7.8. Mapping ecosystem services for impact assessment

Davide Geneletti & Lisa Mandle

Introduction

Impact assessment (IA) processes aim to identify the future consequences of proposed actions to provide information for decision-making. Different types of IA exist, focusing on different topics (e.g. Environmental IA, Social IA, Health IA) or actions from individual projects to high-level policies (e.g. Regulatory IA, Policy IA, Strategic Environmental Assessment). The content of IAs is constantly evolving to reflect new perspectives and emerging issues and concerns. A case in point is the treatment of ecosystem services (ES), a cross-cutting theme which is increasingly included in different IA types, following the recent progress in literature and the development of guidance material. This chapter briefly describes the contribution of ES mapping to IA and presents two illustrative applications related to Strategic Environmental Assessment of plans and Environmental Impact Assessment of projects, respectively.

ES mapping across IA stages

Even though IA processes differ widely and cannot be formatted into a standard sequence of activities, most IA include the following stages (not necessarily in this order):

– Scoping and baseline analysis
– Consultation
– Developing alternatives
– Assessing impacts of alternatives
– Proposing mitigations

During the scoping stage, ES mapping can be undertaken to select priority ES, i.e. the services that are most relevant for the action under analysis and the socio-ecological context. Priority services are of two types: the services upon which the action depends (e.g. tourism development requiring specific cultural services to be profitable) and the services that the action will affect, positively or negatively (e.g. tourism development affecting storm regulation provided by coastal ecosystems). Successful identification of priority ES requires understanding of the spatial relationship between the area affected by the action, the area where the ES are produced and the area where they are used by beneficiaries. Hence, ES maps (even in a qualitative form) represent an essential input for this stage.

During consultation, ES maps help to focus the debate and engage stakeholders. In addition, participatory mapping exercises can be performed to better characterise key features of the local context and understand how ES are perceived and valued by different beneficiary groups (see Chapter 5.6.2). This information can be used to inform the subsequent development of alternatives, for example, by identifying "no-go" areas for specific activities, suggesting priority locations for facilities or land-use conversions, etc.

Concerning the assessment of the impact of different alternatives, spatial analysis allows impacts to be traced to specific beneficiaries.

It provides more explicit information that can be incorporated into environmental and social management plans, as compared to qualitative and non-spatial approaches, by illuminating where and how environmental changes are affecting benefits to people. In this way, it also enables identification of more efficient mitigation options by bringing together environmental and social aspects. In addition, by allowing tracking of benefits to specific people or groups of people, spatially explicit analysis provides the opportunity to ensure that development and any associated mitigation actions do not lead to the creation or extension of inequality in service provision.

All these aspects suggest that ES mapping can contribute to IA by reducing the likelihood of plan or project delays due to unforeseen impacts, reduce reputational risk to public authorities and developers from unintended social impacts and improve overall outcomes of actions and mitigation.

An application in Strategic Environmental Assessment

This section exemplifies how spatial analysis of ES can be used to provide information for Strategic Environmental Assessment of urban plans. Particularly, it presents part of a case study related to the Urban Plan of the city of Trento (Italy). Amongst other things, the plan identifies sites for residential area development, mainly located within the existing urban fabric (Figure 1, left side). These sites consist of ninety-one vacant lots, with a surface area ranging from 1,000 to 5,000 m^2. The purpose of the analysis is to use ES to support the selection of priority sites. Particularly, the analysis presented here focuses on the climate regulation service provided by green urban infrastructures.

The cooling capacity of existing green urban infrastructure was estimated by applying a spatial model tailored to the local climate conditions, based on green areas characteristics, such as soil cover, tree canopy and size. Then, for each urban development site, the expected cooling capacity provided by the surrounding green infrastructures was calculated and classified into six classes (from A+ to D). This allows the sites to be ranked according to the thermal benefit that they are expected to receive, as shown in Figure 1 (right side).

The results show that vacant lots which should be prioritised are, in general, the most peripheral and can be found both in the northern sector part of the city (at the borders of the green wedge that penetrates the built spaces) and in the southern sector (next to the surrounding wooded slopes). However, some vacant lots within the city centre also reach the highest level of thermal benefit provided by the surrounding green infrastructure due to the proximity to urban parks and water bodies. This application shows how ES mapping can be used to compare alternatives and identify priority interventions which represent typical tasks of Strategic Environmental Assessment of spatial and urban plans.

An application in Environmental Impact Assessment

In this section, we show how spatial analysis of ES can contribute to Environmental Impact Assessment for a proposed infrastructure project, using the Peruvian portion of the proposed Pucallpa-Cruziero do Sul road between Peru and Brazil as a case study. We evaluate the likely impacts of the road on several ES provided to over 100 local communities (Figure 2, centre) and determine where

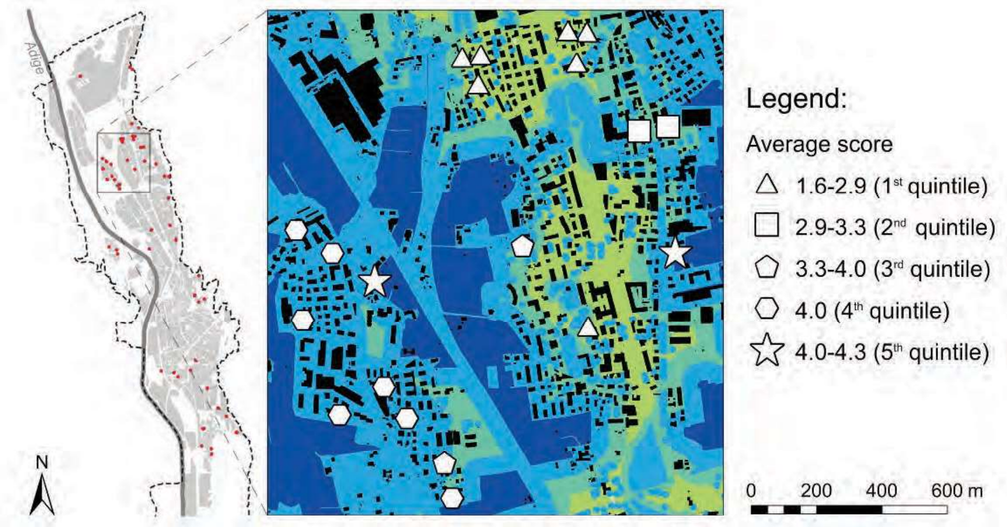

Figure 1. Sites for residential areas development (red dots) identified by the urban plan of Trento (left) and classification of the thermal benefits received by those sites (right). The first quintile include the sites which receive the lowest benefits. Source: Modified after Geneletti et al. 2016.

restoration has the potential to mitigate these ES losses (Figure 2, right side). We focus on carbon storage for climate regulation and sediment, nitrogen and phosphorous retention for drinking water quality regulation.

The combined direct and indirect impacts of the road were estimated by using a spatially explicit land use change model. Based on past trends, the model estimates where road construction is likely to spur conversion of forest to agriculture in the surrounding landscape. We then use the InVEST carbon, sediment retention and nutrient retention models (Chapter 4.4) to estimate how these services would change with road development and associated deforestation, accounting for factors such as soil, climate and land use/land cover characteristics. We use the ES models to determine which population centres were likely to be affected and which services they would lose (Figure 2, centre). Changes in carbon storage affect climate regulation services for everyone, due to circulation and mixing of the Earth's atmosphere. In contrast, only those population centres that take their drinking water from places situated downstream of the road or its associated deforestation, will experience a loss in drinking water quality regulation services. Then, to determine where and how restoration might mitigate these losses, we prioritise potential restoration sites in the surrounding area. The prioritisation was based on the ability of restoration in each location to enhance carbon storage, sediment and nutrient retention and for these functions to benefit the same populations affected by the road (Figure 2, right).

The results show that population centres would lose between one and four ES, depending on the location of the population centre relative to the road and the projected land use change, as well as the characteristics of the intervening landscape. Potential restoration sites in the south-western portion of the watershed are expected to return the greatest ES benefits to affected populations, although complete mitigation of ES losses is not possible in this case. This example shows how spatial ES analysis and mapping can be used as part of an Environmental Impact

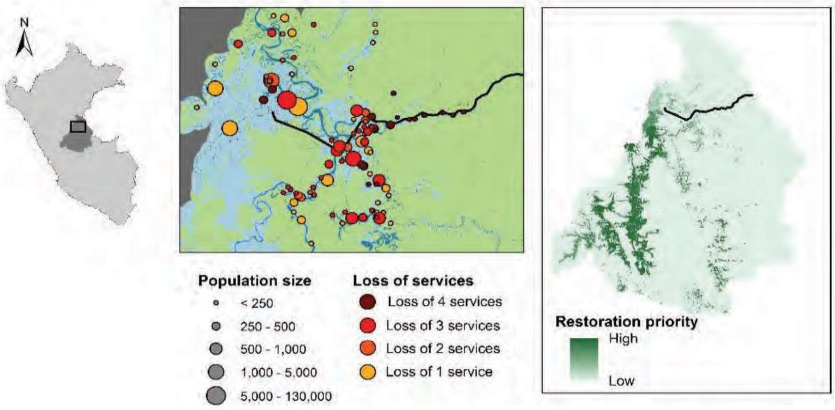

Figure 2. In Peru (left), population centres around the proposed Pucallpa-Cruzeiro do Sul road are be expected to lose climate regulation and drinking water quality regulation services (sediment, nitrogen and phosphorous retention services) with road development and associated land use change (centre). Potential ES mitigation areas (right) in surrounding watersheds can be prioritised by accounting for areas where restoration is both possible and would restore ES benefits to those impacted by road development. Source: Based on Mandle et al. 2015.

Assessment process, linking environmental change from project impacts and mitigation options to changes in benefits to people.

Further reading

Geneletti D (2015) A Conceptual Approach to Promote the Integration of Ecosystem Services in Strategic Environmental Assessment. Journal of Environmental Assessment Policy and Management 17(4): 1550035.

Geneletti D , Zardo L, Cortinovis C (2016) Promoting nature-based solutions for climate adaptation in cities through impact assessment. In Geneletti D (2016) (ed) Handbook on biodiversity and ecosystem services in impact assessment. Edward Elgar (Cheltenham, UK and Northampton, MA, USA), 428-552.

Landsberg F, Treweek J, Stickler NM, Venn O (2013) Weaving ecosystem services into impact assessment. Washington, DC World Resource Institute.

Mandle L, Tallis H, Sotomayor L, Vogl AL (2015) Who loses? Tracking ecosystem service redistribution from road development and mitigation in the Peruvian Amazon. Frontiers in Ecology and the Environment 13(6): 309-315.

Mandle L, Tallis H (2016) Spatial ecosystem service analysis for environmental impact assessment of projects. In Geneletti D (2016) (ed) Handbook on biodiversity and ecosystem services in impact assessment. Edward Elgar (Cheltenham, UK and Northampton, MA, USA), 15-40.

Sharp R, Tallis HT, Ricketts T, Guerry AD, Wood SA, Chaplin-Kramer R, Nelson E, Ennaanay D, Wolny S et al. (2014) InVEST User's Guide. Stanford, CA: Natural Capital Project.

UNEP (2014) Integrating ecosystem services in strategic environmental assessment: a guide for practitioners. A report of Proecoserv. Geneletti D. United Nations Environment Programme, Nairobi.