planning and management demand levels and adapted to their specific urban dynamics.

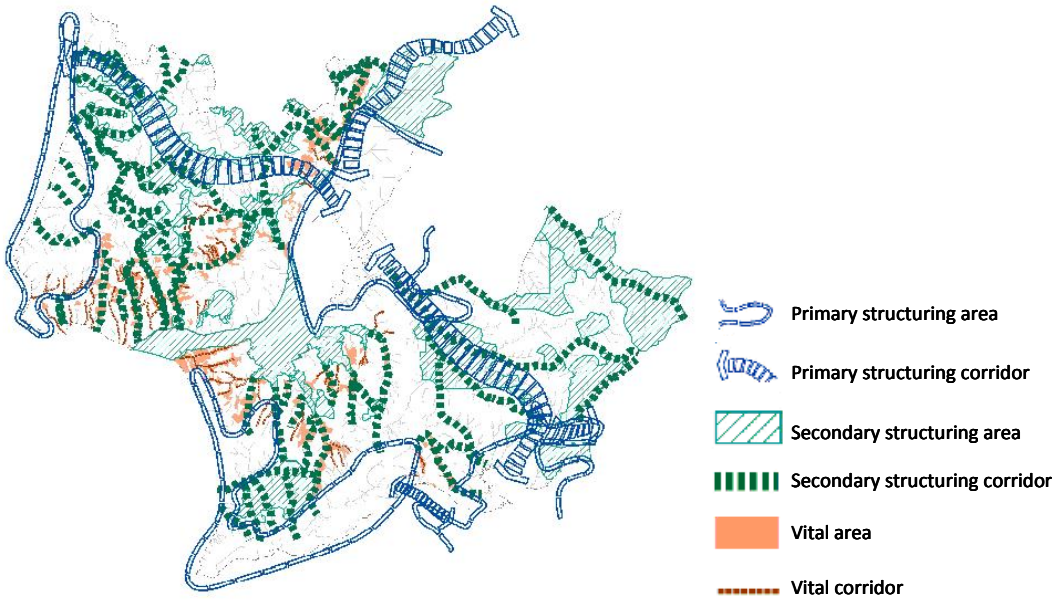

Figure 1 The Metropolitan Ecological Network (*Rede Ecológica Metropolitana, REM*) of the PROT-AML (November 2010).
Source: PROT AML.

Under the REM, the PROT AML covers unique areas with high a conservation value with respect to natural, cultural and landscape resources. These areas cross-cut different REM levels and represent a set of Metropolitan Parks. The final global scheme of the territorial model of the Regional Plan of Territorial Planning in the Metropolitan Area of Lisbon is shown in Figure 2.

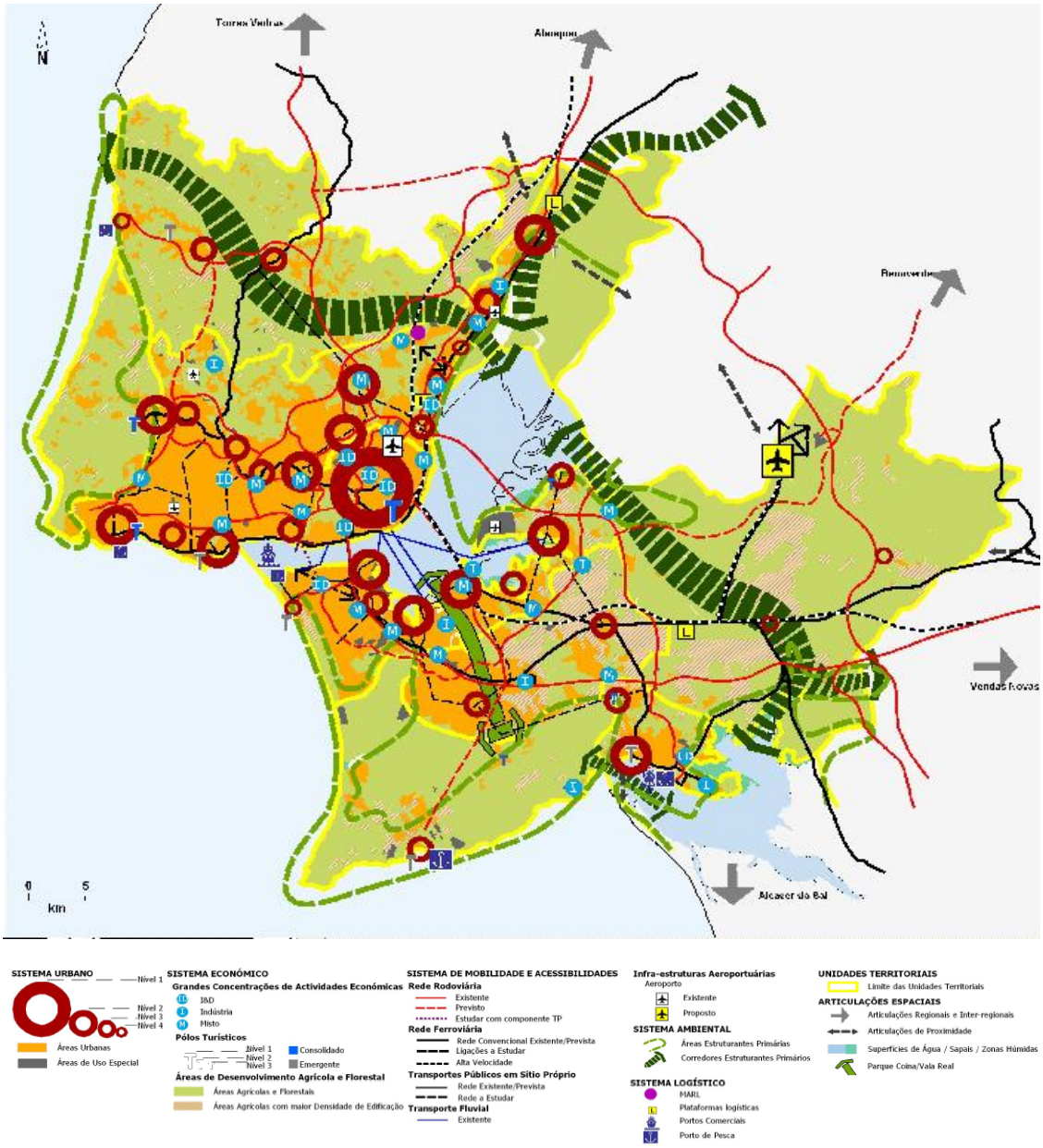

Figure 2. The global scheme of the territorial model (November 2010).

The vital areas of the 3rd REM level (*Rede Complementar*) are areas that are integrated into compact or fragmented urban areas which carry out important functions in urban development and zoning. The final aim is to integrate these vital areas under the land category of "green areas".

The following regions have developed Regional Plans: AML (*Área Metropolitana de Lisboa* – Metropolitan area of Lisbon), OVT (*Oeste e Vale do Tejo* – West and Tagus Valley), Alentejo and Algarve. All of them have established a Regional Structure Plan.

3.2. Specific Objectives

The main objectives of the PROT AML are sustainable development, metropolitan characterisation, social and spatial cohesion and organisation of a metropolitan transport system.

The Strategic Plan for the Metropolitan Area of Lisbon concerns four aspects of sustainable development: competitiveness, environmental sustainability, equitity and governance, all of which are implemented through five domains:

- Supra-regional connectivity, competitiveness and cosmopolitism;
- Multinucleus and compaction;
- Sustainability and compatibility with nature;
- Territorial qualification and social cohesion dynamics;
- Governance.

Under the 3rd REM level, the goal for 2020 under the Regional Structure Plan is to maintain or increase land cover and land use favourable to nature and biodiversity conservation.

The PROT AML project covers the area of as NUTS III Grande Lisboa e Península de Setúbal, including the towns of Alcochete, Almada, Amadora, Barreiro, Cascais, Lisboa, Loures, Mafra, Moita, Montijo, Odivelas, Oeiras, Palmela, Sesimbra, Setúbal, Seixal, Sintra e Vila Franca de Xira, with a population of approximately 2.75 million inhabitants distributed over a surface area of 2,944 km^2.

3.3. Green Infrastructure Elements

The elements which will be affected by the initiative are:

- Protected areas through the Basic Nature Network (*Rede Fundamental de Conservação da Naturaleza,* RFCN);
- Ecosystem service areas: the Regional Structure Plan ensures the incorporation of areas to assure the maintenance of ecological functions;
- Natural connectivity features: the Regional Structure Plan guarantees a connectivity network among ecosystems;
- Urban green areas: the Regional Structure Plan aids in the creation of green urban areas through its different networks and especially through the 3rd REM level and vital areas.

3.4. Implementation Costs

The costs associated with the initiative are not available since the PROT AML is pending formal adoption by the Portuguese government.

The main strategic axes of the PROT AML are as follows:

Strategic Axes of the PROT AML

A1	Improve inter-regional and transboundary connectivity
A2	Maintain and expand knowledge and creative-based activities
A21	Investigation, innovation and competitiveness networks
A22	Health cluster
A23	Creative industries cluster
A3	Consolidate the Lisbon Metropolitan Region as a tourist destination
A31	Nautical tourism
A32	Promotion of hotels
A4	To promote the economic competitiveness, innovation and the differentiation of products and territorial characteristics
A41	Agricultural produce of differentiated quality
A42	Agricultural and forest production
A43	Natural and landscape diversity
A44	Tourist brands
A45	Tourist centres
A46	"Oceanos e Descobrimentos" brand
A47	Aquaculture, fishing and salt production
A5	Modernise industry and services
A51	Logistics and transport
A52	New technologies and competitiveness
A53	New technologies and equal opportunities
B1	Boosting the polycentric model
B11	Strengthening the urban metropolitan system
B2	Streamline construction in rural areas
B21	Consolidation and enhancement of small rural settlements
B3	Enhance regional connectivity
B31	Articulation of policy, planning and mobility management
B32	Priorities for investment in the rail network
B33	Development of the Metro Sul do Tejo
B34	Public transport links
B35	Structuring investment in other transport modes
B36	Investments in the road system
B37	Interfaces in the multimodal transport system and stations
B38	Investment in soft modes of mobility
C1	To ensure the operation of the Metropolitan Ecological Network
C2	Ensure the functioning of natural systems
C21	Soil resources
C22	Watercourses and wetlands
C23	Estuaries and water margins
C24	Strategic groundwater resources
C25	Coastal areas
C3	Exploiting and valuing natural resources with a view to sustainability
C31	Agriculture and forestry production systems that support nature conservation

C32	Tourism in the rural context
C33	Geological resources
C4	Reduce and mitigate risks
C41	Identification and designation of hazardous areas
C42	Structural and non structural protection measures
C43	Plans and emergency relief and early warning systems
C5	Investing in sustainable energy as a lever for innovation and competitiveness
C51	Self-generation and energy efficiency
C52	Biomass energy recovery
C6	Develop potential solutions for more sustainable mobility
C61	Attractiveness of public transport
C62	Disincentive to private car use
C63	Intermediate solutions and innovative transportation
C7	Improve environmental sanitation in the region
C71	Coverage and efficiency of water distribution networks and drainage and waste-water treatment
C72	Reduction in the production of hazardous waste
C73	Reduction in the amount of water extracted
D1	Improve conditions and access to housing
D11	Promotion and diversification of low-cost housing
D2	Valuing heritage and promoting artistic and cultural creation
D21	Equity in access to and participation in cultural activities and knowledge
D22	Protection and enhancement of the built cultural heritage
D23	Protection and enhancement of the intangible heritage
D3	Improving the quality of the landscape and environmental living space
D31	Appreciation of architecture and the urban environment
D32	Urban qualification of the civic and historical centre
D33	Valuing the landscape

3.5. Observed and/or Projected Impacts

Biodiversity Benefits

No assessments of biodiversity benefits are available.

The SEA process had a major influence on the development of the regional plan. The safeguarding of natural and agro-forestry areas, as well as the limitation of the expansion of urban areas, are among the measures adopted by the plan that were strongly influenced by the SEA.

In environmental terms, the SEA of the PROT AML identifies the following benefits arising from the Regional Ecological Network:

- Clearly oriented to recover degraded areas in sensible natural systems and re-naturalisation and improvement of watercourses, related to urban revitalisation;
- Establishing criteria to preserve and recover ecological values in tourism strategies;
- Promoting landscape and natural heritage as regional competitiveness features.

Socio-Economic Benefits

No specific socio-economic benefits are available but the SEA, in reference to the ecological structure and functionality of the PROT AML, has identified the following risks and opportunities:

RISKS	OPPORTUNITIES
• Emergence of a new risk associated with the lack of constraints to build in secondary corridors associated with watercourses. • Development of risks related to the lack of guidelines so that the promotion of the recreational use of water is carried out according to the guidelines established by the Spatial Plan of the Estuary of the Tejo river.	• Reduce risks inherent to tourist occupancy proposals (defined environmental criteria and framework). • Greater opportunities related to the improvement of natural heritage and landscapes. • Reduced risks associated with the transposition and implementation of REM at the local level. • Reduced risks resulting from territorial conflicts due to incompatibilities of exploring natural resources. • New opportunities related to the protection and restoration of the elements that comprise and guarantee the functioning of the water system (underground and superficial). • Increased opportunities related to those ecosystems at risk due to the rise in sea levels and taking adaptation measures. • Lower risks associated with urban sprawl around the new Lisbon airport. • New opportunities to disseminate the natural values of the AML. • New opportunities related to the conservation of the marine environment. • Improved opportunities to protect vital and secondary areas as relevant ecological connectivity elements. • Reduced risks inherent to the occupancy and use of estuaries and coasts.

3.6. Observed and/or Projected Economic Impacts

The PROT AML has resulted in an Indicators System (May 2010), according to which the following economic impacts or expected targets have been estimated:

- Achieving the average productivity level of the EU-27 (GDP/employment) by 2020;
- Achieving 3% of regional GDP invested in R&D by 2020;
- Achieving €5 billion annual turnover of companies in the health sector;
- Increasing by 40% the number of jobs generated by the creative and cultural industries (55,455) by 2020;

- Achieving and maintaining above 10% the proportion of regional employment in transport, storage and communications;
- Achieving and maintaining above 10% the proportion of regional employment in manufacturing of transport equipment.

3.7. Recent Developments and Outlook

The PROT AML was discussed by all regional stakeholders (central administration, universities, municipalities etc.) and subsequently submitted for public consultation, a process which ended on 31 January 2011. At present, it is pending formal adoption. Due to presidential elections in Portugal on 5 June 2011, it will probably be postponed longer than expected.

The Municipal Plan, which is revised every 10 years and adapted to the PROT AML, has in this case been revised 2–3 years before the PROT AML was endorsed (2002). Therefore, a new version of the PROT AML will be approved by a Resolution of the National Ministers Council, which will agree to the adaptation of the Municipal Plan to the PROT AML.

3.8. Summary

GREEN INFRASTRUCTURE BENEFITS	
Ecosystem resilience	✓
Climate change adaptation	✓
Disaster prevention	✓
Ecosystem service provision	✓
Main indicators for measuring ecosystem service provision	
1. Number of species for which the Green Infrastructure element provides habitat	
2. Carbon sequestration/storage capacity per hectare x total area	
3. Trends in number of damaging natural disasters	
4. Abundance and species richness of wild pollinators	

3.9. Contact Details

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4 Comparable Initiatives

1. Policy Initiative

Planning of the network of ecological corridors in the Autonomous Community of Madrid: identification of opportunities for social welfare and conservation of natural heritage (*Planificación de la red de corredores ecológicos de la Comunidad de Madrid: identificación de oportunidades para el bienestar social y la conservación del patrimonio natural*).

2. General Background Information

The Autonomous Community of Madrid planned to develop this initiative, which is now (June, 2011) in project phase (EXP. 10-AT-00124.4/2009 (14-D/10)). The plan has not yet been formally adopted. Its legal basis is the Regional Law 9/1995 and its subsequent amendments.

Law 9/1995 on territorial, soil and city planning policy measures in the Autonomous Community of Madrid defines spatial planning as a public function of the spatial government to, in a rational and balanced manner, organise natural resources, favouring social cohesion and integration. The tools this Law develops to attain these objectives are the new Regional Plan on Spatial Strategy (*Plan Regional de Estrategia Territorial*, PRET) and maintaining the existing Coordination Programmes of Spatial Actions (*Programas de Coordinación de la Acción Territorial*). The Spatial Planning Plans of Natural and Rural Environment protect, preserve and improve supra-municipal territories with respect to their geographical, morphological, agricultural, landscape and ecological values and characteristics.

Law 9/2001 on land of the Autonomous Community of Madrid (Article 16) on protected non-urban land, which partially repeals Law 9/1995, is strictly-speaking an urban planning law, covering spatial planning aspects of previous Law 9/1995. It concerns the definition of concepts of planning implementation and aims to systemise and order in a single text norms already included in other laws. Article 16, of relevance for this initiative, refers to non-developable land and is divided into three points:

1) It defines non-developable land as:

   a. Land under special protection regime incompatible with its transformation, according to regional spatial planning or sectoral legislation, due to its landscape, historical, archaeological, scientific, environmental or cultural values, accredited natural risks in sectoral planning, or due to limitations or easements to protect public domain.

   b. Land that regional spatial planning and urban planning consider necessary to preserve due to the values mentioned above, as well as to agricultural, forest, livestock or natural value.

2) Spatial regional planning will directly classify land that, in any case, should belong to this type of land, which will be completed by the classification carried out in general spatial planning.

3) If, as a consequence of fire or environmental damage, land, vegetation, wildlife or their habitats were to be damaged, and the land were to lose the characteristics that were the

reason for its protection, these will be subject to environmental restitution. In any case, this land cannot be included in any other land classification in the next 30 years except authorisation by law approved by the Assembly of Madrid in which the impossibility of environmental restitution is justified.

The methodology used to design corridors is based on the permeability study of land for the movement of target species, where species are assumed to move in the territory using the same criteria as for habitat selection. The approach used was multi-species and species selection target and was related to the conservation needs of the main landscapes of Madrid. The species have been assessed on the basis of existing fragmentation problems of the landscapes and the number of hosting priority species. This analysis shows that the design of corridors should focus on forest landscapes and agricultural systems of cereals and gypsophila habitats, so it is necessary to select target species for these areas.

Natura 2000-network sites have been used as the nodes of the ecological network, which has several advantages since:

a. They are important for habitats and species conservation;

b. They are required to have ecological connectivity where appropriate;

c. They have been designated by the Autonomous Community of Madrid;

d. They are based on national and European legislation.

As ecological connectivity extends beyond the regional level, Sites of Community Interest in the provinces next to Madrid have also been used as nodes.

In designing the corridors, the Green Park *El Retiro* in Madrid City and the *Casa de Campo* and *Juan Carlos I* Parks in the metropolitan area of Madrid have been considered as nodes. The plan aims to establish the connectivity of green peri-urban systems with green urban areas. The GIS tool used was the *Corridor Designer* version General Use Corridor Designer Toolbox V.02 for Arc-GIS, a tool specifically developed to design ecological corridors. The model assumes that species move using the same criteria as those for selecting a habitat. It is necessary to obtain a layer of information where land suitability for each species/habitat is determined. Its use is based on existing information on habitat selection criteria of a specific species.

The final result is a map that represents the habitat suitability for each species. From there, and bearing in mind the original and proposed nodes, the programme calculates a new raster which represents the movement cost between both nodes (cost-distance raster). The model then calculates the movement with less cost between nodes. This operation is repeated several times between nodes to cover the whole territory. In this way, the movements with less cost to the species have been identified for forest and agricultural systems of cereals and gypsophila habitats (Pascual, 2011).

3. <u>Specific Objectives</u>

The main objective is to design a regional ecological network, based on the following elements:

- Ecological connectivity between Natura 2000 Network sites;
- Integration of the corridor network into municipal planning and protected areas management plans;

- Promote access of the population to the natural heritage;
- Create a metropolitan green ring (suburban green corridors) based on the existing large urban and metropolitan parks;
- Coordination with the Regional Plan for Cyclist and Pedestrian Lanes in the Autonomous Community of Madrid (*Plan Regional de Vias Ciclistas y Peatonales,* CIMA).

4. Green Infrastructure Elements

The Green Infrastructure elements included in the initiative are:

- Protected areas (regional parks): connectivity between Natura 2000-network sites and integration of protected areas;
- Restoration zones: related to the improvement of vegetation in priority areas;
- Green urban areas (such as the network of green railways or the new urban green areas as *Parque Forestal del Sur* – South Forest Park – through the connectivity of large urban and metropolitan parks and the coordination of the CIMA plan;
- Artificial connectivity through the construction of infrastructures to improve ecological connectivity;
- Natural connectivity features.

5. Implementation Costs

Table 1. Overview costs (total & per Green Infrastructure element) / Cost associated with the implementation of the initiative. Source: Pascual (2011).

	Total (Local Currency)	Core areas	Restoration areas	Sustainable use / ecosystem service zones	Green urban and peri-urban areas	Natural connectivity	Artificial connectivity features	Comments
Total Costs	€47,630,414	€22,765,514	€9,941,347	€9,008,552	€1,130,000	€3,840,000	€945,000	– In core areas: habitat recovery in specific areas (intensive treatment). – Restoration: improve vegetation. – Sustainable use: manage habitat of agricultural systems of cereals and gypsophila corridors. – Green urban and peri-urban: projects to develop ecological connectivity around urban land. – Natural connectivity: projects to improve ecological connectivity agricultural and forest land; restore private land and guarantee connectivity among critical spots of the network.

Time covered by total costs (years)	5	5	5		5	5	5	– 2011–2016
Annualised costs	€9,526,082	€4,553,102	€1,988,269	€1,801,710	€226,000	€768,000	€189,000	– Estimated as an average.
Area covered [ha]	29,849.50	758.85	492.15		28,598.50	1,200.00		
Cost per hectare	€319	€30,000	€20,199	€63	€188			– Actions in the core areas and in restoration areas have higher costs.
Financial Costs (list any details e.g. establishing management bodies)								
Opportunity costs (uncompensated) (list any details e.g. foregone resource use)								

The costs of the initial implementation of the ecological network of Madrid focus on the following objectives:

- Establishment of the minimum infrastructure;
- Follow-up detailed mapping of changes in land use and urban law;
- Ensure connectivity at critical points, all associated with major transport infrastructure in urban areas;
- Maintenance of ecological corridors in cereals and gypsophila habitats through compensatory payments that allow the maintenance of agricultural practices;
- Landscape connectivity between suburban parks and Natura 2000.

The actions on forest resources, outside the critical points, will be carried out at the final planning stages. This is because the forests of the Community of Madrid are expanding and, in general, are less threatened than open pseudo-steppe natural systems.

FINANCIAL COSTS		
	Cost	**Comments**
<u>One-Off Costs</u>		
Administrative, management and information costs		
• Establishing management bodies	€22,000	
• Surveys		
• Research		
• Consultation		
• Management plans	€2,090,000	
• Land purchase:		
• Restoring GI:		
Costs of green infrastructure provision		
• Land purchase		
• One-off compensation payments	€2,305,000	
• Creation of green infrastructure elements	€1,445,000	
• Restoration of green infrastructure	€23,340,514	
<u>Ongoing Costs</u>		
Administrative, management and information costs		
• Running of administrative bodies		
• Monitoring	€150,000	
• Ongoing management planning	€425,000	
• Communications	€145,000	
• Managing sites:		
Costs of green infrastructure provision		
• Maintenance of green infrastructure	€9,941,347	
• Costs of management agreements		
• Costs of protective actions		

6. <u>Observed and/or Projected Impacts</u>

No specific information is available on the impacts.

From the point of view of biodiversity contribution, the ecological network of the Community of Madrid has been designed to ensure ecological connectivity between areas of the Natura 2000 network of the Community of Madrid and between these areas with other areas from adjacent regions. The design has followed a multi-species approach where the target species have been selected according to the conservation needs of the major landscapes of Madrid. Therefore, the principal target species benefited are: species linked to forest landscapes, such as deer and wild boar, or species associated with cereal landscapes, like the great bustard, the little bustard, the bargain and grouse, among others; in addition, species linked to gypsophila landscapes, mainly insects and amphibians, will also benefit.

The ecological network has also included the connectivity study in the field of urban ecosystems,

particularly in relation to those spaces and green areas where biodiversity is more dependent on exchange with the surrounding natural areas. The objective of facilitating accessibility to nature for citizens is expected to increae their welfare, quality of life and health.

The result of the Strategic Environmental Assessment concludes that the ecological network's impacts are positive in 97% of the network area. It concludes that the actions to meet connectivity goals will not involve land-use changes. In the remaining 3% of the area, the environmental effects are beneficial as they mainly refer to preservation and improvement of habitats actions and measures. However, they fall under the scope of environmental assessment due to the need to assess alternatives. The corridors occur in urban areas and/or land for development where conflicting interests interact and where an analysis of alternatives will allow reconciling other interests, either private or those due to urban land classification. Hence, there has been a redefinition of those critical spots where possible alternatives were feasible.

According to the table "Analysis of possible significant effects" in the SEA, the environmental aspects which will experience the greatest permanent positive effects will be biodiversity, flora, fauna, soil, water and air quality, climate change impacts, material goods, cultural heritage and landscapes. All except material goods and cultural heritage wil also experience medium- and long-term positive effects.

7. Observed and/or Projected Economic Impacts

An economic assessment of the environmental impacts has not been carried out.

8. Recent Developments and Outlook

The initiative is currently still under development and in the project phase.

9. Summary

GREEN INFRASTRUCTURE BENEFITS	
Ecosystem resilience	✓
Climate change adaptation	
Disaster prevention	
Ecosystem service provision	✓
Main indicators for measuring ecosystem service provision	
1. Proportion of green surface area close to urban areas	
2. Degree of usage by target species (with controls) and their population trends	
3. Area of land managed to HNV standard	

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1. Policy Initiative

Green Roof Building Regulations (Basel, Switzerland).

2. General Background Information

The City of Basel has promoted green roofs via a number of funding streams and policies:

- Investment in incentive programmes, which provided subsidies for green roof installation:
  - The first incentive programme ran between 1996 and 1997, and was funded by the Energy Saving Fund. It focused on the insulating characteristics of green roofs and their capacity to reduce energy consumption.
  - The city consulted various stakeholders when considering green roofs and in establishing the first incentive programme. Stakeholders included the local business association, the horticultural association, the green roof association, the Pro Natura Basel environmental organisation, the Department of Parks and Cemeteries and the National Department of Environment, Forest and Landscapes.
  - The second incentive programme ran between 2005 and 2006 and incorporated design specifications into the green roof guidelines.
- Building regulations: In 2002, following the first incentive programme, and incorporating the outcomes of a research project on the biodiversity value of green roofs by Dr Brenneisen (Brenneisen, 2003; Brenneisen, (2004) – the results of their research showed that green roofs have great potential as valuable habitat for invertebrate species and birds and could be designed to maximise biodiversity by using native plants and soils, varying topography, bare patches and using wood and rocks – an amendment to the City of Basel's Building and Construction Law, was passed. It reads that all new and renovated flat roofs must be greened and also stipulates associated design guidelines.

The incentive programmes were administered by the Canton of Basel and supported by the National Department of Environment and Energy. Due to the semi-independent character of the Swiss cantons in legislative terms, it was possible for Basel's building regulations to be changed at the city level. The Department of Building and Transport led the development of regulations, and included an academic expert in green roofs (Dr Brenneisen) and a group of contractors working in the field of green roofs from the trade association. The installation on green roofs and their maintenance are carried out by the owners of the buildings. The regulation states that all new and renovated flat roofs must be greened to provide valuable habitat.

The main features of the standards for green roofs were (see also Figure 4):

- The growing medium should be native regional soils – the regulation recommends consulting a horticulturalist;
- The growing medium should be at least 10 cm deep;
- Mounds 30 cm high and 3 m in diameter should be randomly built to foster insect life;

- Vegetation should be "Basel mix" – a mix of native plant species;
- Builders of green roofs on flat roofs of 1,000 m^2 or more must consult Dr Brenneisen during design and construction.

Dr Brenneisen's research on green roof approaches to maximise biodiversity played a key role in setting green roof design specifications for the building regulations. Dr Brenneisen is the head of the Green Roof Centre of Competence at the Zurich University of Applied Sciences Wädenswil, where he conducts research and advises on green roof policies and design.

3. Specific Objectives

The specific objectives of the Basel´s green roofs initiative were to reduce energy consumption of buildings and biodiversity protection.

4. Green Infrastructure Elements

Green urban areas.

5. Implementation Costs

Between 1996 and 1997, the City of Basel invested CHF 1 million in a green roof incentive programme. A further CHF 1 million funded the green roof incentive programme that ran between 2005 and 2006. The incentive programme stimulated interest in research on the biodiversity protection benefits of green roofs and Dr Brenneisen received CHF 40,000 to carry out research for this purpose. Finance for these programmes came from the Energy Saving Fund. The average costs/m^2 of installation of green roofs decreased in the 1990s from CHF 100/m^2 to CHF 20/m^2.

6. Observed and/or Projected Impacts

In general, the main benefits of green roofs are documented and include:

- Reduced storm-water runoff, and hence potential savings to developers, as the number of drainage outlets required on a building can be reduced;
- Reduced urban heat island effect by reducing building heat loss and increasing evapotranspiration;
- Creating natural green spaces in urban areas;
- Reduced energy consumption and fuel costs, since green roofs provide cooling in summer and thermal insulation in winter;
- Benefits for biodiversity;
- Reduced air pollution;
- Extended roof life, since the green roof protects the roof's waterproofing membrane, almost doubling its life expectancy;
- Many of these benefits help to address climate-change related risks;

- Green roofs can also provide opportunities for food production.

In the case of Basel, in 2007 approximately 23% of Basel's flat roof area was greened, around 700,000 m² (Brenneissen, 2008). This amount will clearly have an increasing beneficial impact on the city climate. The green roof policy of Basel could be an example on urban heat island problems accentuated by global warming.

An investigation into the bio-ecological potential of the new habitats on roofs in Basel revealed important benefits for biodiversity (Brenneisen, 2004). Extensive green roofs can provide suitable habitat for animal and plant species that are able to adapt to and develop survival strategies under extreme local conditions and are also mobile enough to reach habitats on roofs. Numerous endangered species listed in Red Lists were found on the green roofs, as shown in a survey of spider and beetle fauna. Design of green roofs is a key issue to increase biodiversity value bearing in mind the functionality of a structured surface as well as the use of local soils as substrates.

The results of a study on birds showed systematic use by species with natural preferences to open spaces like grasslands and river banks. Even broods of specific and often endangered birds could be recorded on green roofs, because a possible habitat function of green roofs is the provision of nesting locations for ground-nesting birds. Examples of this can already be found in the literature, particularly with regard to the little ringed plover (*Charadrius dubius*), northern lapwing (*Vanellus vanellus*) and skylark (*Alauda arvensis*) (Brenneisen, 2003). One of the most biodiverse green roofs investigated, the Rhypark building with a close combination of micro habitats, was found to have 79 beetle and 40 spider species. 13 of the registered beetle and seven of the spider species are classified in the Red Lists as endangered species, as indicated in Figure 3.

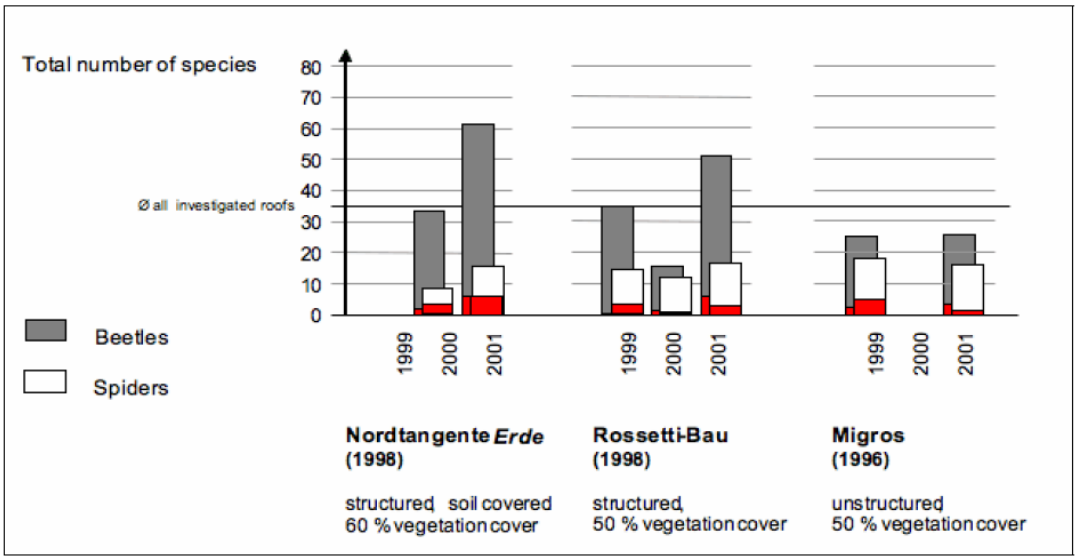

Figure 3: Number of species of spiders and beetles on green roofs in Basel with structured and unstructured design, surveyed over a three-year period.

Source: Brenneisen (2006).

Note: Structured roofs were designed to increase faunal diversity. Red shading indicates species of conservation interest listed in the Red Data Book.

Figure 4. Newly constructed green roof on the Klinikum 2 of the Cantonal Hospital of Basel, built in accordance with the city's new guidelines on green roofs and urban biodiversity. Source: Brenneisen (2006).

Photo: Stephan Brenneisen

Moreover, many authors report that adding green space to densely populated urban environments in the form of green roofs provides eco-restorative habitats for displaced creatures. Green roofs provide food, habitat, shelter and nesting opportunities for spiders, beetles, butterflies, birds and other invertebrates (Brenneisen, 2003; Gedge, 2003). Because most extensive green roofs are inaccessible to the public, they can provide undisturbed habitat (Getter and Rowe, 2006).

7. Observed and/or Projected Economic Impacts

4 giga watt-hours saving/year across Basel (first incentive programme) and 3.1/year (second programme). The savings of the second incentive programme were calculated as follows (Mathys, 2011):

Roof area (A): 38,000 m^2

Mean U-value before: 1.2 W/m^2K

U-value after insulation and greening: 0.2 W/m^2K or better

Delta U: 1.0 W/m^2K

Saving: Delta U x A x HGT

HGT (Heizgradtage, the sum of the product of hours and Kelvin on every heating day = day

with a temperature below 12°C). For Switzerland the annual value is 3,348 x 24 = 80,352Kh (Kelvin hours/year).

Resulting savings: Delta Q = 1.0 W/m^2K x 38,000 m^2 x 80,352 Kh/year = 3.05 million kWh/year.

Other economic benefits were related to local business profits from the sale of materials and supplies relating to installation of green roofs.

8. Recent Developments and Outlook

Data not available.

9. Summary

GREEN INFRASTRUCTURE BENEFITS	
Ecosystem resilience	
Climate change adaptation	✓
Disaster prevention	
Ecosystem service provision	✓
Main indicators for measuring ecosystem service provision	
1. Total amount of carbon sequestered)	
2. Abundance and species richness of biological control agents	
3. Persons/year who experience reduce noise nuisance (defined as a dB threshold that is not exceeded due to green sound absorption)	

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5 Conclusions

5.1 Overview of the Initiatives

Urban elements such as biodiversity-rich parks, permeable soil cover, green walls and green roofs can be part of green infrastructure. They host biodiversity and allow ecosystems to deliver their services. They also serve to connect urban, peri-urban and rural areas.

The three initiatives included in this case analysis show the many policy options for creating or improving urban green areas. Two of the initiatives discussed are territorial planning tools while the third, green roofs, was created as an energy-saving measure. Spatial planning is one option that can further help to promote a more rational and environmentally sustainable use of urban and peri-urban green areas. On the other hand, green infrastructure planning can contribute to creating urban green areas that, in turn, can respond to a network concept with biodiversity conservation objectives and associated goods and services delivered by ecosystems, combined with other objectives to improve the quality of life.

The two spatial planning initiatives – the Regional Land Management Plan of the Metropolitan Area of Lisbon (PROT AML) and the Planning of the network of ecological corridors in the Autonomous Community of Madrid – have in common that they are based on a similar concept which is to integrate natural and cultural heritage values into the territorial regional model through ecological and landscape networks. In the PROT AML, the ecological network is carried out through the establishment of a municipal ecological structure across the entire metropolitan area and in each of the municipalities; this is achieved by appropriate solutions agreed upon by different actors. In the case of the Autonomous Community of Madrid, urban green corridors are designed to connect peri-urban parks with urban green areas across the whole region.

Reducing energy consumption of buildings and protection of biodiversity have been the key driving forces behind the expanding green roof coverage in Basel. Initially, the municipality explored green roofs as an energy-saving measure for buildings, but after research on biodiversity protection benefits of green roofs, biodiversity protection was established as the other important objective of the city's second green-roof incentive programme.

Other policy initiatives and projects not included in this case analysis also demonstrate the potential of Green Infrastructure to improve urban territorial space. The GRaBS project, for example, has the objective of putting in place green and blue infrastructure and facilitating the much-needed exchange of knowledge and experience and the transfer of good practices on climate-change adaptation strategies to local and regional authorities across Europe. The East London Green Grid initiative will improve East London's provision of open space and provide a range of formal and informal recreational uses and landscapes, promoting healthy living and amplifying the public enjoyment of the outdoors. The Third Green Belt of Frankfurt has the intention of creating large-scale green spaces in the context of plans for housing developments. The Green Crown Project of Turin promotes both the exceptional value of the park (with its Savoy architecture) together with the cultural rural landscape. The Andalusian Network of Natural Protected Spaces (RENPA) in Spain is incorporated into the territorial model of Andalusia by considering the peri-urban functions of natural spaces, and a specific project, "Green Doors", has been developed.

5.2 Achievements and Successful Measures

In both planning initiatives, the priorities of land use have been determined at a sustainable and strategic level and cover a large geographic area: the metropolitan area in the PROT AML and the entire Autonomous Community (NUTS 2 region) in the case of the ecological corridors of Madrid. Hence, Green Infrastructure is implemented in both cases through a territorial planning tool, an ecological network in the case of the PROT AML and ecological corridors in the case of Autonomous Community of Madrid, and covers the entire territory. Also, both initiatives are being developed on a legal basis which could, in principle, reinforce their implementation. The PROT AML is formulated under a strategic and regulatory framework – the National Land Use Policy – while the ecological corridors in Madrid will fall under the regional land use law and will be implemented through a medium-term plan (five years). The difference between the two programmes is that under PROT AML the Green Infrastructure tool is integrated in large-scale spatial planning while the ecological corridors of Madrid are included in a plan which is to be integrated into the different municipal urban plans of the region.

Regarding the benefits, both are initiatives that have not yet been formally adopted and consequently implemented, and no data are available on this issue. The opportunities that the PROT AML should provide concern urban green areas as important ecological connectivity elements, integrating the values of biodiversity conservation, landscape protection, susceptibility to natural risks etc. into urban planning and establishing adaptation measures. The most probable successful measures these opportunities will achieve are primarily the recovery of degraded areas in sensitive natural systems, improvement of watercourses, establishing criteria to preserve and recover ecological values in tourism strategies and promoting landscape and natural heritage conservation.

In the case of the ecological corridors plan of Madrid, the main opportunities that are anticipated are their use in connecting urban and peri-urban areas to parks and natural areas, vegetation in streets (to favour the movement of species, but also to allow the application of urban microsurgery: small parks with alternation of certain flora species), and improving urban biodiversity. The most important successful measures expected are habitat recovery measures such as restoring flora in core areas.

From a spatial point of view, green roofs are a policy option to improve aesthetic conditions and to offer amenity areas within urban centres where there is a need for increased residential densities as cities continue to grow in population. As residential infill occurs, a loss of aesthetic green space and amenity occurs. Green roofs may be considered a strategy to help mitigate these adverse effects. The Basel initiative has created 700,000 m^2 of green roofs, representing 23% of flat-roof area in the city, and securing not only important energy savings but also increasing biodiversity through measures to design specific habitats for certain species groups.

It is also now established that green roofs provide a climate-change adaptation function by limiting surface water run off and reducing temperatures in urban areas. A research project carried out by the University of Manchester on the evaporative cooling effects of a matrix of green corridors, green roofs and walls suggests that a 10% decrease in urban green areas can lead to a potential 8.2° C increase in surface temperatures by 2080, while a 10% increase in urban green areas can keep temperatures at, or below, the current levels. The GRaBS project has developed an online risk and vulnerabilities assessment tool, which includes climate change and flood-risk data as well as socio-economic and demographic data to help partners in their planning process. The benefits of green and blue infrastructure include natural cooling to

mitigate the urban heat-island effect, sustainable urban drainage and creation of natural areas for recreation as well as urban gardening and healthier, happier people (Kazmierczak and Carter, 2010).

The East London Green Grid (ELGG) project aims to embrace multifunctionality to better connect the industrial landscape with residential communities, to provide an appropriate setting for utilities (gas, sewerage and water) that are located in parts of the Green Grid in order to provide recreational space and encourage biodiversity, to provide for allotments and local food growing and to mitigate flooding. Six Area Frameworks were produced, which cross local authority boundaries and are unified at the landscape level. They set out strategies for the creation and enhancement of the Green Grid to attract, shape and support growth, and have helped local authorities to plan Green Infrastructure. The ELGG Primer was published in 2006 and sets out a vision for East London's fragmented Green Infrastructure to be brought together into an interlinked multifunctional network. The approach has been embedded in London's planning policy and sets out a range of policy objectives, including tackling climate change, addressing deficiencies in access to open space and nature, promoting sustainable movement and boosting the tourist economy (ERDF, 2010).

5.3 Weaknesses of the Initiatives

One of the main weaknesses of both initiatives, PROT AML and the ecological corridors of Madrid, is related to spatial planning competences. PROT AML has been developed by the regional administration but has to be implemented by local or central administrations. In this sense, these three administrative bodies have to agree on the way of implementing the initiative which could lead to its weakening should they not reach agreement.

In the case of the ecological corridors of Madrid, the regional administration is responsible for designing and approving the plan but its implementation is to be carried out with and by local administration. As in the previous example, this could weaken the initiative since it requires inter-administrative agreements. If the plan is legally adopted, i.e. through a Territorial Special Plan, the ecological corridors plan has to be integrated into territorial urban plans. Should this not prove feasible, there is the possibility of using the plan as a guidance tool by local authorities (when designing urban territorial plans) and by the regional administration (in the different administrative processes, such as SEA, EIA, territorial assessment and definitive endorsement).

Regarding the costs to create green urban areas, the data available from the Basel project (CHF 14,286/ha) shows that it is not a cheap solution. If taking into account other benefits, such as the savings in energy consumption (4.0 and 3.1 Wh/year in each programme period respectively) or the benefits in biodiversity terms, this amount could be considerably reduced. In addition, the benefits to mitigate the effects of climate change should be added.

The estimated costs from the Madrid plan show that developing and implementing the network of ecological corridors will cost €48,872,414, which will imply a cost of €1.53/year/inhabitant and €319/ha over five years. The investment plan to develop projects to improve ecological connectivity around urban land is expected to cost €226,000/year and envisages €418,000/year to develop projects to improve ecological connectivity in forests and agricultural land and €289,000/year to onstruct artificial infrastructure to improve ecological connectivity. An assessment of these data should be carried out once the plan is under development and the data concerning the benefits achieved are available.

5.4 Potential to Contribute to Green Infrastructure

The main potential of the PROT AML is that it defines guidelines for the regional structure on territorial planning, integrating a network of conservation areas – including coastal and riverine areas, aquifer recharge and steep slope areas for erosion protection – and constitutes a framework for municipal territorial plans. The PROT AML establishes the regional ecological network for the sustainable use of natural resources, assuring maintenance and appreciation of ecological and landscape values at the regional level. This objective has to be integrated at the local level.

Achieving this objective is carried out by means of the Metropolitan Ecological Network, REM, which is a hierarchical regional and inter-municipal territorial network with ecological connectivity and continuity functions, and which has the objective of maintaining biodiversity within its areas. REM is a relevant tool to support and accompany territorial planning decisions both at local and regional level; in this sense it is part of the territorial model of the PROT AML and fundamental for the sustainable and balanced functioning and development of the PROT AML. Under the REM, the PROT AML covers unique areas – with high conservation, natural, cultural and landscape values, and risks – at different levels and represents a set of metropolitan parks. These aspects justify the high potential of PROT AML to integrate urban green areas.

In the case of the ecological corridor plan of the Autonomous Community of Madrid, it offers an opportunity to create new urban green areas (South Forest Park, *Parque Forestal del Sur*), through connecting large urban and metropolitan parks. In addition, the plan will promote planting and recovering urban trees to increase vital ecosystem services, such as carbon sequestration. The plan also coordinates with other regional plans, such as CIMA (Regional Plan for Cyclist and Pedestrian Lanes in the Autonomous Community of Madrid).

Other initiatives to integrate Green Infrastructure in urban areas are related to peri-urban functions that have some natural spaces with different protection figures. The peri-urban parks and the Green Doors project has been conceptualised to this end under the Andalusian Network of Natural Protected Spaces. The Green Doors project connects 25 Andalusian cities of more than 50,000 inhabitants with their most immediate natural environment, universities and metropolitan parks by means of the Livestock Routes Network. The Public Domain of the Andalusian Network of Livestock Routes has been delineated and recovered to create these non-motorised Green Corridors. 43% of the Andalusian population lives in areas under peri-urban parks influence, highlighting their importance. The main use of these areas is recreational, and they are also used for walking and promoting contact with nature (ERDF, 2010).

The reasons why Green Infrastructure in urban and peri-urban areas is particularly important are multiple. The range of environmental benefits that can be delivered by urban green infrastructure can include (Forestry Commission, 2010):

- Reduction of air pollution;
- Reduction of flood risk as part of sustainable urban drainage systems;
- Improvement of the perception of the urban area as aesthetically pleasing;
- Amelioration of high summer temperatures caused by the urban heat-island effect and climate change;

- Linking urban, peri-urban and rural areas.

There are many potential socio-economic benefits that green space can provide, and the most significant of these can be grouped into the following broad categories:

- Improvements in levels of physical activity and health;
- Promotion of psychological health and mental well-being;
- Facilitation of social interaction, inclusion and community cohesion;
- Enhancing the quality of life by offering recreation and nature education facilities;
- Stimulating businesses' interests in nature-based solutions such as green walls and green roofs.

Research across Europe has found that those living in areas with a high proportion of nature to be three times more likely to be physically active and 40% less likely to be overweight than those living in areas with low proportions of nature (Ellaway, 2005).

Basel's green roofs create new urban green areas through actions that have energy saving as their main objective, but the incorporation of biodiversity objectives in their design has allowed the realisation of significant biodiversity benefits, albeit energy-related benefits. The potential of this initiative is heavily based on the modification of Basel's Building and Construction Law, which requires that all new buildings with flat roofs should incorporate green roofs, and also on the Energy Fund based on the benefits obtained through tax on electricity.

A similar initiative has been carried out in Brussels City through the Regional Urbanism Law which obliges all new constructions with inaccessible flat roofs larger than 100 m^2 to incorporate green roofs. This modification is a consequence of the 2008–2011 *Plan Pluie* (Rain Plan) developed out by the local government. The initiative's financial subsidies support 50% of the total bill, with grants of €10–30/m^2 (information from the Business Unit Environmental Technologies of the Brussels Enterprise Agency).

Another example to create urban green areas with energy objectives is the initiative of the Municipality of Mirandola (Italy) to create a green belt. The creation of a green belt around the city to provide cooling and shading in summer and as carbon storage is one of the measures of the Local Energy Plan to achieve these objectives. The municipality of Mirandola aims to achieve a significant reduction in energy consumption and contribute to climate change mitigation. The green belt is achieved using the "transfer of development rights" tool, where developers receive permission to increase the size of their buildings if they commit a significant part of their land to green space. The individual green spaces form a continuous green belt. The use of flexible and negotiable standards for developments promotes engagement of developers in town planning and shortens the time for planning permission (Kazmierczak and Carter, 2010). The expected impacts from the creation of 130 ha of forests are 650 tonnes sequestration of CO_2 per year. The green areas are connected and represent a continuous forest around the town of Mirandola, and are also linked with a Natura 2000 site. Afforestation is realised according to specific criteria set by the municipality, which includes the use of native plant species only. Forest is therefore considered to enhance the ecological network around the town of Mirandola. The green belt has additional benefits of reducing the risk of urban flooding, reducing soil erosion, reducing noise and improving the quality of life of Mirandola's residents (Comune di Mirandola, 2008).

Apart from establishing a vast system of green spaces to be protected and to promote the values of the Turin region, the Green Crown project is also a tool for: i) implementing the ecological network at regional and provincial level on the connection and the improvement of natural spaces and waterways and the protection of open spaces and peri-urban agriculture; ii) creating a parks network interconnected with the Savoy system; and iii) ensuring integrated accessibility for all citizens (ERDF, 2010).

5.5 Lessons for a Potential EU Green Infrastructure Strategy

The key lessons from this case analysis offer different policy options to integrate green infrastructure in urban areas.

Spatial Planning

PROT AML and the Madrid ecological corridors plan are two policy options that demonstrate the potential of spatial planning in integrating Green Infrastructure in both rural and urban environments. Legal and planning tools are employed in both cases. The Portuguese National Law (Decree-Law 166/2008) obliges taking into account the National Ecological Reserve which represents Green Infrastructure, in this case when planning at national, regional and local level. The case of the Madrid corridors also uses a legal framework (Regional Law 9/1995) to promote an ecological corridors plan which represents Green Infrastructure.

Since neither of these two plans have been formally adopted and an assessment of their results has not been carried out, it is not possible to draw lessons for an EU Green Infrastructure strategy, although it is worthwhile mentioning that both emphasise the importance of planning and regulating the concept of Green Infrastructure to be effective and positively incorporated into territory.

Strategic spatial planning has a key role to create or remodel outdoor spaces to become resilient to climate change and extreme weather. Green Infrastructure is therefore best achieved through an integrated approach to land management and careful strategic spatial planning.

Network Concept

Both Iberian initiatives use the concept of an ecologcal network to realise Green Infrastructure, and this seems to be an appropriate policy tool since it aims at attaining and improving the Green Infrastructure functionality and promoting, among other aspects, their connectivity.

A similar concept is used in the Andalusian Network of Natural Protected Spaces (RENPA) which aims to integrate RENPA into the territorial regional model, promoting peri-urban functions of certain protected areas. Another political option highlighted is the network of protected areas and fosters the connectivity and functionality of this network with urban and peri-urban areas. This option promotes public and leisure uses in protected-area networks and creates urban Green Infrastructure, and therefore contributes to the reduction of human pressure on other more sensitive areas.

Energy Saving and Climate-Change Adaptation Integrated with Biodiversity Objectives

Other policy options (green belts, green grids, green roofs etc.) have been developed in cities to reduce energy consumption and contribute to mitigating climate change, but also to improving urban environmental conditions, improving cities' aesthetic features which finally affect the quality of urban environments, and improving citizens' living and working conditions. The importance of these options is growing in European cities as demonstrated in the shifting of

urban policies towards the design of high-amenity urban areas. They also demonstrate their potential capacity to increase and protect biodiversity in urban areas. In the case of green roofs, these should be seen less as aesthetic and energy-saving features and more from a perspective of contributing to landscape and ecological planning. Basel's experience has also shown that a successful urban strategy on green roofs should be based on regional research on specific conditions that local species require to colonise green roofs. Experience in Basel has demonstrated that successful implementation of green roofs requires close cooperation between the local authority and nature conservation experts, as well as architects, development and landscape planners, green roof companies and contractors. Green roofs may also help to provide corridors for species' movements in the face of climate change.

Green Infrastructure Dissemination and Stakeholder Cooperation

As the experience of Basel has demonstrated, cooperation between the different private and public stakeholders involved in these types of policy options is of key importance. As described in the PROT AML and corridors network plan of Madrid, cooperation between three types of public institutions (national, regional and local administrations) is vital in developing both initiatives. Cooperation would improve with a major dissemination of the Green Infrastructure concept and the benefits it provides, requiring strong collaboration when developing these initiatives as well as previous Green Infrastructure promotional work emphasising the economic, social and environmental benefits derived.

In summary, Green Infrastructure is aimed at strengthening ecosystems by developing integrated land management. To achieve the multiple benefits that Green Infrastructure can offer, good management practices are of great importance. There is a clear need for cross-sectoral work, including agriculture, forestry, tourism and leisure as well as energy. It is also important to understand that many activities have both benefits and trade-offs – many climate change adaptation or mitigation measures, for example, can have a negative impact on biodiversity and that is why a holistic approach is essential.

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