Chapter 3
Ecosystem Services Assessment from the Mountain to the Sea: In Search of a Method for Land- and Seascape Planning

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Abstract Despite the growing use of ecosystem service (ES) assessment to value natural landscapes exposed to development pressures on the edge of urban landscapes, practical applications have been few. In a pilot research project, we integrate changes in different types of ES along a gradient of land- and seascape units (terrestrial, coastal and marine). This gradient includes developed urban and peri-urban areas, and undeveloped areas including submerged lands in the coastal (territorial) waters of Israel.

The emphasis in our research is on development of a practical methodology for sustainable (urban and rural) development. Goals of the pilot project presented here include: (1) evaluation of various ecosystem services based on categorical indicators for each of the four ES types: provisional, regulating, supporting and cultural; (2) development of a method that can be used on a wider scale across varying landscape units; and (3) refinement of scenario building relevant to local planning institutions and frameworks. The project's final product consists of GIS-generated maps. These maps are the basis for weighing trade-offs in ES across relevant land- and seascape units in the Mt. Carmel region of Israel. Despite some limitations, this approach to ES assessment is helpful, and if improved upon in some of the ways described herein, it can provide the first steps for infusing ES values within planning frameworks in Israel and beyond.

Keywords Ecosystems services • Israel • Environmental planning • Land use • Submerged lands • Remote sensing

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3.1 Introduction

Scientists, policy-makers, and activists have promoted the ES approach to convey the extent of threats to natural ecosystems. Their goal has often been the crafting of effective and socially acceptable policy to address ecological threats. In some cases, the goal is improved decision making within a planning context (Nelson et al. 2009; Portman 2013). Environmental geography has much to offer in both cases. It can integrate between the fields of spatial ecology, geography and urban planning to support the practical application of ES as a "language" for environmental protection, conservation and sustainable development by planning professionals and stakeholders.

Practical methods for identifying, analyzing and quantifying ecosystem services (ES) on land and sea are evolving worldwide. Yet there are quite a few challenges to their implementation (e.g., Portman 2013). Incorporating cross-landscape ES value changes is identified as a challenge to the use of the ES approach in planning decision-making (de Groot et al. 2010; Kohsaka 2010). In Israel, this is especially important because planning authorities influence almost all the spatial aspects of environmental protection. Also, Israel is a relatively small, densely populated country with a heterogenous landscape. Development pressures in peri-urban areas are particularly great.

This chapter describes a case study conducted as a pilot for the Israel Ministry of Environmental Protection. It is among the few research projects examining ecosystem services along a geographic transect looking at different land and seascape units as a continuum at a local level, including areas of urban, peri-urban, marine and coastal landscapes slated for development.

Following an introduction of the concept of ecosystem services we describe challenges related to incorporating the ES paradigm for land-use planning decision making in general. We then describe the pilot study characteristics, methods and results of our research. We briefly present the project's final product, namely GIS-generated maps that indicate expected changes in ES services for the study area and a methodology that can be improved upon as new information becomes available.

3.2 Ecosystem Services: Definition and Purpose

The complex ways in which humans depend on their natural environment are increasingly assessed as ES (Adams 2014). Ecosystem services are the benefits provided to humans by natural systems which allow life and improve its quality (Reid et al. 2005). For many scientists and professionals, ES is a tool that can be used to explain to policy makers and to the general public about the importance of nature conservation and environmental protection (Carpenter et al. 2009; Collins et al. 2011; Kareiva et al. 2011; de Groot et al. 2010; Adams 2014). Some environmentalists have even described the ES approach as "the last great hope" for making biodiversity conservation a priority for planning and resource management (Daily et al. 2009).

We define ES as “the direct and indirect contributions of ecosystems to human well-being” (TEEB 2010). The ES paradigm connects, conceptually and empirically, between ecological health and human well-being. Further, it provides a way to explain and emphasize the importance of nature to policy makers and the public, using terms that make sense to scientists and laymen. Philosophically (and from a policy perspective) such advantages have utilitarian roots about values of products and processes going back to the ideas of Jeremy Bentham and John Stuart Mill (Rawls 2005).

ES are usually divided into four types (Reid et al. 2005; TEEB 2008), although recently there has been some controversy regarding the category of supporting services as explained below. The most straightforward category and perhaps the easiest one to assess is that of provisional services. Simply, these are the *products* obtained from ecosystems and as such are “services” which are directly consumed — for example, food, water, fuel, minerals, etc. “Regulating” services are those arising from ecosystems that help control environment processes (e.g., floods, erosion, climate, carbon storage, pests, pollination, waste decomposition, nutrient regulation and more (Brown et al. 2006). Cultural services are those that contribute to well-being, feelings resulting from heritage values, and from enjoyment, satisfaction, spirituality and aesthetics.

More complex is the remaining category: supporting services. These services “support” the delivery of other services, albeit often indirectly. They include such benefits as soil formation, photosynthesis, and nutrient cycling (Brown et al. 2006). Some recent studies do not include this category based on the claim that supporting services are ecological processes and therefore not ecosystem services per se (Haines-Young and Potschin 2010). Some studies (e.g., TEEB 2008) use habitat as an additional ecosystem service that supports biodiversity and forego other supports.

Measuring ES values is challenging. Problems in assessment arise firstly because ecosystem services must be actions or functions, in other words clearly valued “services”. In most cases, these values are ostensibly anthropocentric. For example, consider pollination by bees. Pollination is a functional process that supports the growth of cultivated produce; while bees should be valued and are an essential part of the process, they are not the “service” itself. Rather pollination is the service. But how is it measured? By the number of bees?

A similar question can be asked about grazing areas. The service can most readily be measured according to spatial attributes such as area, continuity, vegetation type (i.e., whether or not it provides fodder), characteristics such as vegetation height, etc. But these measures are not always agreed upon. Further, valuation may depend on *which* humans are the beneficiaries (Adams 2014). Elements of the environment providing the services (such as livestock) usually have owners and this could lead to biases in assessment and evaluation. Another ambiguity relates to whether services must have some connection to the underlying ecosystem. It is problematic to assess a natural resource, especially a finite one (e.g., natural gas, sand or space), as a service because such “services” are not directly based on ecosystem functions and processes, biodiversity and/or ecosystem health. We have no shortage of these in urban and peri-urban areas where space is at a premium.

Despite these and other challenges, many countries are undertaking large-scale, national or regional-level ES assessments using various methods, categories and indicators. As examples, the UK's recently completed national ecosystem assessment (NEA 2011) classifies services similarly to the UN's Millennium Ecosystem Assessment (MEA). Finland's national ES assessment initiated in 2013 (SYKE-Finnish Environment Institute n.d.), stresses the economic importance of ES as opposed to how services contribute to nature (biodiversity) conservation. The on-going Israel national-level assessment, considers habitat services as a category without other supporting services. "Habitat" includes breeding grounds, transfer stations for migratory species, or the protection of areas where high genetic diversity is identified (HaMaarag 2013). The creation of this separate ES category values wildlife and biodiversity more than other services.

3.3 Applying ES Assessment for Land Use Planning

Common threats to ecosystems include most land use changes and development, especially activities linked to urbanization and rapid population growth. Those most interested in ES assessment may ultimately be seeking to gauge the extent of threats and to create environmental protection and conservation policies (Stibbe 2009). Yet, ES assessment should be designed with planners and other land use professionals in mind because they are directly responsible for decisions about development, especially in urban landscapes and on the peri-urban edges, where significant ES are at stake.

In practice, the disciplinary undertaking of ES study is often biased towards ecology and economics (see Adams 2014). This poses challenges for incorporating ES within an urban planning context. Planners' decisions are not made solely on the basis of scientific data but also as a result of complex social and political considerations often related to policy (Taylor 1998; Portman 2013). Therefore, the research described herein focuses on incorporating the ES approach in a cross-disciplinary manner within an existing land-use planning context.

While many studies have encouraged integration of the ES approach in planning (e.g., Daily et al. 2009; Granek et al. 2010; Kareiva et al. 2011; Nelson et al. 2009), few have provided applicable methods for incorporating assessment results. Characteristics of local, regional or national planning frameworks vary widely from place to place which makes it hard to develop universal approaches. Some planning frameworks are characterized by decentralization; some are highly participatory and others are not. Thus pilot studies and local examples are important. These can readily be conducted using geographic information systems (GIS).

Growth in the use of GIS in the 1980s greatly improved early attempts that considered identifying the benefits of ecosystems (e.g., King 1966; Ryther 1969). GIS consolidates and combines layers of information easily which aids in the tracking of ecological processes, land use changes over time and the changes of potential planning outcomes' influence on ES. However, the use of GIS must be carefully conducted so that urban planners and decision-makers can follow the (often formulaic) modification of data. Problems frequently arise due to lack of scientific consensus regarding the models for generating GIS data (de Groot et al. 2010).

Additionally, ecosystems do not take on the boundaries of socially constructed institutions. Here we use the terms "institutions" in the broadest sense; they include reference to spatial boundaries for policy-making and planning decisions that are often incongruous to the particular extent of ecosystem types, i.e., forest, wetlands, beach, estuaries, etc. Urban master plans and regional plans used for scenario building (e.g., Nelson et al. 2009) will involve numerous ecosystem types. Broad cross-landscape unit coverage, such as that found in plans, requires comparable ES evaluations. Even when applications of ES assessments consider urban and regional plans and planning tools (e.g., Eigenbrod et al. 2010) scale can be problematic. For on-the-ground planning and decision-making, national scale assessments are often not detailed enough.

This study addresses the above-mentioned challenges. We analyze a geographic area that crosses varied land- and seascape units along a transect. As the selected transect is crossed from urban to peri-urban to rural to undeveloped, we apply different valuation methods. These are both qualitative and quantitative, as appropriate, depending on the variables we use as ES indicators.

3.4 The Mt. Carmel to the Sea Case Study

Despite the on-going preparation of National Assessment of ES for Israel (HaMaarag 2013), the country's planning institutions have yet to incorporate ES in decision-making. National Outline Plans (NOPs) such as those for parks and nature reserves (NOP 8), immigration absorption (NOP 31), and coasts (NOP 13) did not adopt the ES framework although language relating to ES is used in some (e.g., NOP 13) (Kaplan 2011). One reason is timing: the on-going Israel National ES Assessment was initiated only in 2012 while most of the national thematic outline plans are several decades old (e.g., NOS 13 was first approved in 1981, although amended since). Recognizing the potential for integration of ES assessment in work done by planning committees, the Israel Ministry of Environmental Protection has taken a lead in ES assessment and funded this work as a limited-area research pilot (Figs. 3.1 and 3.2).

The Mt. Carmel to the Sea pilot transect includes different settlement densities and types (e.g., rural and urban) of varying demographic makeup (Jewish and/or Druze) and land uses (i.e., agriculture, urban, peri-urban, beach, fishing areas). Different statutory authorities have jurisdiction within the transect, for example regional councils, the Jewish National Fund, and the Israel Nature and Parks Authority. The terrestrial area includes a range of ecosystems: forests, Mediterranean scrub, woodlands, agricultural fields, residential and developed urban areas. The coastal area includes gravel and upland dunes. The marine area stretches into the oligotrophic Levant basin to 800 m depth made up of the continental shelf's sandy and clay substrates, submerged shallow and sporadic kurkar ridges and underwater canyons.

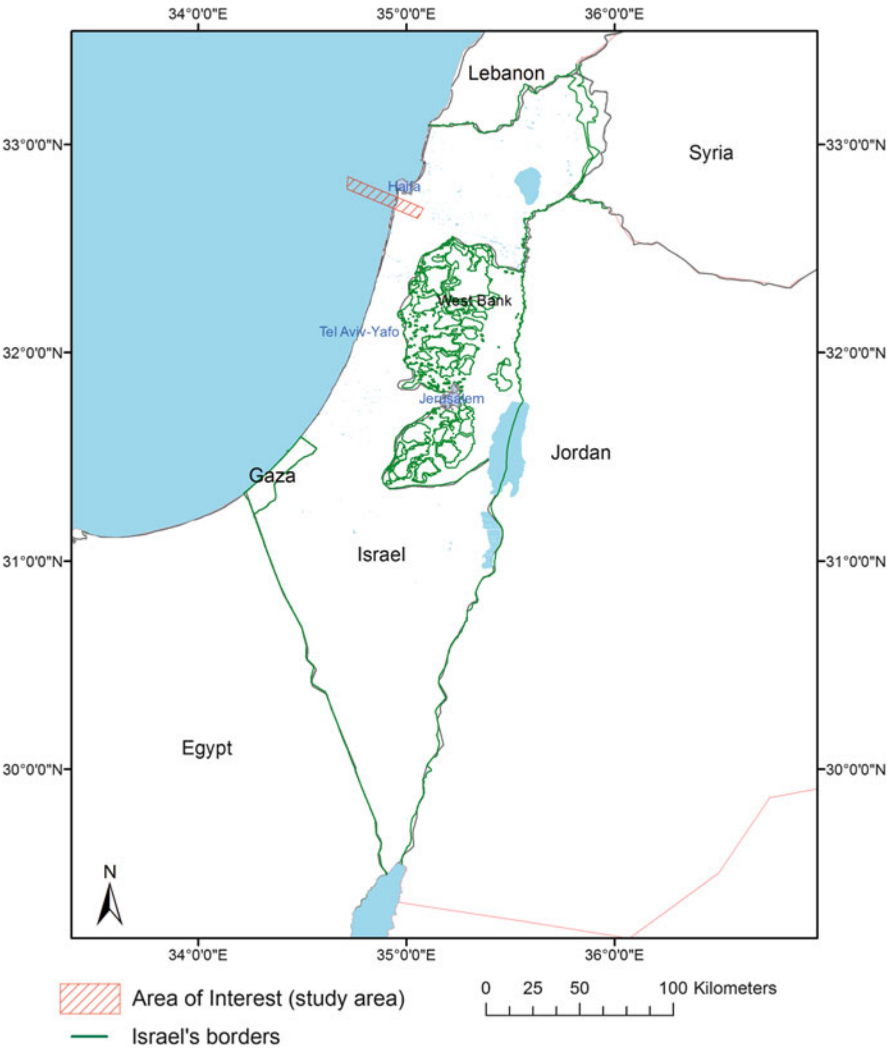

Fig. 3.1 The national context showing the pilot transect running east to west, generally from the top of Mt. Carmel to the outer extent of Israel's territorial waters

3.5 Methods

Our work consisted of the main stages: choosing indicators from a list of ES for each of the major land- and seascape units; mapping the spatial distribution of different ecosystem services (based on the literature and available data); developing scenarios based on existing plans; estimating changes in the indicator services; estimating tradeoffs based on the indicators and developing recommendations for the

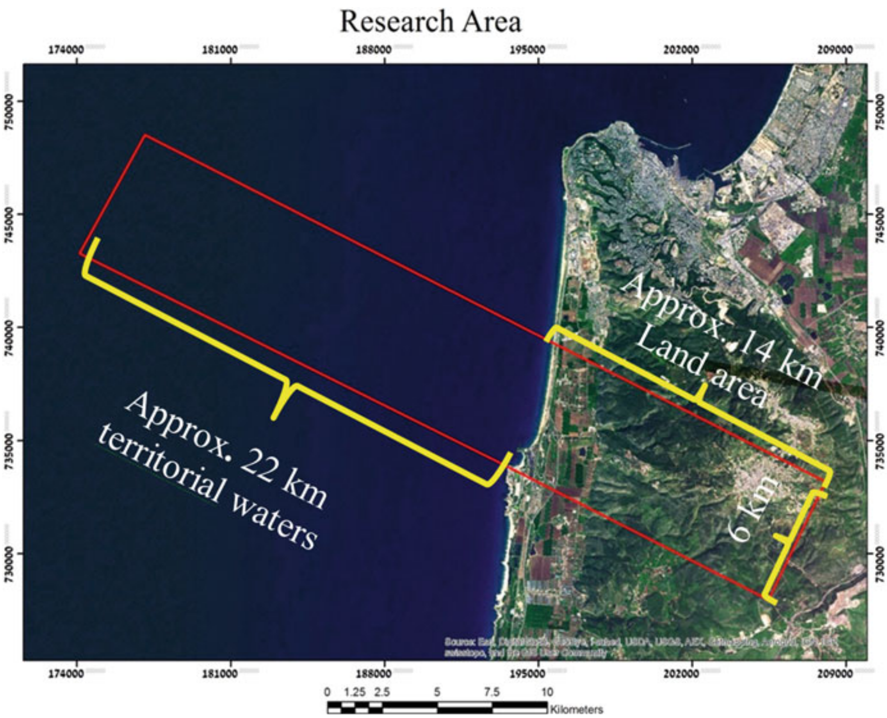

Fig. 3.2 The study area outlined in by the rectangle (with Landsat 8 as background)

future use of the methodology and its incorporation within the planning framework. We conducted some of the work simultaneously (See Fig. 3.3).

For guides, we used various reports and projects, such as the Natural Capital Project (http://www.naturalcapitalproject.org/). These provided the research team with lists from which to choose indicators (Table 3.1); the choice of indicators became a major focus of the work. Conservation planning often requires the use of indicators, due to the large numbers of plant and animal species and the lack of complete knowledge about them (Wilson et al. 2009). Also, Egoh et al. (2012) and Crossman et al. (2013) emphasize the widespread use of representative indicators, or proxies, in ES assessment according to region, land use or socio-ecological system.

Over the different landscape types (terrestrial, coastal, marine) the categories of ES allowed for some consistency. In each land- or seascape unit, we tried to choose at least one indicator for each service type: provisioning, regulating, cultural, and habitat. We based our final selection of indicators on secondary sources of GIS data and therefore were limited to three categories of ES in the marine (seascape) unit (see Table 3.2). Despite reliance in some cases on the broad ES literature, we selected indicators relevant to Israel (as determined by professional and academic

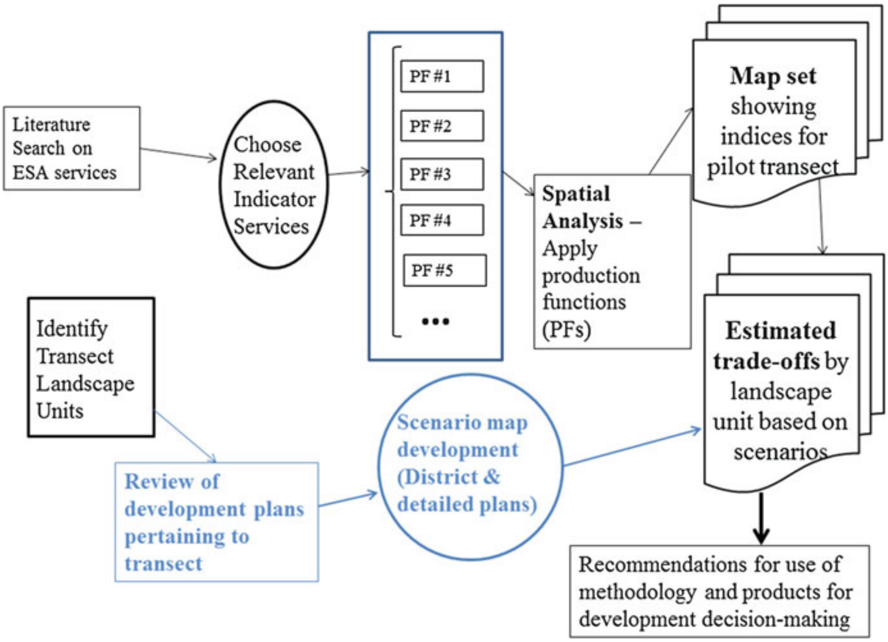

Fig. 3.3 The workflow. Note: Light blue indicates planning and policy-related action items. The concept of production functions (PFs) are explained below

Table 3.1 The ecosystem service types used according to seminal sources

MA (2005)	TEEB (2008)	Current project
Provisioning	Provisioning	Provisioning
Regulating	Regulating	Regulating
Cultural	Cultural and amenity	Cultural
Supporting	Supporting	Habitat (supporting)

literature, expert opinion and site characteristics) and those for which GIS data was readily available (e.g., Orenstein et al. 2012; HaMaarag 2013).

Combinations of fixed environmental parameters (e.g., slope and elevation) and variable environmental parameters (e.g., vegetation types and biomass) allowed calculations of indicator values. Fixed parameters change slowly (over a period of many years or longer) and include variables such as elevation, slope, ground type and more. Variable land-cover and characteristic parameters change in short periods of time and include: vegetation type, rainfall, and chlorophyll concentration in the sea.

One common variable is the Normalized Difference Vegetation Index (NDVI). The NDVI indicates whether the target area contains live green vegetation or not and to what extent. It is calculated from individual measurements of the spectral reflectance measurements acquired in the visible (red) and near-infrared regions

Table 3.2 List of terrestrial, coastal and marine ecosystem services and indices

	Service type	Value	Indices	Source(s)
Terrestrial	Regulating	Water infiltration	(NDVI × 0.5) + (Ground type × 0.3) + (slope × 0.2)	Beets et al. (2011)
	Regulating	Soil retention	(NDVI × 0.5) + (Ground type × 0.2) + (slope × 0.3)	Wylie et al. (2003)
	Regulating	Carbon storage	Changes in NDVI based on Landsat 8 images	
	Provisioning	Grazing areas	Cattle grazing ($Winter_{ndvi}$- $Summer_{ndvi}$>0.001)	
			Goats grazing ($Summer_{ndvi>}$0.2)	
	Cultural	Views (aesthetic/landscape)	DEM layer; viewable area	Reyers et al. (2009)
			Classification area for two groups users: stationary and mobile viewers	
			Based on: height, slope, river, night camps, trail, road, picnic area, sites and land use type	
Coastal	Regulating	Water infiltration	(Soil type × 0.3) + (Vegetation density × 0.2) + (Land Use × 0.5)	Levanony (2011)
	Regulating	Erosion prevention	(Vegetation density × 0.7) + (Land use × 0.3) + (Areas within 1 km of abrasion tables)	
	Habitat	Biodiversity	Landscape value + ecological units (highest value to kurkar ridges)	Duarte (2000)
	Provisioning	Recreation	(Vegetation type × 0.5) + (0.5 × visit sites)	Barbier et al. (2011)
	Cultural	Sea views	DEM layer; viewable area	
			Based on: height, slope, river, night camps, trail, road, picnic area, sites and land use type	
Marine	Regulating	Carbon storage	(0.3 × Chloropyll) + (0.7 × depth)	Orth et al. (2006), Brown et al. (2006), and Barbier et al. (2011)
	Habitat	Marine habitats (biodiversity)	High – kurkar ridges and near shore abrasion tables and rocky outcrops	Krumbein and Van der Pers (1974)
			Medium – continental slope and canyons	
			Low – deep sea and continental slope sands	
	Provision	Water quality	According to biannual chlorophyll rates	Yahel and Angert (2012)

apparent in a satellite image. Functionally, it is the simple ratio of infrared to red characteristics of the image.

On a scale of low (barren, perhaps urban or otherwise developed areas) to high (completely forested areas), NDVI provides a measure of carbon storage taking place. NDVI values indicate about 90 % of the absorption of capacity of carbon (Beets et al. 2011; Wylie et al. 2003). A comparable variable in the ocean waters is the level of chlorophyll. In the sea, depth together with measures of chlorophyll give an indication of absorption of CO_2, in seawater, termed "blue carbon".[1]

For our study, marine GIS data was much more limited than that available for the urban, peri-urban, rural or undeveloped terrestrial and coastal areas. In the marine environment, other than levels of carbon sequestration, we used levels of chlorophyll to indicate good water quality (for purposes of desalination) and benthic information to determine habit quality.

In the coastal landscape unit, determined to be approximately up to 1 km east of the shoreline (bounded by major transportation infrastructure), we mapped vegetation types for the assessment of various ES, such as habitat. Vegetation and the existence of near-shore abrasion tables indicted land retention services (i.e., stabilization of sand dunes and coastal protection from erosion respectively). Here we also used NDVI as an indicator of carbon sequestration and sea views (cultural services) as identified through the use of a digital elevation model (DEM) GIS layer.

3.6 Building Indexes for ES Assessment

The data collected served as the basis for the production of maps indicating the current ES along the transect. For this stage we used existing land modeling techniques (such as in Reyers et al. 2009). For greater detail of variables such as slope and aesthetic views we interpolated the original 25-meter (m) DEM into a 1-m DEM for both the terrestrial landscape unit and the coastal unit. In marine areas, we used bathymetry data, which remained at the coarser 25-m resolution due to data limitations (Fig. 3.4).

We developed ES value indices (see Table 3.2) through the use of production functions (PFs) as described in Nelson et al. (2009). PFs give a value which indicates the relative benefits derived from each ES in the generic form $y = f(x)$, where y is the level of service/benefit and x is the ecosystem component or process (See the example shown in Fig. 3.5). In most cases, experts were consulted to arrive at the approximate (relative) function.

Map layers record the ES delivered for each indicator (see Fig. 3.6). Pixel values are summed between layers for an additive score. Because the set of indicators is slightly different in marine, coastal and terrestrial environments, we prepared one

[1] As opposed to black carbon (particulate matter) and brown carbon (organic aerosols), emitted respectively by the incomplete combustion of fossil fuels and biomass.

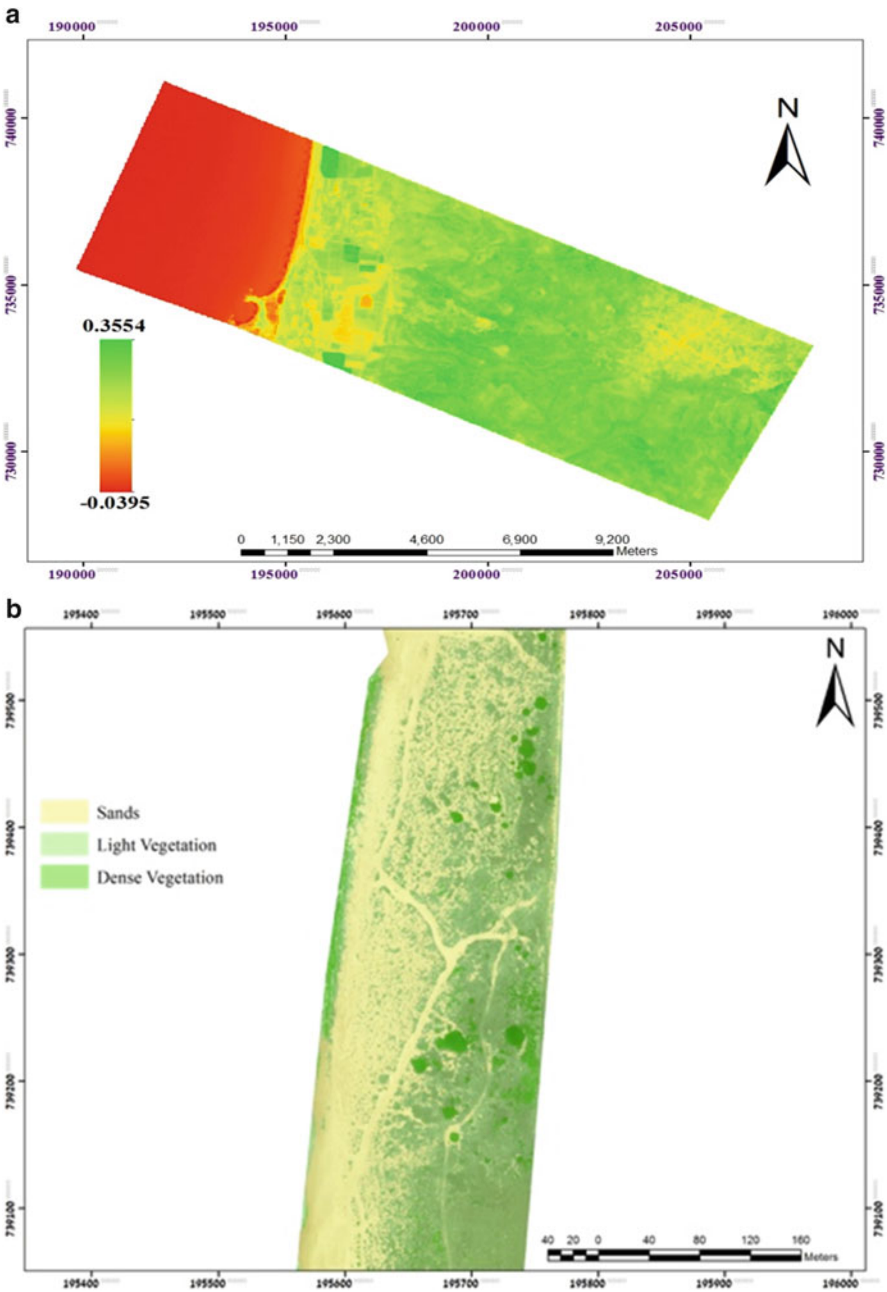

Fig. 3.4 The mapping of abiotic and biotic ecosystem components within the transect: (**a**) NDVI; (**b**) mapped coastal vegetation based on remote sensing images (LiDAR); (**c**) bathymetry which together with chlorophyll levels, indicated carbon storage services

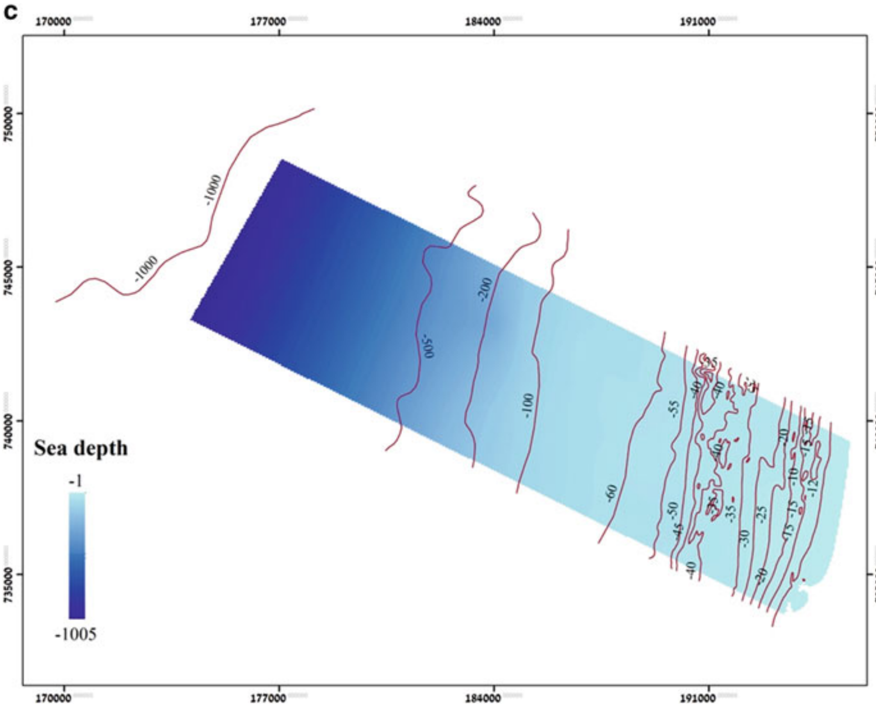

Fig. 3.4 (continued)

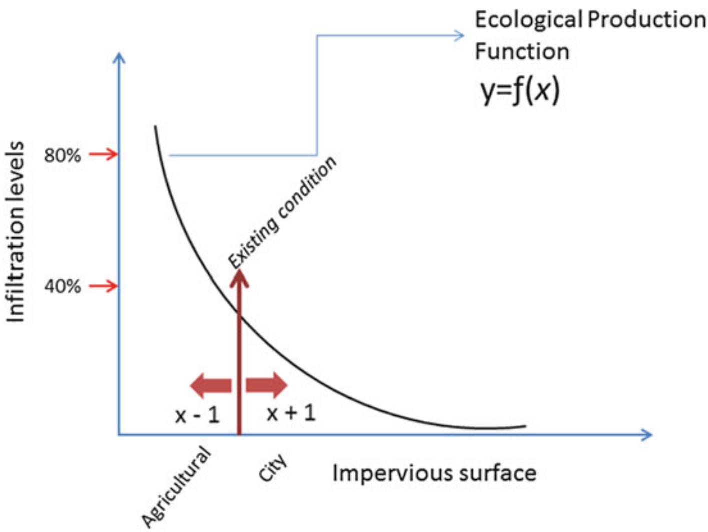

Fig. 3.5 An example PF for the service of water infiltration PFs are generalizations or models of reality (See Nelson et al. 2009)

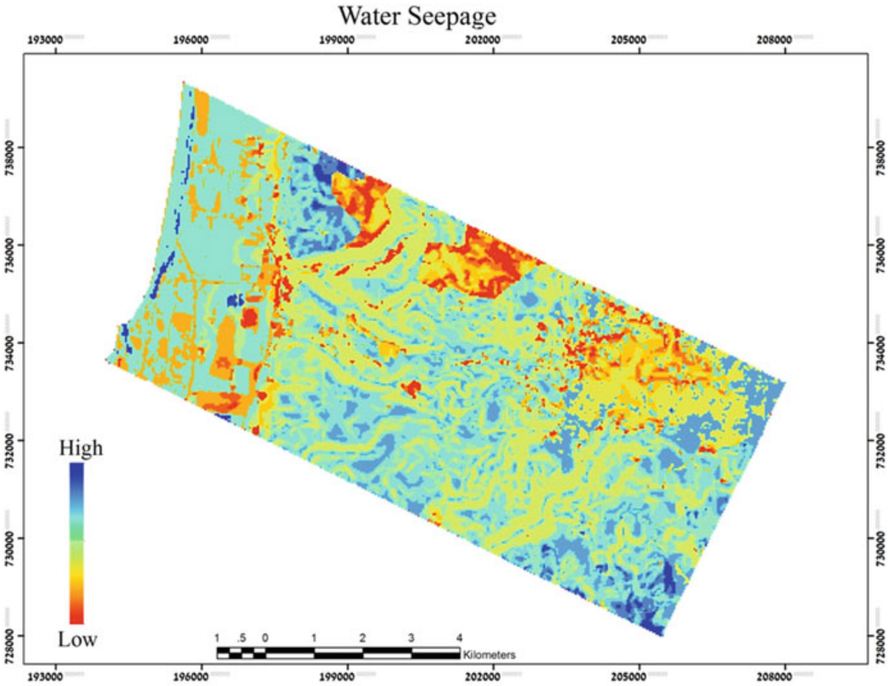

Fig. 3.6 Water infiltration visualized as a gradient, from high infiltration (*blue*) to low infiltration (*red*). The water infiltration PF shown in Fig. 3.5 theoretically describes what is seen here

composite layer for each landscape unit. These additive scores can be normalized and compared across landscape units.

Results of the entire process are the change (trade-off) in services expected from the implementation of approved plans. For the terrestrial landscape unit (Table 3.3) we devised scenarios from two sets of plans: (1) the Haifa District Outline plan; and (2) a compilation of three detailed town plans (Nir Tzion, Dalyiat El Carmel and Atlit Neighborhood Expansion). For the coastal unit we used two plans: (1) the Haifa District Outline Plan; and (2) the National Outline Plan for the Mediterranean Coast of Israel. For the marine area we used: (a) a plan for an offshore liquefied natural gas absorption station (NOS 37); and (b) a compilation of plans prepared as background for the ongoing Israel Marine Plan. As of the writing of this chapter, Israel's first marine spatial plan[2] is under development; we used that effort to cull information on expected uses of the marine area (such as areas slated for mariculture development) (Fig. 3.7).

[2]Covering approximately 27,000 km^2 of sea area. More information can be found at: http://msp-israel.net.technion.ac.il/

Table 3.3 Plans used for scenario development (only terrestrial portion)

Plan level	Land uses	Plan goals	Planning horizon
Detailed. Atlit neighborhood	Housing, public buildings, public open space, parks, commercial, infrastructure, roads, walkways	Residential sub-division; Public building/use areas; land takings	Unspecified
Detailed. Daliyat-Al-Carmel neighborhood	Housing, mixed use tourism, mixed use commercial, public buildings, public open space, infrastructure, walkways, roads	Expansion of urban area	Undefined
Masterplan. Nir Zion	Housing, public buildings, parks, roads, open spaces, hospitality	Town expansion	Undefined
Masterplan. Daliyat-Al-Carmel	Housing, public buildings, parks, agricultural, industrial, roads, open spaces, commercial, tourism, infrastructure	Setting development policies for Daliyat-al-Carmel city; emphasis on Druze identity and history	Undefined long-term
District. Masterplan Haifa District	Towns, cities, villages forests, beaches, infrastructure, agriculture	Improving: (a) commercial, social and physical development for the Haifa district, (b) urban design and construction, (c) environmental quality	2020

Fig. 3.7 The Nir Etzion (town) Masterplan. The plan shows the extent of a new neighborhood slated for construction in the Carmel Mountains

3.7 Results

We used spider graphs to show the tradeoffs expected from implementation of the development plans used for scenario building. Expected effects are shown visually against the existing ES levels for comparison and decision-making. The graphs show relative changes and make scenarios comparable. For example, as shown in Fig. 3.8, if the Haifa District Plan is fully implemented we expect significant reductions in soil control (retention) and slight reductions in grazing and infiltration services. Other services in the landscape unit will remain about the same.

Ideally, indicators can be added beyond those presented in Fig. 3.8 (water infiltration, grazing, carbon sequestration (C02), soil control) and those presented in Table 3.2. Our study used only secondary data, but many more indicators can be added from each of the service types as information improves and funding is secured for primary data collection. This holds true both for the information needed for a more accurate ES baseline assessment as well as for improved scenario building.

The study led to identification of important limitations both in terms of project and in regards to the methodology. Firstly, indicators were chosen based on availability of data and according to ES category; they are not comprehensive nor do they represent a consensus, other than that of the ES categories. Secondly, in regards to the scenarios, a binary, developed/non-developed land use change was assumed.

It is possible that some areas will deliver unanticipated ES once they are developed. For example, in the urban environment, city or neighborhood parks may still allow for a reasonable level of water infiltration. Further, urban outline plans may include parks and open spaces that will provide greater cultural values than will previously "undeveloped" land, thus contributing to urban sustainability though not necessarily as captured in ES assessment. Such analysis requires a finer scale of

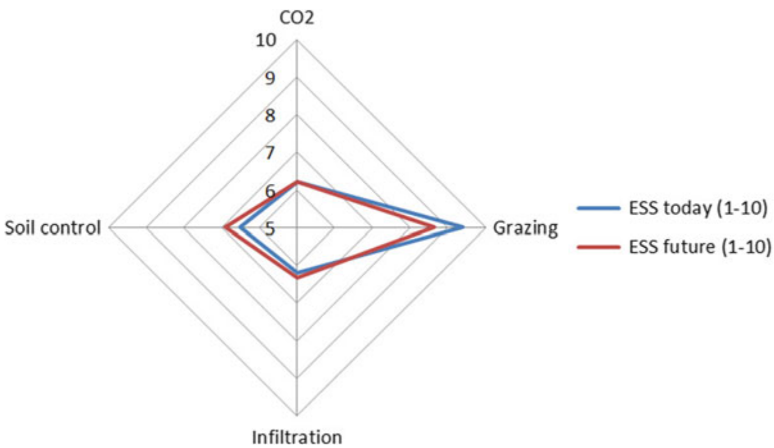

Fig. 3.8 This spider graph shows the expected effects of the Haifa District Plan on ES indicators of the terrestrial (landscape) unit. Values of one thru ten have been normalized. Such a graph was developed for each landscape unit: terrestrial, marine and coastal

information than that provided by the plans used. To conduct a full assessment of cultural values, all elements of the urban park would have to be considered. For example, an urban park may call for the construction of a paved amphitheater (without contributions to conservation) or, if designed differently, it could provide significant bird habitat, both contributing to urban sustainability, albeit in different ways.

Other limitations concern the use of various parameters such as slope, soil type and vegetation cover. As additive scoring is conducted it becomes complex and hard to follow. Having some type of automated system, or GIS application solely dedicated to conducting these analyses, would be helpful. Standards could be introduced for consistency and tracking. More research is needed in this area.

The assessment of ES loss based on approved plans served as the last step in the pilot, evidence that the change in ES can inform planning praxis and thus can contribute to sustainable development within the planning context. Ideally, the ES assessment should be done before plans have been approved and not afterward, as we did. We posit that the same or similar GIS layers of information can be used to assess change expected from future proposals or can be analyzed to identify the loss or gain in ES from different detailed plan alternatives.

3.8 Conclusions

Although the ES approach is just one tool, among many, to achieve nature conservation (Adams 2014), it is increasingly used to articulate the value of nature for humans. Integrating research on ES (of which there is no shortage) into the decision-making processes for sustainability planning remains a significant challenge to the ubiquitous use of ES assessment. This concern has been expressed widely by reports such as the Intergovernmental Platform for Biodiversity and Ecosystem Services (UNEP 2011), and by experts from the planning and conservation fields (e.g., Kareiva et al. 2011; Portman 2013; Adams 2014).

The use of advanced GIS mapping techniques and ES indicators are an important part of our analysis as are the use of production functions and scenario building based on urban and regional plans. The compilation of indices (function results) provides a ***relative*** estimation of ES to be lost through proposed development (scenarios). Scenarios can be formed from various sources: national master plans, approved district master plans and local-level detailed plans. These plan types show development intentions and can alert policy makers to potential (i.e., planned) losses in the ES that will impact sustainability. Furthermore, once the indicators have been chosen for each of the landscape units and comparisons can be made between them through normalization, trade-offs are apparent.

The contribution of this research pilot comes largely from the development of its methodology. Through it we: (1) illustrated the use of indicators for application of the ES assessment across land- and seascape units in urban, peri-urban and undeveloped areas; (2) developed maps that indicate ES values in three landscape units; and

(3) identified shortcoming in the method that can be improved upon for future use. Despite some limitations, we believe that this type of ES assessment methodology can make a significant contribution to sustainability planning and can provide the first steps for infusing ES values within the planning framework of Israel.

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