THE IMPACT OF TWO DECADES OF LAND-USE CHANGES IN POTENTIAL ECOSYSTEM SERVICES SUPPLY IN A PORTUGUESE MUNICIPALITY – COIMBRA

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1. Introduction

- Ecosystems are essential for human life and well-being due to the services they provide. Ecosystem Services (ESs) are generally defined as benefits derived from ecosystems (MEA, 2005).
- In the last 50 years, human modified natural ecosystems quickly and extensively, mainly through urbanization and the practice of agricultural and forest monocultures (Pereira et al., 2009), which led to the accelerated loss of biodiversity and ESs. These losses may represent a significant risk to human activity, since it limits the supply of resources (MEA, 2005).
- The present study evaluates the impact of land-uses changes over the last years on the potential ESs supply in a typical Portuguese urbanizing region.

2. Study area

The municipality of Coimbra (319.4 km²) is located in the central region of Portugal, being crossed by the Mondego river. It has 143,396 inhabitants, distributed by urban cores of variable density (<134 hab/km² to >2020 hab/km²; INE, 2012). Between 1995-2015, agricultural areas occupied 39%-31% of the municipality, while urban and forestry covered 14%-18% and 46%-50%, respectively (Figure 1). Agricultural land decreased 8% due to conversion into forest (4% increase) and urban areas (4% increase).

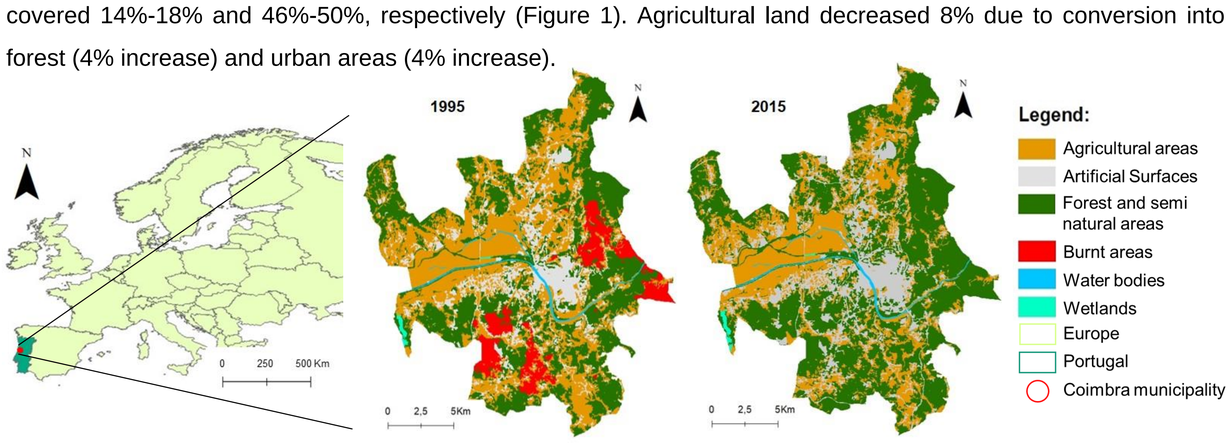

Figure 1 – Location of the municipality of Coimbra and its land-uses in 1995 and 2015

3. Methodology

This study evaluates the variation of the capacity of 28 land-uses (CLC level 3) to provide ESs, through questionnaires filled by experts familiar with study area. A total of 31 questionnaires were completed. The quantification was made using a scale between -2 (strong adverse potential) to 2 (strong positive potential). The modal values of the results were used to develop an ESs quantification matrix with 5 land-uses classes (CLC level 1), and to map the information in the study area for two years (1995 and 2015), using Geographic Information Systems (GIS).

4. Results

4.1 Quantification of ESs by experts

Table 1 shows the greatest negative potential of urban land-uses to provide ESs. Green urban areas stand out as the only urban area with positive ESs potential supply (0 to 2), particularly water and air purification. Thus, there is a large dispersion of values in the quantification of the supply of higher education in urban areas. In contrast, forests ant other vegetation provide the highest potential to supply ESs, especially regulating ESs. Mixed forests stand out for monocultures in the supply of cultural heritage. Among the vegetated land-uses, the sparsely vegetated areas provide about 1/2 of the total potential supply of ESs of forest and natural grassland, with similar potential to some agricultural areas (fruit trees). The agricultural land-uses with the highest potential of ES are those with natural vegetation, followed by annual crops, fruit trees and berry plantations, and the olive groves. These areas mainly contribute to the supply of crops and pollination. However, they impair the supply of water purification, pest and disease control and freshwater.

Table 1 – Matrix of quantification of ESs supply by land-uses (CLC level 1) type in Coimbra

Ecosystem services / Land-uses	Regulating ESs	Global climate regulation	Local climate regulation	Air quality regulation	Water flow regulation	Water purification	Natural hazard regulation	Erosion regulation	Nutrient regulation	Pollination	Pest and disease control	Regulation of waste	Provisioning ESs	Crops	Biomass for energy	Fodder	Fishing	Livestock (domestic)	Timber	Wild food & resources	Mineral resources	Biochemicals & medicine	Freshwater	Cultural ESs	Recreation & tourism	Landscape aesthetics & inspiration	Knowledge systems	Religious & spiritual experience	Cultural heritage & diversity	Natural heritage & diversity	Total ESs
Artificial Surface	-149	-2 to 2	-2 to 2	-2 to 2	-2 to 2	-2 to 2	-2 to 1	-2 to 1	-2 to 1	-2 to 1	-2 to 1	-2 to 1	-123	-2 to 0	-2 to 1	-2 to 0	-2 to 0	-2 to 0	-2 to 0	-2 to 0	0 to 2	0	-2 to 0	-29	-2 to 2	-2 to 2	-2 to 2	0 to 2	-2 to 1	-2 to 1	-301
Agricultural areas	11	-1 to 1	1 to 2	0 to 2	0 to 2	-1 to 1	1 to 2	0 to 1	1	1 to 2	-1 to 0	1	57	1 to 2	0 to 1	0 to 2	0	0 to 2	0	0 to 2	0	0 to 1	-1 to 1	46	0 to 1	1	1	0	0 to 2	0 to 1	114
Forest and semi-natural areas	97	1 to 2	1 to 2	1 to 2	1 to 2	0 to 2	1 to 2	1 to 2	1 to 2	1 to 2	0 to 2	1 to 2	62	0	1 to 2	0 to 1	0	0 to 2	0 to 2	1 to 2	0	1	1 to 2	48	0 to 1	1 to 2	1 to 2	0	0 to 1	1 to 2	207
Wetlands	18	1	2	1	2	2	2	2	2	2	1	1	3	0	0	0	0	0	0	0	0	1	2	6	0	1	1	0	1	2	27
Water bodies	15	2	2	2	2	2	2	0	2	0	0	1	11	2	0	0	2	2	0	2	0	1	2	9	2	2	2	0	1	2	35

4.2 Mapping ESs

In both years, Coimbra presents areas with high potential to provide ESs, located mainly in the periphery of large urban centers, associated mostly with green areas. In the center of the municipality, where most people concentrate, denoting the limited capacity to provide ESs. Nevertheless, throughout the municipality some spots with intermediate and low capacity to provide Ess are absorved.

These are representative of population clusters and agricultural areas, the last ones located mostly in the area of *Baixo Mondego*. Despite the limited ESs provided by urban areas, green spaces are relevant for the provision of ESs essential for human well-being. The negative effect of a forest fires is visible in 1995, through the very damaging spots to the ES supply.

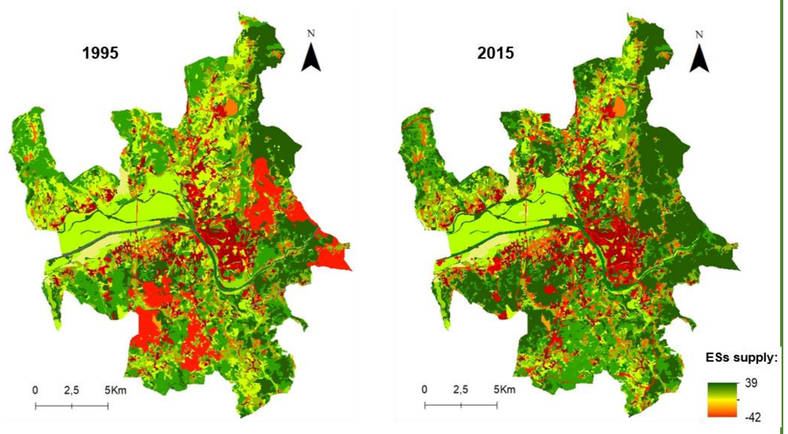

Figure 2 – Potential ESs supply in Coimbra municipality in 1995 and 2015

4.3 Temporal changes in potential ESs supply

Forest s are the land-uses contributes the most to ESs supply in Coimbra municipality (47%-59%), followed by agricultural areas (25%-18%). Wetlands (0.2%) and water bodies (1%) have a minor supply of ESs due to their small areas. In general, artificial areas with lowest potential ESs supply (25%-18%), followed by burn forest areas (9%) recorded in 1995.

The land-uses that contribute to the ESs supply (73%-78%) outweighs those which harms it (27%-22%). In general, there was na increase in Ess supply from 1995 to 2015 (11 – 14), due to the recovery of burnt areas. During this period, urban areas increased but, even so, the burnt area in 1995 had a worse effect on the supply of ESs than the urbanization impact.

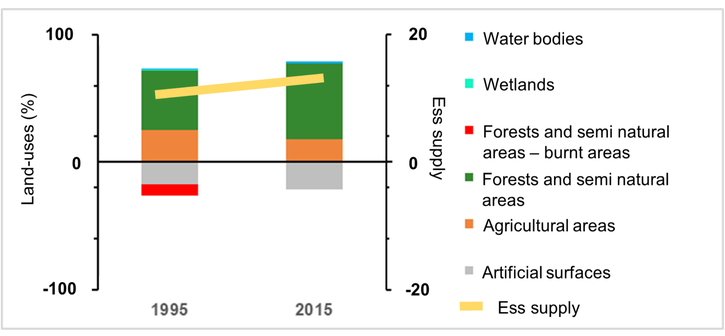

Figure 3 – Percentage contribution of different land-uses to ESs supply in 1995 and 2015

5. Conclusions

- Urbanization and forest fires decreased the potential supply of ESs. In contrast, green areas, such as forests provide highest ESs. Due to the recovery of burnt area, the overall ESs supply increased from 1995 to 2015.
- Assessing the impact of land use changes on ESs supply is important to (1) anticipate problems driven by reducing environmental services, such as flood mitigation, and (2) support urban planning and management, to enhance the provision of ESs in urban areas, and the development of sustainable cities.
- It is important to implement solutions that maximize the integration of green areas in urban centers. Renaturalization of urban areas, including public gardens, roofs and green facades, should be considered in urban planning.

References

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