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Research Article

Contribution of integrated ecosystem services to urban planning tools: Can it be more functional for the sustainability of ecosystems?

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Abstract

The biodiversity of ecosystems and their services (ecosystem services - ESs) are declining worldwide due to decisions regarding land-use/land-cover (LULC). As a result, global risks related to climate change are exacerbating as these areas are needed to adapt to climate change and mitigate these risks. The integration of ESs into spatial decision-making is seen as an opportunity to ensure their sustainability. Despite the scientific and practical studies on this issue, it is stated that more studies are needed to clarify how ESs will be used in spatial decision-making. The proposed approach as Integrated ESs (IESs), which builds on the LULC assessment, has the potential to develop ESs-based spatial decision-making by enabling comprehensive approaches to be made. This paper aims to evaluate the results of IESs assessment incorporated with scenario analysis in the context of the integration of ESs into spatial decision-making, to discuss the contributions that this integration can make to the sustainability of ESs in light of these results and to provide straightforward suggestions on how ESs can be linked to the spatial planning tools in Istanbul. The findings of the research prove that ESs in many contexts are relevant to various stages of spatial planning and a spatial decision-making approach that incorporates ES knowledge can contribute to ensuring the sustainability of ESs and achieving sustainable development.

Keywords

Integrated ecosystem services (IESs), urban planning, land-use/land-cover (LULC), spatial decision-making, Istanbul

Introduction

Global climate change due to land-use/land-cover (LULC) decisions, the quality of life and well-being of approximately 3.2 billion people worldwide are negatively affected and biodiversity with ecosystem services (ESs) are lost to the extent of 10% of global annual gross domestic product in terms of economic value (IPBES 2018). The sustainability of human life is directly related to the continued provision of food, fresh water and energy and the observed global change in the LULC is driven by the exploitation of natural resources to meet these urgent and prioritised human needs at the expense of degraded environmental conditions or ESs (Foley et al. 2005). The need for these resources is also increasing in line with population growth and the degradation of ESs is projected to continue until 2050 and beyond due to the change in LULC according to global scenarios that do not involve a fundamental change (IPBES 2019). It is stated that "*healthy ecosystems are needed to achieve the Sustainable Development Goals and to address climate change*" as "*they can provide 37% of the mitigation needed to limit global temperature rise*" (UN - United Nations 2019). Therefore, the role of healthy ecosystems in combatting climate change, ensuring the sustainability of ESs that are essential for the continuity of human life and achieving sustainable development are understood and, in this context, the protection of integrated ecosystem services (IESs) areas, which represent the most functional areas in this sense, comes to the fore.

Land uses associated with various ESs, such as food, fibre and freshwater, provide basic needs for human well-being. At the same time, decisions on these land uses can also lead to the degradation of other ESs/ecosystems essential for providing different ESs, in which, in the long term, ESs cannot be sustained, and human well-being is jeopardised (Foley et al. 2005). The comprehensive approach to ESs, defined as the "Integrated ESs" (Tezer et al. 2018), which builds on the LULC-based ESs assessment (Burkhard et al. 2014), is developed to evaluate the integration of ESs into spatial decision-making better as the relevance of ESs to spatial decision-making has become apparent with several scientific studies (Onur and Tezer 2015, Tezer et al. 2018, Terzi et al. 2019, Grunewald et al. 2021, Başak et al. 2022, Wei and Zhan 2023). Despite the abundance of scientific studies on the integration of ESs into the spatial decision-making process, it is stated that there is still a gap between scientific knowledge and the practical use of ESs to support and guide spatial decision-making (Gray et al. 2022, Qiu et al. 2022, Longo et al. 2024). This study aims to contribute to this science-practice gap by clarifying the interrelationships between the ES knowledge and the spatial planning process and providing solid suggestions on how ES knowledge produced as IES potential can be implemented in Istanbul's high-level plans.

The spatial planning system has long been recognised as containing important mechanisms for environmental protection. It is also recognised that there are various opportunities for using environmental information in land-use decisions in spatial planning (Cowell and Lennon 2014). ESs stand out in defining the relationship between spatial use and environmental quality as they can serve as a tool that examines the nature-human interaction in a spatial dimension and they allow the interpretation of the impact or benefit of how the space is used (Menteşe 2018). With the ESs approach, the benefits that ecosystems provide to people and how they provide them can be revealed at different scales and multiple dimensions (quantitatively, spatially and temporally), the complex relationships between these benefits (ESs) can be revealed and the effects of interventions on ESs with land-use decisions can be understood in a multidimensional way. In this context, the utilisation of the information on the IESs has the potential to contribute to the sustainability of ESs and, thus, the narrative that "*ESs are the last hope for making environmental conservation a priority for planning*" may be borne out in practice (Portman 2013).

Although the relevance of ESs to spatial decision-making has been recognised (Grunewald et al. 2021) and there are studies on the extent of information on ESs and their use in different stages of spatial planning (McKenzie et al. 2014), there is a need for studies on how to integrate the information of ESs into spatial decision-making processes (de Groot et al. 2010, Grêt-Regamey et al. 2017, Wei and Zhan 2023). In Turkey, there is no legal obligation in laws or implementation norms regarding the integration of ESs into the spatial planning process and there are minimal examples of ESs being included at the implementation level. Besides, no study has yet been conducted to reveal how ESs can be related to spatial planning tools in Turkey. Therefore, this study aims to elucidate the potential for the integration of ESs into spatial decision-making process by analysing the change of the IES potential between the scenarios, which reflect different land-use decisions and are developed for the case of Istanbul and to provide explicit recommendations for the integration of ES information into the spatial decision-making process. The following research questions were addressed to elaborate the research objectives:

- How can an IESs approach contribute to spatial decision-making when incorporated with scenario analysis?
- To what extent do Turkey's existing policies, legislation and plans include ESs?
- How and in which dimensions can IESs be adopted and integrated into spatial planning tools in Turkey?

The content of the article will include:

1. the application of scenario analyses;
2. the generation of IES Potential Maps for each scenario;
3. the evaluation of the changes in the IES potential for each scenario quantitatively and spatially;
4. recommendations on integrating ESs to existing spatial planning tools in Istanbul (Fig. 1).

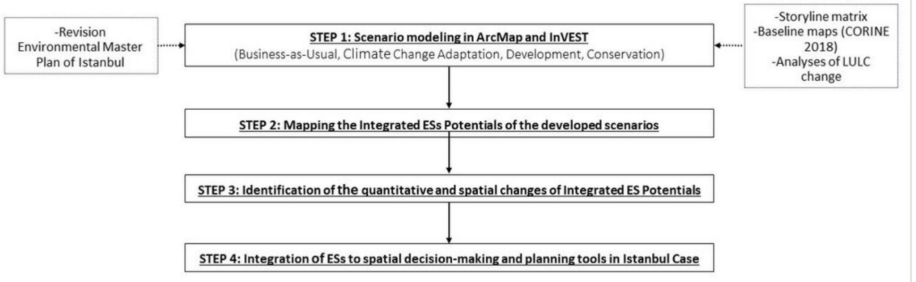

Figure 1.

Conceptual framework of the steps followed in the study.

Case study area: Istanbul

Istanbul is situated northwest of Turkey and has a unique location, lying on two continents and serving as a crossroads between the Marmara and Black Seas (Fig. 2). This unique geographic location provides the city with abundant natural resources, a diverse range of flora and fauna and a wealth of ESs (Özhatay et al. 2005, Güneralp et al. 2013, Gülersoy and Gökmen 2014). Istanbul holds the distinction of being the largest city in both Europe and Turkiye, with the highest population density and its rapid and uncommon land-use changes set it apart from other cities ((Gülersoy and Gökmen 2014, Menteşe and Tezer 2021).

Istanbul, being the financial focal point, attracts the largest share of national investments. This leads to significant changes in natural areas, such as forests, agricultural lands, pastures, coastal areas, wetlands and watersheds, which are critical for the sustainability of ESs. Analysing the effects of these land development interventions/different land-use decisions on the IES potential that the LULC of Istanbul offers is critical for the sustainability of ESs, mitigation of climate risks and achieving sustainable development in Istanbul.

Models and tools utilised in the methodology

The methodology proposed for the study consists of three steps:

1. scenario modelling;
2. IESs Mapping of each of the scenarios and
3. mapping the changes in the IES potentials for each of the scenarios.

For the first step, the baseline map used for the scenario modelling was developed from the open CORINE (Coordination of information on the environment land-cover (LC) data) (European Environment Agency 2019b) and it was prepared using the ArcMap 10.6.1 software. Three scenarios, namely, Business-as-Usual, Climate Change Adaptation and

Maximum Conservation, were modelled using the Scenario Generator Model of InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) Software Models (Sharp et al. 2020). The assumptions related to the LULC replacements, the maximum area size determined to be converted and the number of runs of the model are given in Suppl. material 1. For the Maximum Development Scenario, the Business-as-Usual Scenario LULC was updated with the Revision Environmental Master Plan of Istanbul in 2020 (Ministry of Environment, Urbanization and Climate Change 2020) promulgated by the Ministry of Environment, Urbanization and Climate Change. For the second step, an integrated approach developed by Tezer et al. (2018) has been applied to form the IES Potential Maps of the scenarios using the ArcMap 10.6.1 software. For the third step, the IES potential changes were assessed quantitatively and spatially using the ArcMap 10.6.1 software.

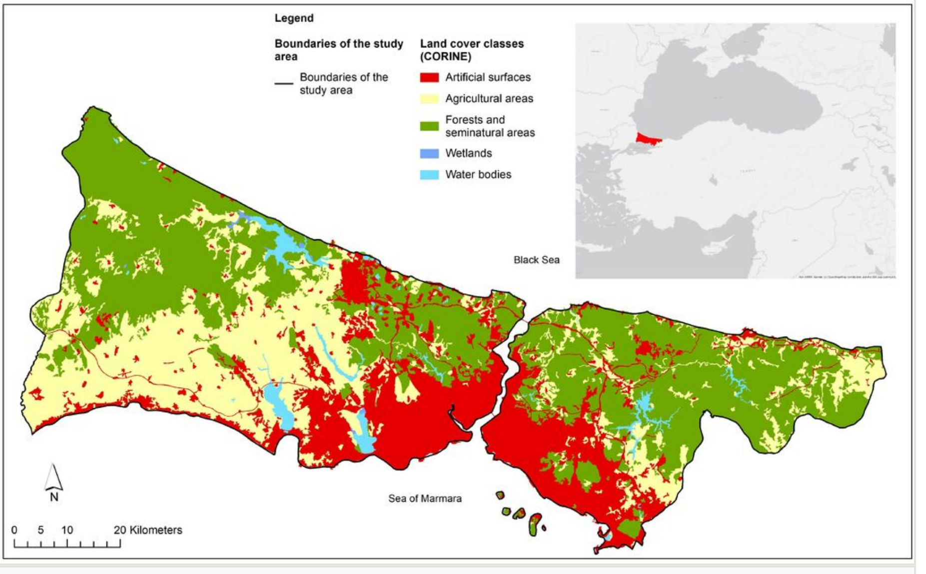

Figure 2.

Case study area Istanbul with LULC classes (European Environment Agency 2019b).

Scenario development

Scenario analysis is a commonly used method to test various visions and assumptions and the outputs potentially guide spatial decision-making (Sun et al. 2022). In this study, four different scenarios, namely Business-as-Usual, Climate Change Adaptation, Maximum Development and Maximum Conservation Scenarios were developed for this study to reflect the diversity of land-use decisions that determine the conservation-use balance of natural resources (Fig. 3). Each scenario is built on assumptions of LULC change (Suppl. material 1) grounded in perspectives of natural conservation and natural resource protection.

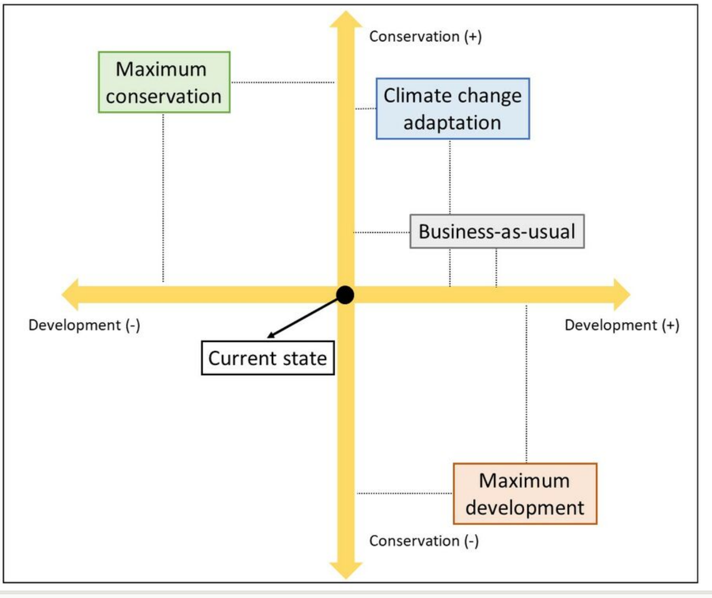

Figure 3.

The axes and variables of the scenario storylines (adapted from Onur and Tezer 2015, Harmáčková et al. 2016).

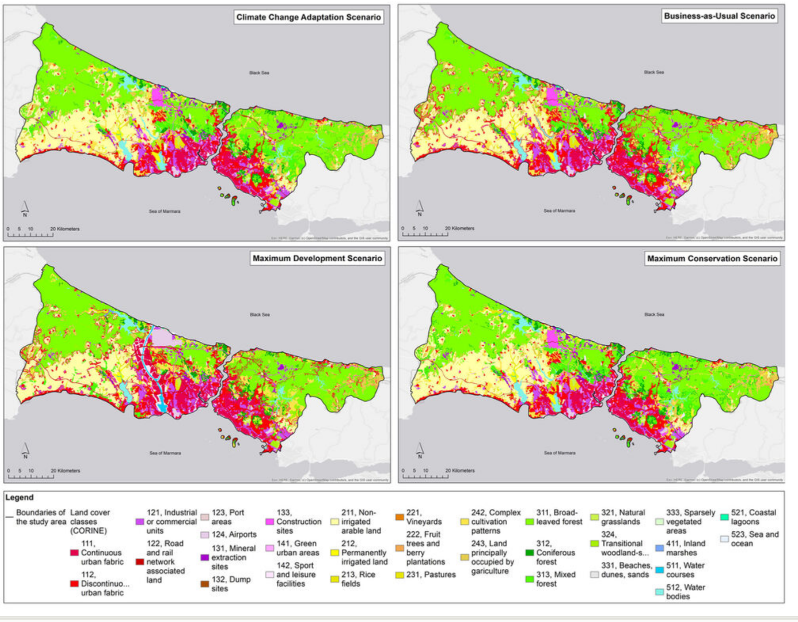

Figure 4.

Spatial scenarios of Istanbul.

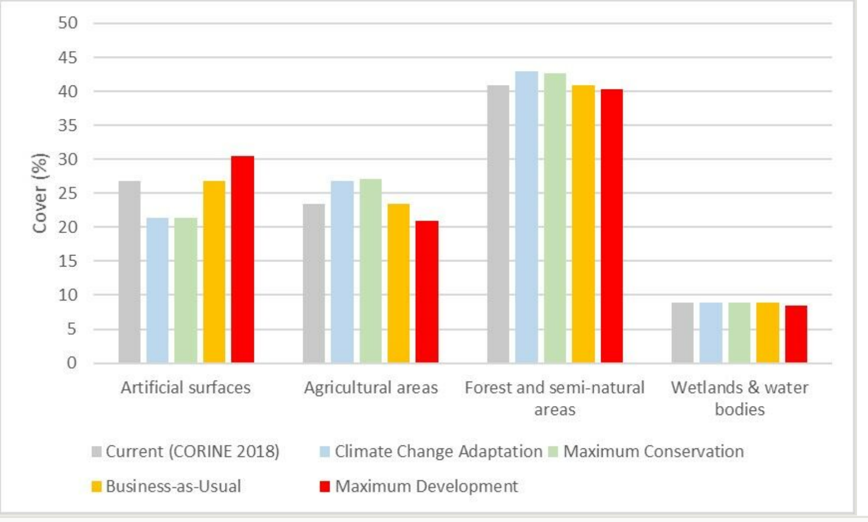

Figure 5.

LULC (%) in each scenario (wetlands and waterbodies are classified in one class as wetlands covering a relatively small area).

The Business-as-Usual Scenario assumes that the LULC change between 1990 (European Environment Agency 2019a) and 2018 (European Environment Agency 2019b) in Istanbul will continue. It involves expanding urbanised areas, population growth and rising demand for food, water and urbanised land, causing increased pressure on natural areas and resources.

The Climate Change Adaptation Scenario assumes that the population growth is moderate, while the expansion of urbanised areas is minimal. Protecting and rehabilitating natural areas are prioritised actions for climate change adaptation.

The Maximum Development Scenario assumes that the current LULC change trend continues, the mega-projects that have already been included in the Revision Environmental Master Plan of Istanbul have been implemented and the LULC change brought about by this implementation has taken place.

The Maximum Conservation Scenario assumes that Istanbul's population and urbanised areas will stabilise. Protection and rehabilitation of natural land are prioritised actions.

Integrated ecosystem services (IESs) assessment

The comprehensive approach “Integrated ES Potential” by Tezer et al. (2018) is proposed to better incorporate the ESs' approach into spatial decision-making and evaluate this integration. It is based on the matrix approach linking LULC classes to ES supply capacities, ranging from 0 for no potential, 1 for very low potential, 2 for low potential, 3 for medium potential, 4 for high potential and 5 for very high potential (Burkhard et al. 2014). In this integrated manner, all ESs are accepted as equal importance and the arithmetic mean value of the sum of the ES supply capacities was calculated to obtain the IES potential for the relevant LULC. The IES potential values calculated for the LULC classes of Istanbul and the classification are given in Table 1. High and very high IES potential areas depict the most functional areas for ensuring ES sustainability, thus, climate risk adaptation and sustainable development.

Table 1.

Calculated IES potential values and classes for the case study area (adapted from Burkhard et al. (2014), Tezer et al. (2018)).

Note: Scale from 0 to 0.47 = very low potential; 0.48 to 0.99 = low potential; 1.00 to 1.73 = medium potential; 1.74 to 3.09 = high potential; 3.10 to 3.23 = very high potential.

	CORINE LULC class	**IES potential**	**IES potential class**
1	Road and rail networks and associated land	0.06	Very low potential
2	Airports	0.06	
3	Construction sites	0.06	
4	Dump sites	0.10	
5	Industrial or commercial units	0.19	
6	Port areas	0.35	
7	Mineral extraction sites	0.35	
8	Continuous urban fabric	0.48	Low potential
9	Discontinuous urban fabric	0.52	
10	Sport and leisure facilities	0.52	
11	Sparsely vegetated areas	0.65	
12	Rice fields	0.77	
13	Vineyards	0.90	
14	Green urban areas	1.00	Medium potential
15	Beaches, dunes, sands	1.00	
16	Permanently irrigated areas	1.19	
17	Pastures	1.32	
18	Inland marshes	1.32	
19	Complex cultivation patterns	1.35	
20	Transitional woodland-shrub	1.39	
21	Non-irrigated arable land	1.48	
22	Fruit trees and berry plantations	1.55	
23	Coastal lagoons	1.74	High potential
24	Land principally occupied by agriculture, with significant areas of natural vegetation	1.84	
25	Natural grasslands	1.87	

	CORINE LULC class	IES potential	IES potential class
26	Watercourses	1.87	
27	Waterbodies	2.10	
28	Sea and ocean	2.26	
29	Coniferous forest	3.10	Very high potential
30	Broad-leaved forest	3.13	
31	Mixed forest	3.23	

Table 2.

Changes in IES potentials (in %) in each scenario compared to the current situation.

IES potential change / Scenario	Climate Change Adaptation	Maximum Development	Maximum Conservation	Business-as-Usual
	Change (%)	*Change (%)*	*Change (%)*	*Change (%)*
Increased IES potential	0.03	2.61	4.26	0.00
Decreased IES potential	0.00	14.16	0.00	6.05
No change	97.28	83.22	95.74	93.95

Results

This section gives the spatial results obtained as maps and quantitative results of the proposed methodology. First, the results related to scenario analysis are presented, followed by the results of the IESs assessments.

Spatial and quantitative changes of IESs

If the change of high and very high IES potential areas, which represent areas of critical importance for all scenarios, is analysed compared to the current situation, it can be seen that there is a sharp decrease in both high IES potential areas (-6.87%) and very high IES potential areas (-6.14%) in the Maximum Development Scenario. These critical areas are increasing in the Climate Change Adaptation Scenario. However, the sharp increase in these areas is in the Maximum Conservation Scenario, with an areal increase of 2.16% and 9.68% in high and very high IES potential areas, respectively. Very low and low IES potential areas are increasing for the Maximum Development Scenario and the Business-as-Usual Scenario. The areal changes in IES potential classes for each of the scenarios compared to the current situation are given in Table 3.

The IES Potential Maps for the scenarios are shown in Fig. 6. For the second step, the spatial changes related to the IES potentials are analysed using ArcMap 10.6.1. Green areas show that there is an increase in the IES potential, while red areas show that there is a decrease and the beige areas show that there is no change (Fig. 7).

Table 3.

IES potential change (in ha and %) in each scenario compared to the current situation.

IES potential class / Scenario	**Climate Change Adaptation**		**Maximum Development**		**Maximum Conservation**		**Business-as-Usual**	
	Change (ha)	*Change (%)*	*Change (ha)*	*Change (%)*	*Change (ha)*	*Change (%)*	*Change (ha)*	*Change (%)*
Very low potential	-1936.09	-4.04	15580.93	32.51	-2417.68	-5.04	10200.72	21.28
Low potential	948.41	1.30	33829.31	46.37	923.92	1.27	21041.71	28.84
Medium potential	-12333.86	-7.56	-32970.63	-20.20	-20420.78	-12.51	-26796.80	-16.42
High potential	-1615.36	-3.49	-3175.85	-6.87	998.87	2.16	-106.07	-0.23
Very high potential	14936.90	6.92	-13263.76	-6.14	20915.67	9.68	-4339.56	-2.01

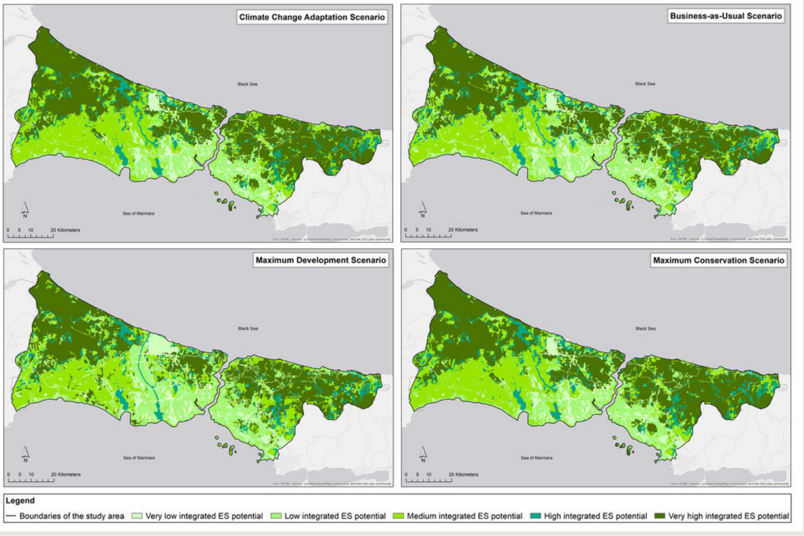

Figure 6.

IES potential maps of the scenarios.

The significant decrease in the high and very high IES potential areas calculated for the Maximum Development Scenario quantitatively is noticeable, especially in the area where the Canal Istanbul is planned to be constructed (Ministry of Environment, Urbanization and Climate Change 2020). For the areas with increases, decreases and no change in the IES potentials, the changes are given in Table 2 as percentages.

Scenario development

The LULC maps modelled with the Scenario Generator Model (Sharp et al. 2020) are visualised in ArcMap 10.6.1. They are given in Fig. 4. Compared to the current situation

(CORINE 2018 LC data from European Environment Agency (2019b)), the artificial surfaces have increased (from 26.82% to 30.46%) only in the Maximum Development Scenario, where agricultural areas (from 23.39% to 20.87%), forests and semi-natural areas (from 40.96% to 40.29%) and waterbodies and wetlands (from 8.83% to 8.38%) show decrease. The most significant increase in agricultural areas is in the Maximum Conservation Scenario (23.39% to 27.11%). For forests and semi-natural areas, the most significant increase is also in the Maximum Conservation Scenario (40.96% to 42.61%). In the Climate Change Adaptation Scenario, agricultural areas (23.39% to 26.83%) and forests and semi-natural areas (40.96% to 42.89%) increase like the Maximum Conservation Scenario. The comparison of LULC areas of each scenario is shown in Fig. 5.

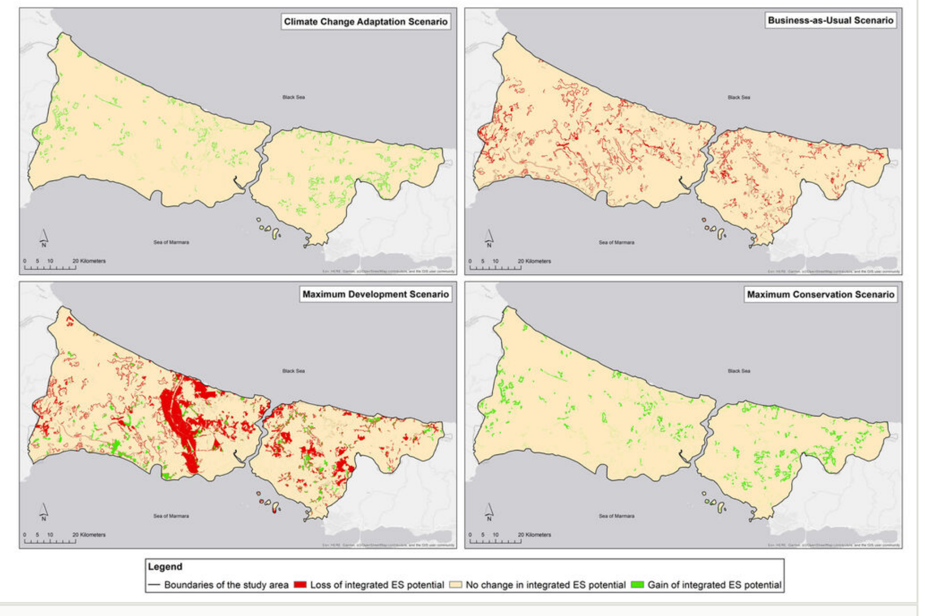

Figure 7.

Maps showing the changes in IES potentials of the scenarios (Red = loss of IES potential; green = gain of IES potential; beige = no change in IES potential).

Findings and discussion

In this study, four different scenarios, reflecting different perspectives and approaches to conservation and development, are first developed to see the spatial consequences of these different land developments on LULC. The scenario analysis reveals that the development-driven scenarios favour built-up areas by decreasing natural areas. On the other hand, in conservation-driven scenarios, agricultural areas, forests and semi-natural areas are more widespread than in the current situation (Fig. 5). The central hypothesis of this study is that integrating the ESs concept into spatial decision-making via scenario analysis has the potential to contribute to ESs sustainability and, thus, sustainable development. To test this hypothesis, an integrated approach developed as “Integrated ES Potential”, based on the matrix (Burkhard et al. 2014) by Tezer et al. (2018), is applied to the four developed scenarios, namely Climate Change Adaptation, Business-as-Usual, Maximum Development and Maximum Conservation. The results show that, in the Business-as-Usual and Maximum Development Scenarios (Development-driven scenarios), high and very high IES potential areas are traded-off to low and very low IES potential areas. On the other hand, in the Maximum Conservation and Climate Change Adaptation Scenarios (Conservation-driven scenarios), low and very low IES potential areas are transformed into high/very high IES potential areas.

The results obtained as the IES Potential Maps have the capacity to guide spatial planning by showing the impacts of different land-use decisions. The mapping approach also enables the evaluation of the consequences of various land-use decisions in terms of IES potential change compared to the current situation. The proposed methodology makes it possible to interpret the consequences of different spatial decisions as impacts on IES potential. These results make it clear that the ESs concept is closely related to spatial decision-making. Accordingly, the following section provides suggestions and recommendations on how the proposed methodology can be integrated into spatial planning tools in Turkey and Istanbul.

Evaluation of the existing policies, legislation and spatial plans in Turkiye and Istanbul in the ESs context

In developing recommendations for integrating ESs into spatial planning tools in Istanbul, firstly, the extent to which existing policies, regulations and plans in Turkiye incorporate ESs' approach is analysed.

The ESs' approach is incorporated in several sectoral policies at different utilisation levels in Turkiye. As summarised by Başak et al. (2022), the content of these incorporations involves generating general targets related to the identification, protection, monitoring and evaluation of ESs (Başak et al. 2022). However, it is stated that, without the necessary methodological framework for integrating ESs, putting these targets into practice is unlikely. The National Watershed Management Strategy, like these summarised sectoral policies (Başak et al. 2022), includes the determination of various objectives for ESs. Although it does not constitute a legal obligation, it has the quality of guiding the implementation. In Turkiye, it can be seen that ESs are implemented in two special provision determination projects, namely the Büyükçekmece Dam Lake Watershed and the Melen Dam Lake Watershed Special Provision Determination Project. The legal basis for these projects is the “Regulation on the Protection of Drinking-Irrigation Water Basins”. Even though integrating ESs with spatial plans is not obligatory according to this legal tool, the integration was supported by the related ministries or local-level governmental institutions (TUBITAK-MAM) (Grunewald et al. 2021). In both of these projects, ES information is used in the determination of the protection zone with the mapping of the critical areas in terms of water-related ESs and these areas are shown in the final map regarding the protection areas of the watersheds (Ministry of Agriculture and Forestry 2019, Ministry of Agriculture and Forestry n.d.). In watersheds where watershed protection plans are prepared, the national regulations are invalid and there is a legal obligation to implement the finalised watershed protection plans by the governorship. Therefore, it can be said that ESs have found a place in practice for Melen and Büyükçekmece Dam Lake Watersheds in Turkiye (Ministry of Agriculture and Forestry 2019, Ministry of Agriculture and Forestry n.d.).

In addition to watershed protection plans, the ESs' approach finds its place in the definitions of functional planning as well, in a concrete form and in a way that can be used in practice (Ülgen et al. 2020). “The Principles and Procedures for the Preparation of Ecosystem-based Functional Forest Management Plans” Communique was published in 2017 by the General Directorate of Forestry (General Directorate of Forestry 2017). In the Communique, ESs are expressed as ecosystem functions and only forest ESs are covered and evaluated in three classes: economic, ecologic and socio-cultural. Under these classes, relevant ESs are identified (Quality and speciality wood production, plant products, gene protection, flood prevention, drinking water supply, aesthetic appearance, education, research etc.).

Başak et al. (2022) state that implementing the targets set in sectoral policies also requires political will, institutional rearrangement and capacity building. Therefore, when the environmental master plans are evaluated in terms of ESs incorporation, it was observed that no direct information related to ESs was used. However, the current Environmental Master Plan of Istanbul (2009) indirectly includes ESs in the plan report (Istanbul Metropolitan Municipality 2009). The Plan Systematics Section states that, when making land-use decisions related to new settlements, only minor damage should be given to the natural environment, while providing benefits from nature to these settlements. In the sections related to forestry, forest ESs are referred to as forest functions and the ESs that benefit the public and villagers are defined. In addition, within the scope of Istanbul’s Natural Structure Synthesis, data on Critical Soil Resources for the Sustainability of Water Purification have been produced and mapped (Istanbul Metropolitan Municipality 2009).

In addition to these, in Turkiye, The National Spatial Strategy Plan is still being prepared and the projects related to the development of this plan involve an ESs-based conservation approach (Ministry of Environment, Urbanization and Climate Change 2020, Ministry of Environment and Urbanization 2021a, Ministry of Environment and Urbanization 2021b). The legal basis for The National Spatial Strategy Plan is the “Regulation on Spatial Plan Making” and The National Spatial Strategy Plan hierarchically precedes the environmental master plans. Three reports are published within the scope of The National Spatial Strategy Plan, namely The Strategic Environmental Assessment Scoping Report, the Draft Strategic Environmental Assessment Report and the Draft Strategic Environmental Assessment Report Annex. Examining these reports shows that ESs are directly covered in all three reports. It is observed that the reports include information on ESs in many dimensions. ESs are used strategically as a component in determining the conservation approach. In addition, ESs are used practically and the critical areas in terms of IESs are mapped nationwide. The areas critical for climate change adaptation are evaluated in light of the IESs approach. In addition, indicators, such as critical areas in terms of IESs per capita and critical areas in terms of climate change adaptation per capita, are also identified and calculated. The National Spatial Strategy Plan is being prepared, so Turkiye has not yet planned to guide the environmental master plans.

Recommendations on how can ESs be linked with spatial planning tools in Istanbul

ESs approach provides a framework to define and conceptualise the interconnections of nature and human well-being. It is also considered an essential common language amongst stakeholders, decision-makers from different sectors or actors from different spatial units with conflicts of interests (Hauck et al. 2013). The ES research community recognised three modes of ES knowledge use to be employed in different planning stages, namely conceptual, instrumental and strategic use (McKenzie et al. 2014, Grunewald et al. 2021, Wei and Zhan 2023). Conceptual use involves conveying the importance of nature to society from the perspective of ESs. In comparison, strategic use involves advocating for specific actions, policies or resolutions to address stakeholder issues and conflicts. Instrumental use refers to scientists using technical tools to assist decision-makers in selecting the best policy options and intervention ways (Wei and Zhan 2023) (Fig. 8).

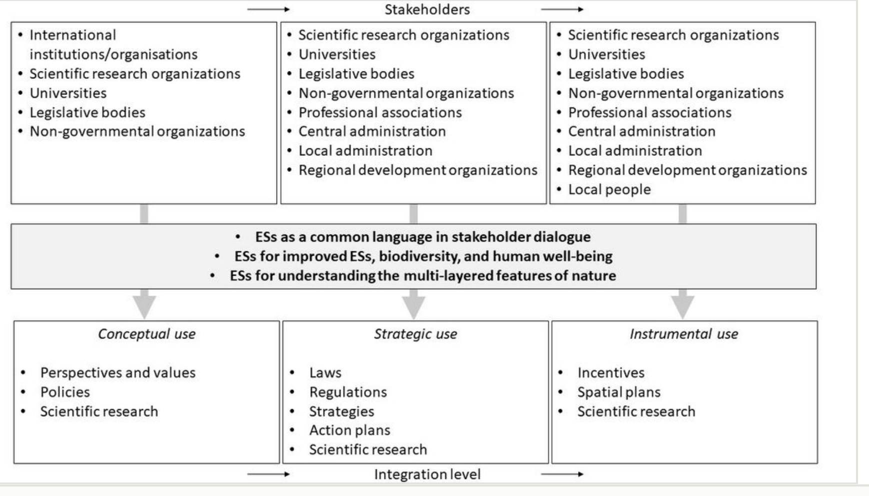

Figure 8.

Conceptual framework of ES knowledge use in different stages of the planning process (adapted from McKenzie et al. (2014)).

ES information produced through these defined three modes (conceptual, strategic and instrumental) can be linked to many stages of spatial planning (Fig. 9). ESs can be used conceptually in all the stages of the spatial planning process involving stakeholder participation by providing a way to communicate the importance of nature to people, the global common risks/local hazards and risks and providing a common language in stakeholder dialogue where the stakeholders have conflicts of interests. It can provide new ways of thinking and facilitate the generation of new ideas (Wei and Zhan 2023).

Strategies, goals and objectives involving environmental conservation, rehabilitation, human well-being and sustainable development can be set and shaped, based on ESs so that ESs can be used strategically in spatial planning. The instrumental use of ESs is closely related to more phases of spatial planning. ES information can guide the development of plan alternatives and ESs-based information can be produced afterwards. An approach, such as IES, as used in this study, can enhance the spatial and quantitative ES information mentioned above. It also can help to reveal the potential consequences of the alternative plans in terms of ESs, for which ESs trade-off/synergy analysis or the evaluations based on the IES potentials can be used in this way. This qualitative and spatial information can also facilitate the communication of potential consequences to decision-makers. The generated ES information can be utilised in conceptual, strategic and instrumental modes and can be linked to many spatial planning stages (Fig. 9). Thus, ESs-based spatial decision-making can sustain ESs and ensure sustainable development with improved human well-being.

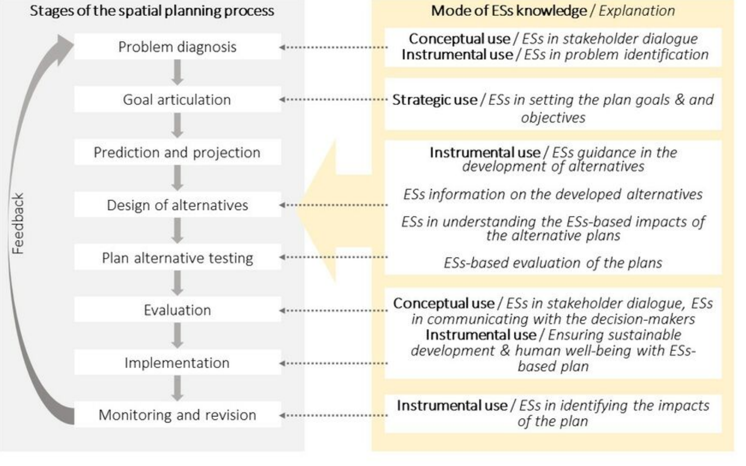

Figure 9.

Integration of ESs into spatial planning (adapted from Baer (1997), McKenzie et al. (2014), Wei and Zhan (2023)).

In light of the Istanbul case study findings and the theoretical information related to integrating ESs into spatial decision-making, recommendations are developed for integrating ESs into spatial planning tools in Istanbul. These recommendations include high-level plans (Regional Plan and Environmental Master Plan).

The Regional Plan of Istanbul is "*the setter of the socio-economic development trends, development potential, priority intervention areas and sectoral targets of the Istanbul Region. It aims to ensure sustainability and effective and appropriate use of resources. The Plan will determine the relationship between the plans, policies and strategies produced at the national level to ensure the Istanbul Region's socio-economic development". "The Regional Plan is a top-scale plan that also guides the strategic plans to be prepared by* *public institutions, especially local governments*" (Istanbul Development Agency In press). ESs can be incorporated into the plan since "*the sustainability, effective and appropriate use of resources*" is defined as an aim in the general definition of the plan. ESs can also be used as a facilitator within the scope of plan preparation studies.

Within the scope of the Regional Plan preparation studies:

- Preliminary policy and strategy studies can involve ESs regarding the setting of the policies and strategies.
- Evaluation of the previous regional plan can include ESs-based evaluations to assess progress. ES indicators can be set to be monitored. The change in IES potential can be monitored.
- Current situation analysis can involve ESs-based assessments for the evaluation of Istanbul's current environmental situation. The IESs' approach can be used in this analysis.
- ESs can provide a common language amongst the stakeholders in the thematic meetings, meetings with institutions and provincial meetings. It can facilitate the communication of ESs to stakeholders regarding environment-related strategies.

Within the Regional Plan:

- The strategies related to the environment can involve ESs. One of the four visions of the current Regional Plan of Istanbul 2024-2028 (Istanbul Development Agency 2022) is Green Transformation and Target 2.2 is set as "*The city's natural resources will be protected and sustainable resource management will be ensured for their efficient use*". This target can be improved with ESs, as ESs can be used as a layer to identify sensitive areas that need to be protected. It can also be used to raise public awareness about conservation.
- The generation of the Istanbul Spatial Development Map can involve ESs as a layer to indicate critically significant areas.
- The evaluation of the plan can involve ESs in the related strategies and targets. Within Target 2.2 of the Regional Plan of Istanbul 2024-2028 (Istanbul Development Agency 2022), one of the performance indicators can be set as ESs-based, for example, the Ratio of Critically Significant ES Areas (The ratio of the sum of the high and very high IES capacity areas to the whole area of Istanbul, in percentage). Another indicator can be set as the Critically Significant ES Area, based on the IES potential per capita (the Ratio of the sum of the high and very high IES potential areas to the number of inhabitants in m^2/person).

Istanbul's Environmental Master Plan can cover ESs in several sections. In the current Environmental Master Plan of Istanbul (Istanbul Metropolitan Municipality 2009), the central conflict is defined between economy and ecology and the central philosophy of the plan is "*resolving the conflicts between the natural and built-up environment".* In this context, as ESs provide a framework for the relationship between humans and nature, they can be used at many stages of the plan to help address these conflicts.

Within the Plan Systematics:

- ESs can be used to define conflicts. The ESs framework involves concepts like the potential of ES and the demand for ES (Burkhard et al. 2014). These concepts can help to understand and identify these conflicts. This work may require an ESs' assessment specific to Istanbul made at the provincial scale. However, matrix-based approaches can be used as a first step (Burkhard et al. 2014, Jacobs et al. 2015, Burkhard and Maes 2017, Campagne and Roche 2018) as they are easy to understand and implement.

Within the Natural Structure Section:

- ESs can be used within the scope of the Ecological and Biological Structure Sub-Section. Modelling and mapping approaches can also be used here to assess and map the ESs of Istanbul. Critical ESs in terms of vulnerability, sustaining water quality or adaptation to climate change can be defined and mapped.
- The Section of Forest Areas can involve ESs, as forest areas can provide multi-layers, even for the most diverse ESs.
- The Section Agricultural Areas can also incorporate ESs as many provisioning ESs related to agriculture are classified (Crops, fodder, fibre, biomass for energy etc.).
- An analysis of urbanised areas intersecting with critical ES areas can enhance the section on the Residential Areas and Quality of Life.

Within the SWOT Analysis Section:

- ESs can enhance the SWOT Analysis because Istanbul's ESs-based strengths, weaknesses, opportunities and threats can be defined in light of the definitions, quantification, analyses and assessments made in the previous sections.

Within the Synthesis Section:

- ESs can be used as a layer of spatial information in the Natural Threshold Synthesis. They can be used to identify the areas of protection and to define the degree of protection.
- A map of Istanbul's green-blue network can be created with ES information for the Spatial Sustainability Synthesis.
- The spatial information related to the critical ESs can enhance the Natural Structure Tolerance Rating Map.
- By incorporating IESs in Natural Threshold Synthesis, Spatial Sustainability Synthesis and the Natural Structure Tolerance Rating, ESs-based Natural Structure Synthesis can be obtained.

Within the Planning Approach Section:

- ESs can enhance the Targets and Strategies Section. ESs-based strategies can be set within the scope of environment-related targets (e.g. protection of critical ES areas).

Within the Plan Decisions Section:

- ESs-based identification of protection areas can be made in the Protection Areas for Environmental Sustainability Section as in(?) the proposed IESs.

In this way, the decision-making process related to Istanbul's Environmental Master Plan can be enhanced by integrating ESs to improve well-being and achieve sustainable development.

Conclusions

This study evaluates the integration and contribution of the ESs concept to spatial decision-making. The comprehensive approach, defined as the IES potential, combines scenario analysis for the case study area Istanbul. The IES potentials of Istanbul for each of the developed scenarios are evaluated and the change is assessed compared to the current situation, both quantitatively and spatially, to see the consequences of different land-use decisions and make an overall spatial assessment.

The results show significant decreases in very high and high IES potential areas in the Maximum Development and Business-as-Usual Scenarios, while these areas are increasing in the Maximum Conservation and Climate Change Adaptation Scenarios. This assessment showed that the ESs concept combined with the scenario analysis can contribute to spatial decision-making by providing a quantitative, qualitative and spatial understanding of the impacts of different land-use decisions in the context of ESs. The methodology incorporating the IES potential with scenario analysis reveals results that indicate the effects of different land development decisions on IESs, supporting the hypothesis that the utilisation of ESs in spatial planning can contribute to sustainable development by helping to achieve Cities and Communities (Goal 11) and Life on Land Goals (Goal 15). IESs integrated decision-making also helps to sustain ecosystems' health, which is related to Climate Action Goal (Goal 13) as stated by UN - United Nations (2019).

In addition, an evaluation related to the inclusion of ESs in current policies, legislation and land-use plans in Turkiye is made to develop explicit recommendations for integrating ESs into spatial planning tools in Istanbul. The inclusion of ESs is common in legislation in Turkiye. However, in implementation, ESs are incorporated only in Watershed Protection Plans developed for Büyükçekmece and Melen Reservoir Watersheds (incorporated directly as ESs) and Forest Management Plans (incorporated indirectly as functions).

The ESs' concept enables different modes of knowledge production to be utilised in different spatial decision-making stages: conceptual, strategic and instrumental. This study developed recommendations for the association of these modes of use and the stages of spatial decision-making. As a further step, suggestions for using ESs in Istanbul’s high-level plans, which are considered the Regional Plan and the Environmental Master Plan, are developed to clarify the potential linkages between ESs and the content of the plans. The concept of ESs is highly relevant to both plans as ensuring sustainability and analysing the conflicts between nature and humans in the economy-ecology opposition are defined as the main aims of the plans. The involvement of ESs in high-level plans can contribute to sustaining the health of ecosystems and ESs, improving human well-being and achieving sustainable development.

Further research is required as this study has limitations regarding the consideration of only the potential side of ESs, lack of prioritisation with stakeholder considerations and the detail level of LULC data used. The first limitation of the study is that, although the CORINE LC data (European Environment Agency 2019b) used in this study contained limited detail, it facilitated the testing of the basic approach of the research. However, a more comprehensive approach with more location-specific information on ESs (such as forest management data) would support more realistic results. The second limitation of the existing research framework of the study is that the assessment was made on the IES potential value calculated, based on the ES potential, which is defined as "*the hypothetical maximum yield of selected ESs*" (Burkhard et al. 2014). Research shows that studies on ESs commonly focus on ES potential (Wang et al. 2022), which constitutes the supply part of ESs and can also be expressed as the capacity of the natural structure to provide benefits to humans, but studies that consider ESs holistically and include ES demand with ES flows, which refer to the *de facto* used ESs (Burkhard et al. 2014) may facilitate better management and achievement of the sustainability of ESs. The IESs approach, developed within the framework of this study, assumed that all the ESs are of equal importance, which may have another limitation, but may also have practical advantages. The approach can be facilitated in practice, while it would be useful to develop the approach to identify sensitivities in terms of different ecosystems and the critical ESs they present. For example, in Turkiye, within the scope of the project "Developing Integrated Watershed Management Plans Based on Ecosystem Services in Ömerli Basin" (Istanbul Development Agency 2015), stakeholder workshops were conducted to prioritise the ESs of the study area. The ES areas vulnerable to climate change and urbanisation in the Ömerli Basin were identified, based on the views of relevant actors within the scope of the stakeholder workshop. If the ESs were weighted and IES potential of Istanbul was calculated in line with the prioritisation of ESs in this study, the areas that actors perceive as critical would differ from those considered critical in the current assessment. The main objective of this study is to highlight the contribution that incorporating ESs into spatial decision-making can make by underlining the role of spatial planning as a generator of land-use decisions and, thus, a driver of LULC change. However, since ESs, by definition, represent the benefits that humans derive from ecosystems, it would be preferable to determine the importance levels of ESs by incorporating the user dimension as stakeholders in the evaluations, both in terms of addressing ESs holistically with nature and human aspects and in terms of achieving the success of the plan by the adoption of the plans by all stakeholders. For example, in their study, Sohel et al. (2015) selected ten local experts for the mapping assessment, based on the matrix approach for Lawachara National Park (Sohel et al. 2015). Besides the prioritisation of ESs, stakeholders can be involved in the scenario analysis step for participatory scenario planning to improve the process (Palomo et al. 2011, Malinga et al. 2013, Plieninger et al. 2013). Improvement of this integration framework with further studies in line with these research avenues can better guide the use of ESs in spatial decision-making.

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Author contributions

Conceptualisation: Zeynep Türkay, Azime Tezer; Methodology: Zeynep Türkay, Azime Tezer; Formal analysis and investigation: Zeynep Türkay; Writing – original draft preparation: Zeynep Türkay; Writing and editing: Zeynep Türkay, Azime Tezer; Funding acquisition: Azime Tezer; Resources: Zeynep Türkay, Azime Tezer; Supervision: Azime Tezer; Project administration: Azime Tezer.

Conflicts of interest

The authors have declared that no competing interests exist.

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Supplementary material

Suppl. material 1: Land-use/land-cover replacements, the maximum area size determined to be converted and number of runs of the Scenario Generator Model
doi

Authors: Zeynep Türkay, Azime Tezer
Data type: Modelling data
Brief description: The assumptions of land-use/land-cover replacements, the maximum size determined to be coverted and the number of runs of the Climate Change Adaptation, Maximum Conservation and Business-as-Usual Scenarios.
Download file (55.77 kb)