Practical framework for cultural ecosystem service in urban landscape design

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Abstract

The cultural ecosystem service (CES) has been rarely expressed in the area of urban landscape and design. This study tries to find a framework to apply the CES usage in the literature of landscape design. The results show that most indicators have expanded in the areas of “landscape elements” followed by the “ecological infrastructures.” In addition, the aesthetic indicators in the biological aspect have been mainly focused on plants; moreover, birds have been more considered than the other species. Other findings indicate that, in addition to the existing proceedings, the link with the sustainable development objectives, the effects of the drivers for change and the ecosystem’s improper services' indicators are factors that should be considered in the area of landscape design in a framework of ecosystem cultural services.

Keywords

Cultural Ecosystem Services (CES), Urban Ecosystems, environmental interventions, indicators, aesthetics

Introduction

The users and planners developed the concept of ecosystem services in order to create a platform, based on the market demand and society’s values for sustainable use of the natural resources (Pröpper and Haupts 2014). The Millennium Ecosystem Assessment (MEA) has divided the ecosystem services into four main categories of provisioning services, regulating services, cultural services and supporting services. Amongst the existing categories, the cultural services are known as non-material benefits which are acquired by the people through the ecosystem's spiritual enrichment, cognitive development, leisure and aesthetic experiences (Reid et al. 2005). Cultural services are the most effective ecosystem services for the beneficiaries' awareness of appreciating

nature (Andersson et al. 2015) which leads to the connection between nature and people in socio-ecological systems through the provision of intangible values (Balázsi et al. 2021).

Conceptualising and operationalising the CES is very complicated (Gould and Lincoln 2017). In other words, lack of sufficient information and analysis about these services makes it difficult to consider this concept in the landscape management policies and methods (Kosanic and Petzold 2020). Additionally, there are practical challenges in transferring the CES into the landscape design (Cheng et al. 2021) and, when it is about measuring and operationalising these services, there is no conceptual clarity. Since the urban environments are places with a high density of cultural services (La Rosa et al. 2016), the management of the urban ecosystems has necessitated the use of CES to step towards the creation of sustainable cities (Berghöfer et al. 2011) in a way that the natural environment values can be identified and specific recommendations for the purpose of planning can be suggested (Kabisch 2015).

Based on the conducted studies of Haase et al. (2014), on the area of urban ecosystem services (during the 1973-2012 period), it can be inferred that, in most studies, the relationship between the research and planning has been limited in policy-making. Moreover, when statements are made about the way they should be implemented, the precise argumentation about it, which explains under which conditions this approach can be implemented, is not being provided. This, in turn, can be recognised as the existing gap between theoretical discussions in the area of urban ecosystem services planning and their implementation in design which can be observable. The economics of the ecosystem and biodiversity (Berghöfer et al. 2011) are suggesting an approach for the use of ecosystem services in decision-making and policy of the urban management. In fact, this approach, explains six different stages: determination of the problem or issue of policy-making, determination of the ecosystem services with the maximum relevance to the problem in order to assist solving it through raising questions about the existing problem and then prioritising the services, specifying the needed information and assessment methods, evaluation of the (future changes) of the ecosystem services, identification and evaluation of the management/policy options and evaluation of the effects of policy-making options on the stakeholders' side. In addition, the interaction between the stakeholders in all six stages has been emphasised. In the study by Ahern et al. (2014), a framework for adaptive urban planning and design was represented, based on a scientific approach, experimental design and a set of predetermined ecosystem services indicators and criteria have also been provided. This framework includes six steps: definition of the urban ecosystem objectives which are relevant to the specific plan, prioritisation of the urban ecosystem services goals and consideration for the exchanges and alternatives, experiment design, specifying the indicators and criteria for measurement of the objectives, evaluation and supervision of the results with the use of the indicators and criteria and application of the findings. Participation of the factors such as the scientists, experts, stakeholders and policy-makers has also been under attention in their studies and it is expressed that, regarding the ungeneralisable nature of the research, this framework cannot be transferred. They

consider the presence of a common collection of the standard ecological criteria and indicators, transferrable, understandable, strong and defendable which are crucial for the development of the urban ecosystem services.

Cheng et al. (2021) suggested three cases with the purpose of transfering the concept of CES in landscape design with emphasis on the urban parks. Firstly, definition of the type of the park and its scale matters. Secondly, the data collection procedure to support the methods should be gathered and thirdly, development of the evaluation methods, toolboxes and practical guides are required in order to assist the designers. Tandarić et al. (2020) have provided a framework that is named the 5P which includes the five main factors of place, people, past, practices and purpose which the planners should consider for planning the CES in the cities.

In terms of the relationship between the man and the urban green space, Liu (2018) have provided six variables. These variables are included as the importance of the green spaces, green space facilitation, the distance between the visitors and the green space, the socioeconomic status of the visitors, the frequency of visits and the visitors' activities that are related to proceedings of urban ecosystem cultural services.

Additionally, Blicharska et al. (2017) have conducted research with the purpose of investigation of four components of the concept of ecosystem services which are mainly considered in the CES research. The provided concepts include: linkage of the CES to a specific ecosystem or elements of an ecosystem, identification of the human needs, determination of spatial scale and determination of temporal scale.

In a review study which was conducted by La Rosa et al. (2016) on the area of assessment of CES indicators that are being used in the urban planning processes, it is indicated that no indicators specifically have addressed the urban ECS. They have cited "ESID" (2012) in their study where,in the database of ECS indicators (that is created by the global sources), no indicators have been reported for both types of ecosystem "cultural" services and "urban" ecosystems. Additionally, Hernández-Morcillo et al. (2013) , in a review study on ECS indicators, have concluded that most indicators have flaws in terms of clarity in definitions, objectives and perception of the processes that should be measured.

De Groot et al. (2002) consider the ecosystem services to be valuable in the three categories of ecological, sociocultural and economic. Different studies have categorised the ECS indicators under different titles, based on their own requirements (Table 1). However, there is no common title that can be used in all studies and it is not clear on what basis the indicators` categorisation it can be done. Thus, based on a literature review, no clear and applied framework in the area of urban landscape design has been formerly performed in which the use of proceedings effective in the ECS and its relevant indicators has been provided.

Methods

Identification of the Effective Proceedings in ECS in the Urban Landscape Planning and Design

In order to identify the effective proceedings in the ECS in the area of urban planning and design and also based on the literature review, the current study has addressed existing theories and frameworks of the abovementioned field. Additionally, through the analysis of the previous and related literature, the effective proceedings in the ECS has been elaborated.

Framework of Urban Landscape Design by the Use of ECS

The applied approach in the urrent study is to develop the framework that can deal with the utilisation of the effective proceedings in the ECS and its relevant indicators in urban planning and design. This methodology has been taken from the study which was conducted by Sowińska-Świerkosz and García (2021). The economics of ecosystems and biodiversity (Berghöfer et al. 2011) implies three types of assessment: quantitative, qualitative and financial. In the current study also, the indicators are categorised, based on this basis that reflects the following cases:

1. Qualitative indicators: Describe the importance and level of ecosystem quality and show the connections amongst ecosystems and economic and social flows on a spatial scale;
2. Quantitative indicators: Showing the increase/decrease in the ecosystem services proceedings that are expected to be derived from a specific policy and
3. Financial indicators: The financial value of the selected ecosystem services or the value of increase/elimination of specific services under different scenarios (Heink and Kowarik 2010).

An indicator in the ecology and environmental planning is a component or amount of the phenomena which is related to the environment that is used for elaboration or assessment of the environmental conditions or changes or determination of the environmental objectives (Heink and Kowarik 2010).The policy-makers can adjust their decisions based on the evidence, identification and prioritisation of the interventions, the path of progress towards the objectives and be informed about timely corrective actions using these indicators (Layke 2009). Additionally, these indicators can assist in order to supervise, assess and report the progress of implementation of the policy and the distance to objectives (Van Reeth 2013). The indicators have been extracted from the studies which are mentioned in Figs 1, 2, 3, 4, 5, 6, 7, 9, 11, 12. Various studies have used these services under different titles in order to collect the indicators which are relevant to the aesthetic services. Therefore, titles such as “aesthetic services,” “aesthetic joy,” “aesthetic value” and “aesthetic perception of nature” are all included in this category. In addition, in some studies, it is discussions about the “functional traits” of living creatures in the ecosystem services (e.g. de Bello et al. 2010, Goodness et al. 2016) which have been considered as indicators in the current study. This is possible because the

relationship between the functional traits and ecosystem services can be developed as indicators for research and management (Goodness et al. 2016). It should be noted that the considered indicators should not necessarily be the urban landscape indicators, but they have been either related to the natural ecosystems, urban green space, plant species of urban green sites, non-native species, non-native trees, vascular plants, bird species and urban ecosystems and landscapes or could not be allocated to a specific ecosystem. Since all the green and blue spaces in urban regions are urban ecosystems, in the current study, they have been considered with this assumption of indicators that can be transferred to the urban landscapes.

Five assumptions were specified to be influential in developing the framework, based on the related literature in Table 2.

Results

Identification of the Proceedings Effective on ECS in the Urban Landscape Planning and Design

The results which are obtained from the analysis of the studies have led to the categorisation of the proceedings of the ECS into the following categories as shown in Fig. 8, each one of the categories having been investigated separately in Fig. 8,Table 2

1. Elements (Structure) of Landscape: The landscape is made of environmental elements, such as water, soil, creatures and climate (Sheybani and Motalebi 2015) and when there are discussions about the landscape elements or structure, the mentioned cases are included in this category. Basically, the ECS can be provided in different spatial scales, such as a single tree (Blicharska et al. 2017). The type, abundance and variety of landscape elements are all amongst the variables that determine the quality of providing ECS. The main bases of the ecosystem services have been adapted and the landscape ecological features with the model that is provided in this study which is entitled “The Landscape Design Model, Values and Elements of the Landscape” and have found design strategies to improve the landscape of the Sefidrood River (Taghvaei et al. 2018). Jamali and Mosler (2014) have also used a framework that involves the basics of the ecosystem services approach in order to dynamically design the river landscapes. This framework indicates the relationship between the landscape elements, cultural services and design elements. Additionally, Yang and Dobbie (2019) evaluated five types of water-sensitive urban landscape design elements with the purpose of increasing the provision of the ECS so that they would be able to design and manage these elements. They have concluded that the size and scale of the water-sensitive urban landscape design elements are amongst the determinant factors in the provision of the ECS in the multipurpose landscapes and the public perception.

2. Geological features: Geological features, such as slope and topography, are different from the landscape structure and are related to the geographical environment. Hence, it can be divided into a separate category with a landscape approach. Basically, linking the ECS to physical landscape features is considered an efficient way to create an abstract concept in designs (Cheng et al. 2021).
3. Time: The landscape is a dynamic and ever-changing phenomenon (Mansouri 2020) that affects the provision of the ECSs. For example, the future developments may lead to disappearing or emergence of some ECSs over time (Blicharska et al. 2017) and/or the seasons and characteristics of plant phenology change over time and are in line with the cultural services they provide, which also affects the perception of the audience.
4. History (Past): The landscape is the product of the community's interaction with history (Mansouri 2020). The rate of changes in the landscapes and uses is culturally and ecologically dependent on the flow of history/past or the quality of a landscape in the audience's mind with the changes that are made at present which can be derived from its quality in the past. If the use of history is carefully combined with the new function of the site, the new opportunities that are represented may assist us to produce many cultural benefits (Tandarić et al. 2020). For example, in a study by Jamali and Mosler (2014), the desired changes in the river landscapes have led to the creation of new identities and meanings in their function, structure and form over time. Thus, new definitions of the ECSs are required to support the citizens' welfare.
5. Accessibility: The rate of access or being close or far from (distance) the ECSs production source is amongst the effective proceedings. Accessibility can be examined from the physical, visual, auditory, olfactory and taste dimensions. For example, some studies have emphasised visual perception as a key factor in the determination of the vastness of the area in which the ECSs can be experienced by humans (Blicharska et al. 2017). On the other hand, the ECSs can rely on the functions, structures and processes of the ecosystem in a place, while they have been experienced somewhere else (Ibid). Xiao et al. (2017) have provided a framework that indicates to the audience the way of using specific cultural benefits even if he/she is not in the same place in which the cultural services are presented.
6. Distribution and Dispersion: The rate of dispersion or combination of the ECSs production sources is important because it leads to the increase or decrease in the presented benefits or, in another view, there are different spatial relationships between the services production context and the benefits of the context of the services (Fisher et al. 2009). The integration of different contexts is also influential in the final result of the audience's perception. The supply/demand patterns of the ECSs and their related proceedings can be used as a path for implementing inter-regional environmental management or, in other words, the landscape pattern can assist the provision of ecosystem services (Xiao et al. 2017).
7. Welfare Infrastructure: The presence of welfare infrastructures is amongst the factors that are effective in providing the ECSs. The number, quality and location are considered in the welfare infrastructure proceedings. As for instance, the

number of facilities or the degree of cleanliness of urban green spaces can act as welfare facilities in order to attract the audience (Liu 2018). Additionally, weighting the factors that are related to the place, such as the location of the elements and buffering the surrounding processes, can affect the occurrence and intensity of production of cultural ecosystem disservices (Tandarić et al. 2020).

8. The Ecological Infrastructures: The ecological infrastructures are made of the landscape's elements (structure). The urban ecological infrastructures play a basic role in the sustainable provision of the ecosystem services which are required by the citizens, such as leisure, educational and cultural needs (Li et al. 2017). As Taghvaei et al. (2018) have implied, the role of the leisure and cultural services in the improvement of urban rivers margins or multipurpose landscapes plays an important role in the provision of different benefits through ECSs for sustainable management of rainwater (Yang and Dobbie 2019). The integration of urban ecosystem services in urban planning is low; however, it is a promising progress in using innovative measures such as nature-based solutions (Romero-Duque et al. 2020). Therefore, it seems that the ecological infrastructures can be investigated as effective proceedings in providing the ECSs. Generally, the ECSs can be related to the biophysical environment through participatory mapping of specific places which are perceived as the providers of the ECS (Blicharska et al. 2017). As provided in the theoretical framework of the ECSs by Fish et al. (2016), the environmental spaces are mentioned that can include the places, regions and land and sea landscapes in which the people interact with each other and the natural environment. Moreover Burkhard mapping framework could be used to integrate related research regarding biotic characteristics (Burkhard et al. 2018).
9. Policy-making Options: Planning methods, landscape management budget and creating the necessary opportunities to provide cultural services can be considered variables related to policy-making options. For example, the active participation of the local authorities and experts is important because it would ensure that the urban green and blue spaces are properly distributed, planned and managed. They meet the needs of the urban population or not (Tandarić et al. 2020). It should be mentioned that the challenges of the urban green space management processes and how they are related to the area of the ecosystem services were investigated by Kabisch (2015). From another view, in a study that was conducted by Kandulu et al. (2014), it was revealed that a positive environmental effect has been made due to the water management in the provision of the ECSs which has been formerly investigated. Therefore, different investment options can play an important role in the effectiveness of the ECSs.
10. Dependent characteristics of the stakeholders: The demands and preferences of the stakeholders, characteristics such as age, socioeconomic status, the willingness to pay for the cultural services and the presence of the stakeholders that are introduced by indicators, such as the number of visitors, are amongst the proceedings on which the ECSs depend. Even if not clearly specified in the literature related to the ECSs, it is usually imagined that they are important for some people (Blicharska et al. 2017) since the use of urban green and blue spaces is highly influenced by the demographic characteristics of the users and

personal factors (Tandarić et al. 2020). The stakeholders' participation is important in the determination of the perception and planning related to the concept of ecosystem services (Berghöfer et al. 2011). For example, Yang and Dobbie (2019) have used the Importance-Satisfaction Analysis (ISA) of the ECSs for water-sensitive urban design elements in different areas that can be used by the landscape architects and water and soil managers and planners. It is also helpful in the development of these landscapes. The concept of the ECSs can be an efficient framework to know the visitor's perception and experiences (Ram and Smith 2019). However, these services might be evaluated quite differently by various people and under different socioeconomic conditions (Plieninger et al. 2015). This issue is amongst the challenges of landscape design and planning, especially in cities with a high density of stakeholders.

Framework of Landscape Design based on the ECSs

The framework which is provided includes three main stages: (1) Determination of the related goals and services, (2) The first stage of the solution selection and (3) Analysis of the primary solutions by the suggested questions as shown in Fig. 10.

Stage 1 plays the main role in the selection of the indicators. Meeting the existing challenge, the design scale and different dimensions of human welfare are the factors considered in this stage (e.g. the revitalisation project in the scale of River A to obtain the physical and psychological dimensions of the human welfare). Later, the main objective was determined, the specific objectives were separately divided into three categories as economic, ecological and socioeconomic valuation (the objectives may not be necessarily separable in all three categories). For example, the soft landscape increase (ecological dimension), the increase in interaction between man and the river (cultural dimension) and promotion of employment through the possibility of fishing (economic dimension). Determination and prioritisation of the challenge-related cultural services can be specified by policy-making plans or participation of the experts and stakeholders as shown in Fig. 10.

In stage two, the categorised specific objectives are filtered by the factors which are effective on the urban landscape planning in a way that the solutions that lack the desired requirements would be eliminated. These factors include the following: (1) Prioritisation of the interventions (Layke 2009) (e.g. regarding the urban management policies, development of the city gardens is a priority for the organisation), (2) Factors that are required for planning and management: (e.g. presence of the manpower and expert managers for advancement of the goals/presence of infrastructures, basic needs and infrastructure facilities (Hashemzadeh Ghalejough et al. 2020), (3) Technology and sciences: (e.g. the solution that is proposed leads to creation of new opportunities, transformation of the urban management system and affects the productivity and innovation) (Ibid), (4) Measures related to financing (availability of the financial credits) (Ibid) (e.g. the existing budget prefers the cost-effective solutions), (5) The environmental factors (Ibid) (e.g. the solution proposed is not consistent with the existing climate and

environmental problems) and (6) Demographic-social factors (Ibid) (e.g. the community's requirement of the time is the existence of walking trails).

In the third stage, first, the suggested questions have arisen, based on the proceedings effective on the ECSs to form the basis for the final solutions. Each concept covers two questions as shown in Fig. 13.

In the next step, the indicator selection should be considered in a way that it is related to the objectives of the "SMART" policy" (specified, measurable, accepted, realistic, time-specific) as the permanent link between the management and supervision of the policies advancement (Van Reeth 2013). The SMART objectives and/or indicators play an important role in results-based management or responsiveness. In addition, the indicators should be objectively approvable, i.e. various researchers should be able to obtain similar information while using the same indicator (Hernández-Morcillo et al. 2013). Additionally, the selected indicators should be scientifically meaningful and easily perceivable by the target audience and should have a correct and practical process that leads to quantitative measures (even if they are based on the qualitative data). In addition, there should be a short interval between the state and condition of the mentioned measures and the indicator's accessibility. In addition, the indicators should have the potential for supervising the changes and evaluating the progress over time, helping with the decision-making through being effective and cost-effective (Tratalos et al. 2016). The stakeholders' participation can also play an important role in the selection of the indicators.

The calculation of the indicators, as shown in Figs 1, 2, 3, 4, 5, 6, 7, 9, 11, 12, has not been amongst the objectives of the current study because the indicators that are listed in the figures have been selected from studies which have barely specified the assessment methods and have only been implicitly introduced, such as the indicators of: Qualitatively or quantitatively measurable indicators or mapping capability (Moshari et al. 2020), services mapping capability (Egoh et al. 2012), financial or non-financial indicators (Sánchez et al. 2020) or those used with no titles.

Finally, The solutions can be compared, based on the three valuation dimensions: economic, ecological and socio-cultural. This stage helps the policy-makers to categorise each solution according to valuation dimensions to show which ones are more likely to be explored, evaluated and implemented. It also facilitates planning to provide the necessary proceedings for implementing solutions Figs 1, 2, 3, 4, 5, 6, 7, 9, 11, 12.

Discussion and Conclusion

As there is lack of a specified exclusive framework with respect to the ECSs in the field of urban landscape design, this study aimed to propose a framework in order to represent a starting point to use the ECSs and the main proceedings in relation with this area, in a way that this concept is implemented with more precision in the practical planning. In addition, collecting indicators related to ECSs in total and classifying them in qualitative,

quantitative and financial data, provides a broader insight for awareness of the types of indicators which are available for these services. However, some assumptions about the framework have been made in previous studies (e.g. Ahern et al. 2014andBerghöfer et al. 2011), a comprehensive framework which is focused on the ECSs proceedings and indicators that were proposed. In this proposed framework, the landscape design has been considered in the solution selection stage since it was discovered that, based on the existing indicators, the information is flawed in the ECSs assessment methods. Therefore, the framework which is proposed by Ahern et al. (2014) is introduced in this study adaptively. However, due to the uncertainty, the indicators were not usable in the experimental plans and projects as they were small in terms of the spatial extent. Hence, the proposed framework in the current study is also not suitable for use in the post-implementation stage.

In terms of the indicators, on the other hand, the framework instructions indicate that most aesthetic indicators can be expanded in the area of "elements/structure of landscape" which are in the form of proceedings that are followed by the "Ecological infrastructures." Importantly, it shall be mentioned that, more expansion is required for the other proceedings. Generally, the qualitative and quantitative indicators include a major portion of the indicators and the financial indicators have not been developed in the area of the ECSs. The challenge of the economically limited valuation of the ECSs can also be met by the expansion of the financial indicators. In addition, the aesthetic indicators in the biological dimension are mostly focused on plants and, amongst the animals also, birds have been more focused than the other species. The accumulative results indicate that the indicators are usually expanded in the objective and the visual dimension and other dimensions of human senses include fewer indicators.

The results that are obtained from the current study indicate that the effective factors on the ECSs in the area of urban landscape planning and design include various other cases in addition to the main proceedings which are relevant to it and they need to be gathered under a common framework in future studies as shown in Fig. 14. As for instance, sustainable maintenance and use of ecosystems is a key factor in global sustainable development (Haase et al. 2014). The results that are obtained by Wood et al. (2018) indicate the role of the ECSs in achieving the goals of sustainable development. The assessment of the millennium ecosystem also has implied drivers for change and their interaction with the biodiversity, ecosystem services and human welfare in its theoretical framework (Reid et al. 2005). For example, climate change, pollution and change of land-use are amongst the direct drivers of change in the ECSs (Kosanic and Petzold 2020), In addition, the urban ecosystems not only produce ecosystem service but also can produce ecosystem disservices (Gómez-Baggethun and Barton 2013). These services can be perceived as material harm when the ecosystems or species create threats for people's livelihood, security or health or even they can be recognised as acts that cause immaterial harm when affecting the mental welfare and identity or induce aesthetic issues (Echeverri et al. 2019). These can be included as the invasive or native species that reduce aesthetic values (Lyytimäki 2015), but its characteristics have not been sufficiently developed in order to be used in this study.

Based on the gathered results in the current study and identification of the existing gaps in the field, the following suggestions are provided for enhancing further studies in the area of urban landscape design and planning, which are based on the ECSs:

1. Expansion and explanation of the assessment methods which are proportionate to the ESCs indicators in order to facilitate implementation of the framework in the practical projects.
2. Development of the ECSs indicators which are in line with the different dimensions of human senses and all environmental elements of the landscape.
3. Expansion and infusion of the main and effective factors of the ECSs in the urban landscape design framework as shown in Fig. 14.

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Author contributions

H.Sh wrote the manuscript, A.H carried out the review and contributed to the development of the research theme; moreover, A.H developed the concept and ideas and supervised the project.

Conflicts of interest

The authors have declared that no competing interests exist.

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Does the primary solution strengthen the link between cultural services and landscape elements?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Plant shape, Leaf shape, Plant growth form, Plant arrangement, Color (color of leaves, flowers, and fruits), Sound from the movement of trees in the wind, Scent from flowers and grass, Touch of plant elements, Quality or Edible characteristics of plants, Bird morphology (neck, eyes, tail), Birds color, Birds singing in the landscape, Birds and chirping birds in the landscape, Natural sounds such as fountain and birds chittering in the landscape, Singing of several species relative to one Specific species **b.** Cute or charismatic animals, Colorful flowers **c.** Beautiful song of birds **d.** Blooming or non-blooming plants, Tree canopy shape, Planting geometry **e.** Existence of plant life, Existence of water levels, Richness of species	**a.** Temperature **b.** Hardness of plants **c.** Plant size (overall plant size, width and height), Tree canopy, Tree canopy fit, Leaf nitrogen content, Leaf characteristics (leaf phosphorus concentration, dry matter content), Plants role in reducing or regulating noise, Bird size **d.** Number of photos including native and non-native trees **e.** Type and amount of animal and plant species, Age of species, Number and variety of species **f.** Complexity of land cover	**a.** Comparative value of properties near cleaner waters
a. (Goodness et al., 2016) **b.** (Kaeffer & Kull, 2017) **c.** (Echeverri et al., 2019) **d.** (Pradhan et al., 2020) **e.** (Sánchez et al., 2020)	**a.** (Gret-Regamey, 2008) **b.** (de Bello et al., 2010) **c.** (Goodness et al., 2016) **d.** (Vaz et al., 2018) **e.** (Moshari et al., 2020) **f.** (Sánchez et al., 2020)	**a.** (Layke, 2009)

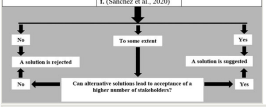

Figure 1.

Aesthetic indicators relevant to the landscape elements (structure).

Does the primary solution match the geological features?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Viewshed from the point of view, Existence of peaks of land surface transformations due to natural factors	**a.** Slope **b.** Variety of land surface transformations due to natural factors	-
a. (Sánchez et al., 2020)	**a.** (Sherrouse, 2011) **b.** (Sánchez et al., 2020)	-

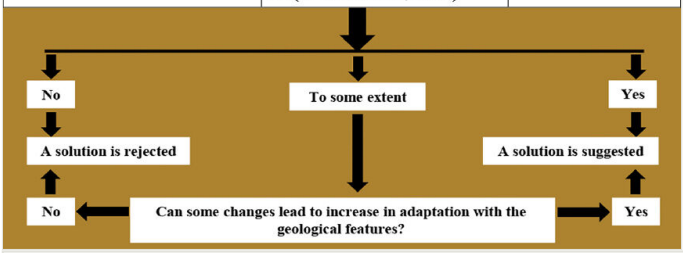

Figure 2.

Aesthetic indicators relevant to the proceedings of geological features.

Can the primary solution respond well over time?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Phenological features (time and season) related to flowers blooming	**a.** climatic diversity (4 seasons)	-
a. (Goodness et al., 2016)	**a.** (Moshari et al., 2020)	-

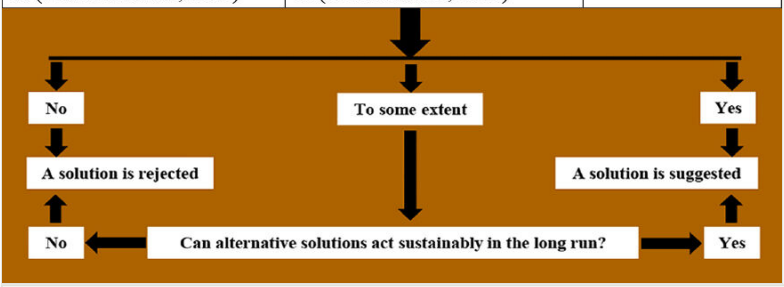

Figure 3.

Aesthetic indicators related to time proceedings.

Does the primary solution match the history (past)?		
Qualitative indicators	Quantitative indicators	Financial indicators
-	**a.** Existence and diversity of material elements and paces relevant to the history, Time depth	-
-	**a.** (Sánchez et al., 2020)	-

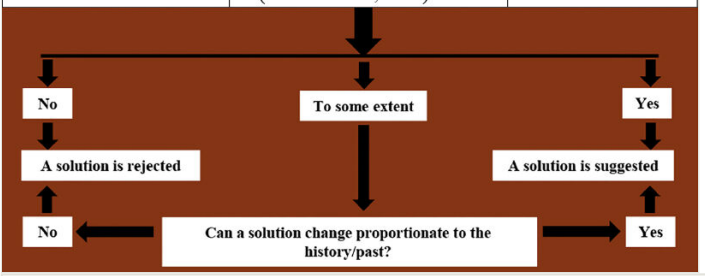

Figure 4.

Aesthetic indicators related to history (past) proceedings.

Does the primary solution facilitate accessibility?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Facilitated access	**a.** Average tree cover percentage on the earth, which is measured in the home view **b.** Estimation of travel time **c.** Distance to the landscapes, Distance to the animal and plant species **d.** Access to the favorite regions or spots	-
a. (Moshari et al., 2020)	**a.** (Sander & Haight, 2012) **b.** (Van Berkel & Verburg, 2014) **c.** (Moshari et al., 2020) **d.** (Sánchez et al., 2020)	-

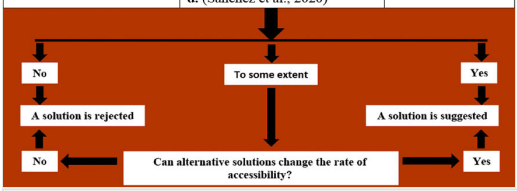

Figure 5.

Aesthetic indicators related to accessibility proceedings.

Can the primary solution be effective in distributing the ECSs?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Existence of biological sounds (biophony) with birds singing in the landscape, Combining bird sounds with other sound landscapes such as waterfalls in the landscape, Existence of birds in the background of urban noise such as traffic **b.** How the spectacular landscapes are dispersed, How the species are dispersed	-	-
a. (Goodness et al., 2016) **b.** (Moshari et al., 2020)	-	-

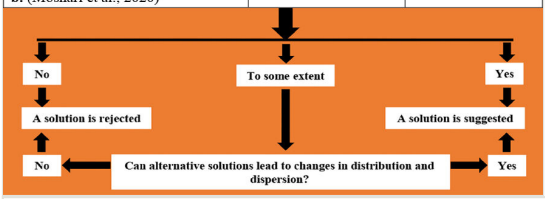

Figure 6.

Aesthetic indicators related to distribution and dispersion proceedings.

Can the primary solution create welfare infrastructure?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Existence of spaces with the use related to entertainment, Existence of facilities, Existence of recreational, educational, or cultural activities	-	-
a. (Sánchez et al., 2020)		

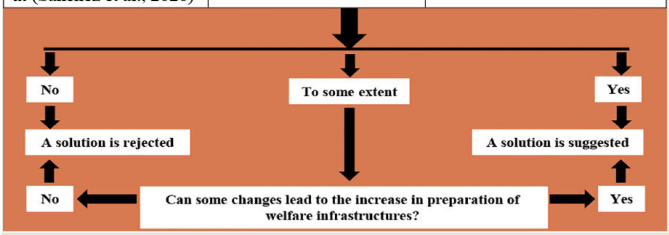

Figure 7.

Aesthetic indicators related to welfare infrastructure proceedings.

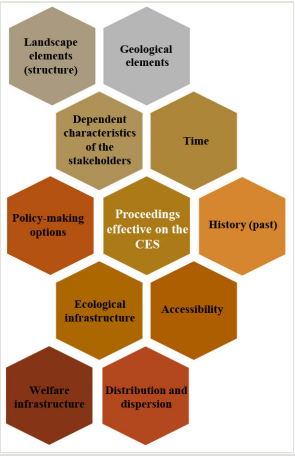

Figure 8.

The proceedings effective on the ECSs in urban landscape design and planning.

Is the primary solution effective in creating ecological infrastructure?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Impenetrable ground cover **b.** Being natural instead of man-made elements **c.** Landscape use **d.** Existence of protected natural areas, The degree of naturalness of the landscape, The degree of openness of the landscape, The richness of the habitat	**a.** Photos density **b.** Number of landscapes, Extent of landscapes, Area of landscapes, Variety of landscapes	**a.** Comparative value of properties closer to cleaner waters
a. (Sander & Haight, 2012) **b.** (Riechers et al., 2016) **c.** (Moshari et al., 2020) **d.** (Sánchez et al., 2020)	**a.** (Casalegno et al., 2013) **b.** (Moshari et al., 2020)	**a.** (Layke, 2009)

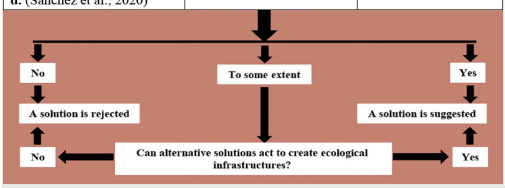

Figure 9.

Aesthetic indicators related to ecological infrastructure proceedings.

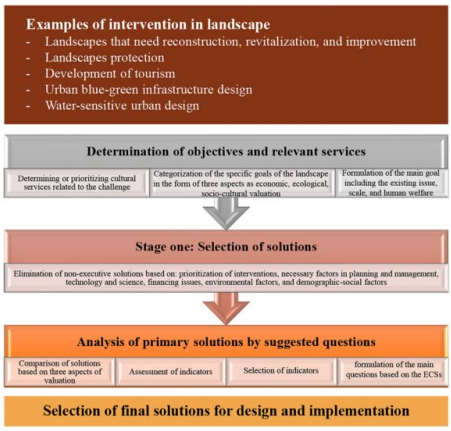

Figure 10.

Framework of urban landscape design, based on the ECSs.

Does the solution respond well to policy options?		
Qualitative indicators	Quantitative indicators	Financial indicators
a. Methods of protection **b.** The existence of an active management system **c.** Landscape beautification, Landscape design	**a.** protection level	-
a. (Moshari et al., 2020) **b.** (Sánchez et al., 2020) **c.** (Sen & Guchhait, 2021)	**a.** (Sánchez et al., 2020)	

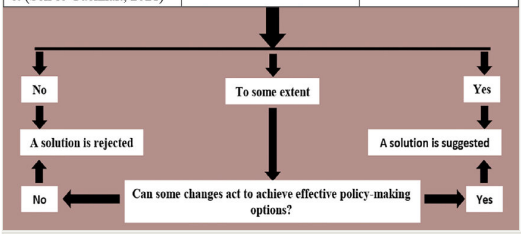

Figure 11.

Aesthetic indicators related to policy-making options proceedings.

Can the primary solution support the acceptance of a wide range of stakeholders?		
Qualitative indicators	Quantitative indicators	Financial indicators
-	**a.** Number of nature visitors	**a.** Property and house prices **b.** Willingness to pay for water quality improvement **c.** Willingness to pay to maintain landscape, Estimating travel expenses
-	**a.** (Layke, 2009)	**a.** (Rönnbäck et al., 2007) **b.** (Layke, 2009) **c.** (Van Berkel & Verburg, 2014)

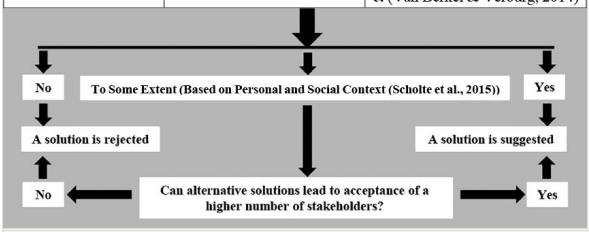

Figure 12.

Aesthetic indicators related to dependent characteristics of the stakeholders proceedings.

Figure 13.

Relationship between the proceedings effective on the ECSs and the suggested questions.

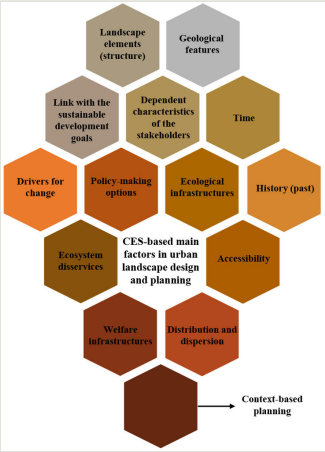

Figure 14.

The main factors in urban landscape design and planning, based on the ECSs.

Table 1.

Titles of the ECS indicators.

Reference	Indicator type
(Moshari et al. 2020)	Objective, structural, mental, cultural
UNEP-WCMC (2009) Hernández-Morcillo et al. (2013)	Status, function, intermediary services, profit, effect
(Biedenweg et al. 2014)	Mental, cultural, social, physical, economic, governmental
(Tandarić et al. 2020)	Supply, demand
(Stanik et al. 2018)	Time depth, historical richness (relevant to the cultural heritage indicators)
(Sánchez et al. 2020)	Financial, non-financial, structural values, physical/natural values, environmental values, historical values, consumption values
Liu et al. (2021)	Ecological, socioeconomic

Table 2.

Assumptions of the Framework.

Assumptions	Instances	Effects on the framework
The type of indicator depends on the issue that forms the basis of the purpose of the environmental intervention.	The purpose or context of application is important for analysing indicators in different ecosystems (Feld et al. 2009). Indicators of ECS should respond to the purpose and questions (Hernández-Morcillo et al. 2013). For example, it can be used to be informed about policy improvements or better resource management or it can help focus information to answer important questions or review, justify and set local goals and priorities (Tratalos et al. 2016).	The framework begins with setting goals, which determine the basis for selecting the relevant indicators in the next steps. Objectives can be discussed from three valuable aspects: ecological, cultural and socioeconomic.
The type of indicator depends on the spatial scale of the existing problem.	The scale (s) in which the indicator is used is important, such as fragment ("farm"), local, regional, national, sub-global and global scale (Feld et al. 2009). The Millennium Ecosystem Assessment also provides a framework for the interaction between biodiversity, ecosystem services, human welfare and drivers of change that can occur at different scales (international, regional and local) (Reid et al. 2005) or in another study, the different spatial coverage of ecosystem services is important, which can be available on a local or global scale (on a global scale, services do not necessarily have to be produced close to the source of the problem, but non-transferable services must be close to the location of consumption) (Bolund and Hunhammar 1999).	In the first stage of the framework, the spatial scale of the existing problem is determined. This would help determine the indicators that fit the scale of the problem.
The type of indicator should meet the main purpose of ecosystem services.	Ecosystem service indicators should be highly relevant and understandable to policy-makers and effectively convey key findings of the impact of ecosystem change on human welfare. In addition, these indicators must fit into a coherent framework for analysis "that addresses the functional relationship between nature and human welfare" (Van Reeth 2013). The effects of the ECS on human welfare can be divided into three categories: physical, mental and public welfare (mainly in cases where welfare is not specifically defined - the term public welfare is used) (Kosanic and Petzold 2020).	When setting goals, it must be taken into account that the proposed solutions that are set in line with the goals can be responsive to human welfare in any field.
Indicators depend on the existing conditions and their use in different stages.	Different policies and management initiatives are likely to create their indicators to answer the specific questions they face, so it may be best to confine setting up indicators for the ECS, for the temporary cases in which the resources are available (Tratalos et al. 2016). Identifying which indicators of the ECS should be assigned is important to show the most appropriate spatial and temporal context given the availability of data and the requirements of the indicator (Hernández-Morcillo et al. 2013).	In this framework, the indicators related to the proposed solutions are determined before the implementation of the project and are not related to the evaluation of projects that is carried out in the field of the ECS.

The type of indicators depends on the participation of stakeholders at the individual and social levels.	Indicators of the ECS should not be built solely on individual assessments. Both at the individual and social levels, consideration of preferences demonstrates a kind of democratic approval (Hernández-Morcillo et al. 2013). In fact, ecosystem services are a function of different perceptions of the stakeholders (Fisher et al. 2009). The stakeholders' participation in ecosystem service research is important in terms of framework development, ecosystem service selection and related indicators (Haase et al. 2014).	If possible, the stakeholders' involvement should be considered during the framework steps.