USING THE ECOSYSTEM SERVICES APPROACH TO ASSESS LANDSCAPE QUALITY

***Aiga Spage**
Latvia University of Life Sciences and Technologies, Latvia
*Corresponding author's email: aiga.spage@llu.lv

Abstract
Globally Covid-19 has proven how important nature and landscape are to ensure human well-being physically and mentally. This research used a systematic literature review method to get an overview of existing research articles that specifically assess landscape quality in large scale landscapes using nowadays widely used ecosystem service approach. Research answers four key questions – (1) Which ES were assessed to evaluate the quality of landscape? (2) Which methods were used to assess ES? (3) Which ES indicators were used to determine the quality of landscape? (4) What data were used to conduct the research? The most widely assessed ecosystem service group is focused on the visual quality of the landscape. The most frequently used method group includes statistical analysis and surveys and questionnaires, followed by spatial assessment methods. Indicators that were frequently used in research included general land-use types and separate landscape elements. In order to use such indicators, qualitative and large amount of spatial data are needed to evaluate the quality of the landscape. Wider research is needed to understand landscape quality assessment methods before the ecosystem service term appeared in the research field.
Key words: ecosystem services, landscape quality, systematic literature review, assessment.

Introduction

Nowadays society faces major challenges globally, and the Covid-19 pandemic has demonstrated how important and integral nature and landscape are in our everyday lives (Havinga *et al*., 2021). Landscape quality and all ecosystem services (ES) that landscape provides are vital for our mental and physical well-being. People's perception of landscape is formed from both – biophysical features (elevation, vegetation, etc.) and personal or cognitive perception, but there are still discussions on which approach is more accurate to evaluate visual landscape quality (Jovanovska *et al*., 2020; Price, 2013) or how to quantify landscape quality in general (Swetnam, Harrison-Curran, & Smith, 2017). People's understanding of landscape quality varies from the perception of visual or sensual qualities to the overall understanding of ecological processes, history and culture that affects landscape character and our personal feelings towards specific landscape (cognitive perception) (Gottero, Cassatella, & Larcher, 2021; Solecka *et al*., 2022; Swetnam, Harrison-Curran, & Smith, 2017; Wartmann *et al*., 2021).

ES approach is widely researched and used to evaluate different features of nature, landscape and urban environments, to produce trustworthy evidence of ecosystem function and public goods to support decision making. ES are being described differently in different sources, but one of the first definitions in Millennium Ecosystem Assessment stated that ES are benefits that people gain from ecosystems (Millennium Ecosystem Assessment, 2005). The definition of ES had a snowball effect and a large number of research articles concentrated on ES and their evaluation (Brzoska & Spāģe, 2020).

The urban environment has been researched widely from different perspectives, including the landscape quality in urban environments, especially because of rapid urbanisation. Many more residents move to cities and to ensure their well-being urban ecosystems and their services are vital (Gómez-Baggethun & Barton, 2013; Haase, Frantzeskaki, & Elmqvist, 2014). For large scale landscapes, ES assessment needs more high-quality data and method choice may differ. Usage of spatial data in ES assessment has increasingly shown that a large amount of data can provide an overview of potentially high-quality areas that provides a range of ES (Ungaro *et al*., 2016). As the assessment of landscape quality has become increasingly important in recent years, interest in assessing the quality of landscapes through ES is also growing (Swetnam & Tweed, 2018). Defining high-quality landscapes can point out landscape sensitivity in specific places to specific changes or transformations (Senes *et al*., 2020) and that sort of information can help decision-makers to protect landscapes from degradation. Before mentioned aspects forms an aim for this research – get an overview of how frequently the ES approach was used to assess the quality of the landscape, which indicators and methods were used to do so and which data categories were used. In order to achieve the aim of this research four key questions were defined in the Materials and Methods section.

Materials and Methods

The research method presented in this paper is a systematic literature review after Pickering and Byrne (Pickering & Byrne, 2014) (Figure 1). The aim of using this method was to gather an overview of the research field that specifically concentrates on ES assessment to evaluate the landscape quality. The first step was to understand the search key words and attributes, define the aim of this research – to understand how often and how the ES approach was used to determine

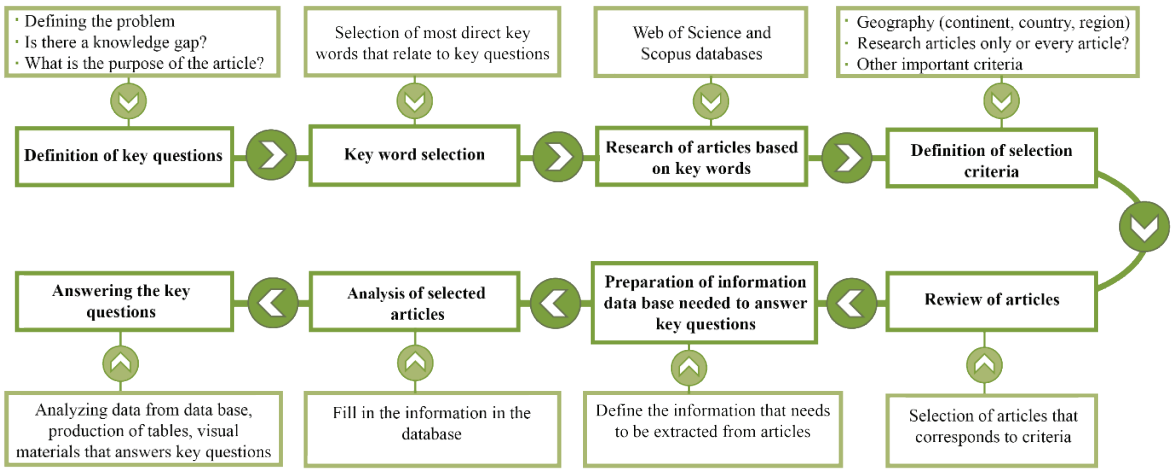

Figure 1. Flowchart of the systematic literature review method used in this article (Source: after Pickering, & Byrne, 2014).

the landscape quality, which methods were used, and based on which ES indicators research was done and to assess the possibility of particular method repetition. Also, used data was analysed. To achieve the aim of this paper, four key questions were defined: (1) Which ES were assessed to evaluate the quality of landscape? (2) Which methods were used to assess ES? (3) Which ES indicators were used to determine the quality of landscape? (4) What data were used to conduct the research?

The next step included a selection of key words that were used to conduct a search in two databases – 'Web of Science' and 'Scopus'. Searches were conducted by adding the search terms 'ecosystem services' and 'landscape quality' in both databases, the search was narrowed to specific fields – title, key words, or abstract. After the search was finished, cross-check was done to exclude repeated articles. At the starting stage key words like 'landscape character' and 'landscape aesthetics' were included, but when reviewing search outcomes, it was concluded that these key words are focusing on a different area of landscape evaluation. The search identified 47 results in the 'Web of Science' database and 36 results in the 'Scopus' database. After cross-checking search concluded with 51 research articles that were evaluated afterwards based on the following steps of the method.

To avoid possible misunderstandings and misleading results of the research, some selection criteria were defined. Firstly, as the interest of this research is to target large-scale landscapes, the research area must be on a regional or other large spatial scale and exclude evaluation just in an urban environment. As the landscape is very specific to each geographical region and even more continental differences are too significant, the second selection criteria stated that the research article must evaluate landscape in Europe. To understand the applicability of methods used in research articles, the third selection criteria stated that the article must use a real case study. After the first review of search results, another criterion was determined; it was related to the main focus of a research article, whether the ES assessment is used to measure the quality of landscape or it is mentioned in the abstract just based on the topicality of this research field nowadays, and that is the reason it turned up in the systematic search.

The next step included the first review of the selection of articles and cross-checking which articles correspond to all of the selection criteria. Reviewing of articles concluded with 18 articles that met all criteria. Most of the articles were excluded from research, because the aim of the articles was not to evaluate landscape quality or they were not using the ES approach, just mentioned specific key words in the abstract. A few articles were excluded because of the research scale being only urban environment and research was not conducted in Europe and not having a case study.

After the initial article review, the next step included the preparation of a database for analysis of selected articles. The database included the main characteristics of the article like title, authors, year of publishing, location of case study, and other basic information. The aim of the database was to extract specific information from articles that can answer stated key questions. Main information in the database included methods that were used in articles, which ES were examined, which indicators were used and what kind of data was used for a specific article. In addition, the differences in the tools that were used in articles also were extracted from articles. The final step was to combine and analyse the information in

the database to answer the key questions and draw conclusions.

Results and Discussion

Figure 2 represents an answer to the first key question, which ES were examined in selected articles. ES were classified according to the Common International Classification of Ecosystem Services (CICES) V5.1 (European Environment Agency, 2018) groups and includes three groups of the Cultural ES section, six groups of the Regulation & Maintenance section, and one group from the Provisioning ES section (Figure 2). Unfortunately, most of the reviewed articles were not using CICES to specifically define which ES classes were examined, to correctly demonstrate the results; therefore, ES were not divided into ES classes (more specific distribution) but divided into groups instead. Each ES group includes several ES classes, as several articles assess several ES. The results in Figure 2 depict the number of times a specific ES group was assessed, sometimes more than once in one article. The most assessed ES section was Cultural which mostly focused on such ES that correspond to the beauty of nature, sense of place, etc., which is directly connected to the assessment of visual landscape quality, then followed by ES group related to recreation. Most researchers on reviewed articles relate landscape quality to aesthetics, which is shown also by the results of the first key question. Cultural ES are one of the most complicated ES to quantify (Swetnam, Harrison-Curran, & Smith, 2017) and the assessment of aesthetics of landscape has been a challenge for decades. New technologies and data sets like Geographic Information Systems (GIS) are enabling new ways and methods how to quantify and measure the visual quality of ES (Jovanovska *et al*., 2020). The second most assessed ES section was Regulation & Maintenance, more specifically, several ES on the ES group of regulation of baseline flows and extreme events (Senes *et al*., 2020), which relates to facts that vegetation, green spaces, forests, etc. are accumulating water runoff, controlling the erosion rates, etc. Several articles assessed ES group of lifecycle maintenance, habitat and gene pool protection by assessing the natural habitats for wild plants and animals (Gottero, Cassatella, & Larcher,

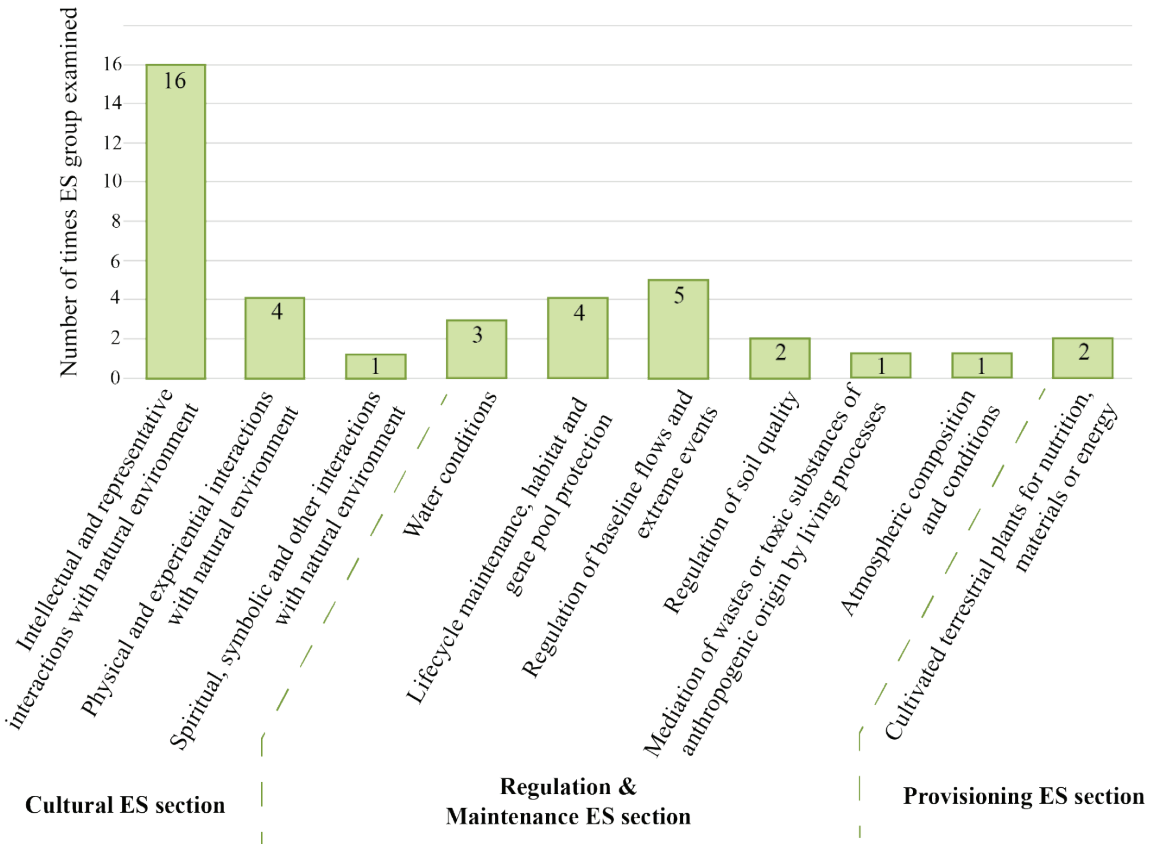

Figure 2. ES groups assessed by analysed articles, according to CICES V5.1, values in the graph depict the number of times ES were assessed, not the number of articles (several articles examine multiple ES, e.g. Gottero, Cassatella, & Larcher, 2021; Mäntymaa *et al*., 2018; Niedermayr *et al*., 2018; Senes *et al*., 2020). (Source: all selected research articles).

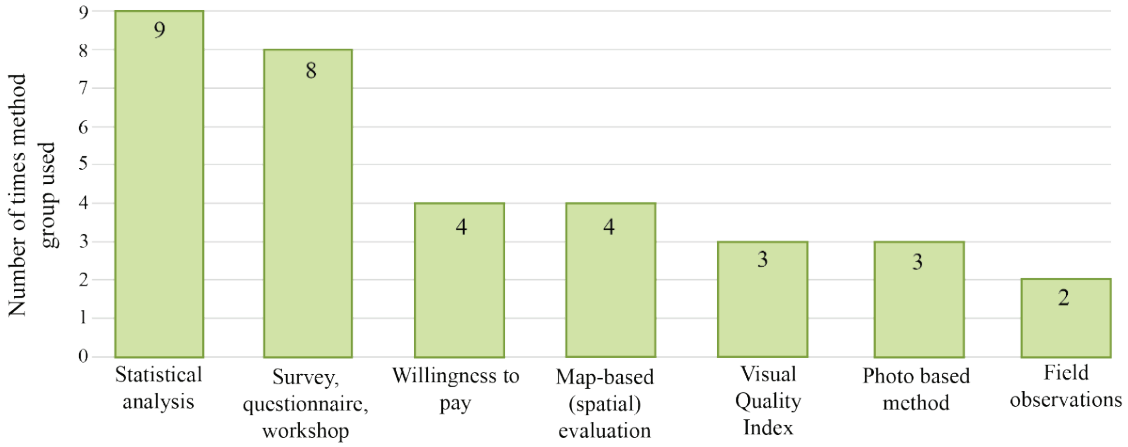

Figure 3. Method groups used in analysed research articles, values in the graph depict the number of times the method in the specific group was used, and several articles used multiple methods (Source: all selected research articles).

2021; Mäntymaa *et al*., 2018; Niedermayr *et al*., 2018; Senes *et al*., 2020). Only two articles assessed the Provisioning ES section, both taking into account the presence of agricultural land as a source of food production (Gottero, Cassatella, & Larcher, 2021; Senes *et al*., 2020).

The results of the first key question provide a basis for a discussion on how researchers understand the term 'landscape quality. Results reveal a large portion of articles that research visual landscape quality, which is only one of the ways how to interpret landscape quality. European Landscape Convention states that landscape quality objective, for the specific landscape, needs to be formulated by competent public authorities, which includes the needs of the public taking into account landscape features (Council of Europe, 2020). This formulation means that every country or region can formulate its understanding of landscape quality, and there is no common understanding of what landscape quality is and what it encompasses.

The second key question explores which methods were used in selected articles (Figure 3). Results in Figure 3 represent the times that a specific method group was used, most of the cases research articles used several different methods. As the researched topic is related to ES and mostly deals with a large amount of data, the most used method group is statistical analysis, which includes different variations of methods differentiating based on specifics of analysed data and amount of it. The previous key question referred to the frequent evaluation of cultural ES and because of that, the results of the second key question are self-evident, as the most frequent approach to evaluate cultural ES is based on society's choices or perceptions involving the public in surveys and questionnaires. As technologies are advancing, the usage of GIS is becoming more precise and is being used more often (Jovanovska *et al*., 2020). Whether spatial evaluation is included in a method called Visual Quality Index or used for map-based evaluation methods, it has been popular for the past decade, mostly by assessing regulation & maintenance ES (Brzoska & Spāģe, 2020). Technologies in this field are increasingly showing more potential also in the evaluation of cultural ES, by using tools that allow active public participation in the process, for example, participatory GIS. Spatial analysis methods can be time and labour saving methods, but only when high-quality data is available to work with (Sowińska-Świerkosz & Michalik-Śniezek, 2020; Vannoppen, Degerickx, & Gobin, 2021). Equally the same amount of times method called willingness to pay was used. It economically expresses stakeholder, visitor, or local people's perception of the improvement of landscape quality in the monetary form, by stating how much they would be willing to pay for specific actions or plans to improve landscape quality (Mäntymaa *et al*., 2018; Niedermayr *et al*., 2018). Finland has presented Payments for Ecosystem Services system called Landscape and Recreation Value Trade that proposes that forest owners are compensated for voluntarily enhancing and maintaining the landscape value (Mäntymaa *et al*., 2021). To set up this initiative, the research is needed beforehand to understand the amount of money that tourists or stakeholders are willing to pay to improve the quality of the landscape, and at the same time make their business more attractive.

Figure 3 also represents that photo-based methods (Martín *et al*., 2018) appear in researched articles that are mostly based on photos from social media databases (Havinga *et al*., 2021; Sottini *et al*., 2019). There is a reason to believe that methods involving social media will become more popular to evaluate

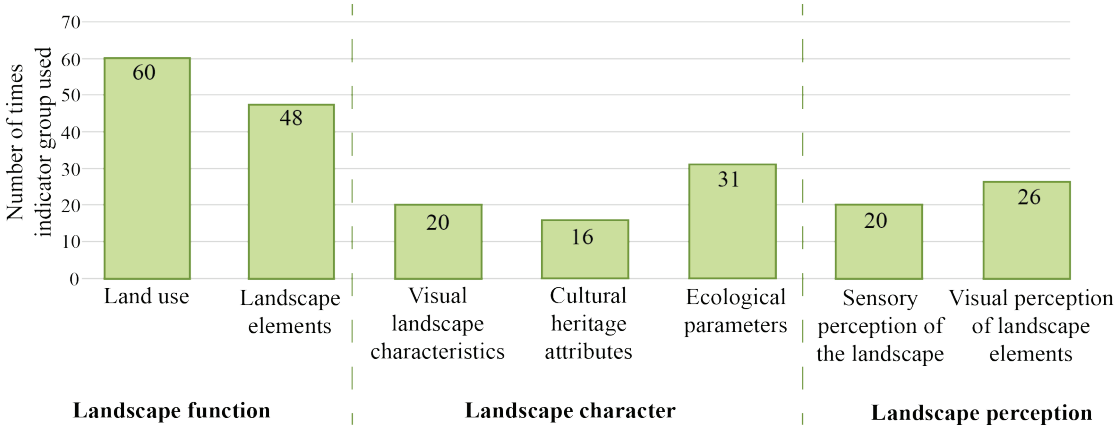

Figure 4. Indicator groups used to assess ES, values in graph depicts the number of times indicator in the specific group was used and several articles used multiple indicators (Source: all selected research articles).

people's preferences towards the landscape. The most rarely used method group was field observations, which is a result of fieldwork usually being time-consuming and asking for quite big expenses.

Figure 4 represents the indicator group type and frequency of times a specific indicator group was used to assess ES, which is the result of the third key question. The most frequently used indicator groups were related to landscape function – land use and landscape element assessment. These two indicator groups were most assessed using GIS or other spatial evaluation methods and mostly corresponded to visual landscape quality. Results in Figure 4 depict how many times specific indicator group was used in research articles, for example, several articles used land use indicator group to assess ES, articles used multiple land use types in the assessment (e.g. Gottero, Cassatella, & Larcher, 2021; Sottini *et al*., 2019; Vannoppen, Degerickx, & Gobin, 2021, etc.).

The second most frequently used indicator section is related to landscape character and the most assessed indicator group in this section refers to ecological parameters, which are connected to evaluating regulation and maintenance ES. An interesting result is that cultural heritage attributes are the least used indicator group, either the cultural heritage elements are not fully linked to the quality of the landscape in the article author's opinion or the availability of such data is scarce. Commendable is the tendency to evaluate people's perception of landscape, either sensory or visual. Several authors point out the necessity to evaluate not only biophysical indicators but also people's perception of landscape (Jovanovska *et al*., 2020; Swetnam & Tweed, 2018; Swetnam, Harrison-Curran, & Smith, 2017). People's perception of landscape leads to a better understanding of the necessity of nature protection and landscape preservation (Gobster *et al*., 2007; Jovanovska *et al*., 2020; Pueyo-Ros, Ribas, & Fraguell, 2018). When talking about landscape quality not always it is perceived as a visually appealing landscape, because most of the landscapes that provide a wide range of ES are natural, not managed (Wartmann *et al*., 2021), and even not accessible, when asking people's opinion about visually appealing landscape, results can be quite opposite compared with biophysical evaluation; for example, a road in a landscape is evaluated as negative aspect for visual landscape quality by biophysical evaluation, but from people perspective that is not the case, because the same road can provide accessibility to landscape (Solecka *et al*., 2022).

Figure 5 represents the results of the fourth key question by showing the frequency of specific data categories used to assess ES and evaluate the landscape

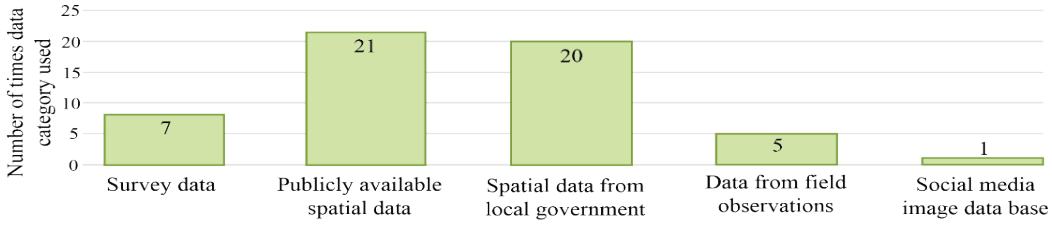

Figure 5. Data categories used in analysed research articles, values in the graph depict the number of times data category was used and several articles used multiple data sources (Source: all selected research articles).

quality. Even though the results of the second key question showed that surveys and questionnaires were between the most used method groups, used data categories represent different results. The reason behind this situation is that research articles that assessed ES with methods using spatial data mostly used several data sources and several kinds of spatial data to perform their research and that raises the count of times spatial data sources were used. Most of the articles with different methods used some type of spatial data to conduct their research or to represent the results.

Several methods used spatial data provided by national surveys or local municipalities enabling more precise data with much less labour and time involved to perform such research. To use ecological indicators (biodiversity, presence of specific flora species, etc.) there is a need for specific, precise data about species diversity in a specific landscape, and that sort of information in reviewed articles is provided by municipalities, but not all municipalities have such detailed data available. To repeat the research method, it is necessary to have the same type and amount of data or there is a need of adjusting the method (Jovanovska *et al*., 2020; Swetnam & Tweed, 2018; Swetnam, Harrison-Curran, & Smith, 2017), but in some cases the method is not applicable because the data in a specific place is scarce or not existent.

Conclusions

The ecosystem services approach nowadays is being widely used, but this research proves that there is still a gap when using ES to assess the quality of the landscape on a large scale. Landscape quality and ecosystem services, in general, are very popular topics to research which is proven by the results after a systematic search in databases, where only a third part of the articles that were found evaluated the quality of landscape using the ES approach. Other articles mention these terms in abstracts to point out the relevance of these topics in general. This article points out the problem with the term 'landscape quality' definition and understanding, while several articles assess the visual quality of the landscape, other researches are wider including ecological and cultural aspects of the landscape.

In order to achieve the aim of this research, four key questions were answered. The first key question analysed which ES were assessed to evaluate the quality of landscape, where the most assessed ES section was cultural ES, followed by Regulation & Maintenance ES, and only few articles considered Provisioning ES section in the assessment of landscape quality. The second key question analysed used methods in selected articles for assessing the ES. Most of the articles used different types of statistical analysis, where a large amount of data was processed, gathered by GIS enabled mapping methods or surveys and questionnaires, which points out the need for computed analysis method usage more frequently. The third key question analysed which ES indicators were used to evaluate the quality of landscape, where ES indicators were combined into groups. The most used indicator group was land use where the distinction of several different land-use types was used to assess the quality of landscape. To analyse the possible repetition of used methods, the fourth key question analysed the data used in selected research articles. Most of the analysed research articles used spatial data either publicly available or derived from local governments.

The topic of this study can be further explored in-depth by analysing articles that have studied landscape quality prior to the creation of the term 'ecosystem services', accordingly using a different set of key words.

References

Brzoska, P., & Spaǵe, A. (2020). From city-to site-dimension: Assessing the urban ecosystem services of different types of green infrastructure. *Land*, 9 (5), article No. 150. DOI: 10.3390/LAND9050150.

Council of Europe. (2020). *The European Landscape Convention*. Preamble. ETS No. 176., Florence.

European Environment Agency. (2018, January). *The Common International Classification of Ecosystem Services* (*CICES) V5.1*. Retrieved February 2, 2022, from https://cices.eu/.

Gobster, P.H., Nassauer, J.I., Daniel, T.C., & Fry, G. (2007). The shared landscape: What does aesthetics have to do with ecology? *Landscape Ecology,* 22 (7), 959–972. DOI: 10.1007/s10980-007-9110-x.

Gómez-Baggethun, E., & Barton, D.N. (2013). Classifying and valuing ecosystem services for urban planning. *Ecological Economics*, 86, 235–245. DOI: 10.1016/J.ECOLECON.2012.08.019.

Gottero, E., Cassatella, C., & Larcher, F. (2021). Planning peri-urban open spaces: Methods and tools for interpretation and classification. *Land*, *10 (8)*, article No. 802. DOI: 10.3390/land10080802.

Haase, D., Frantzeskaki, N., & Elmqvist, T. (2014). Ecosystem services in urban landscapes: Practical applications and governance implications. *Ambio*, 43(4), 407–412. DOI: 10.1007/s13280-014-0503-1.

Havinga, I., Marcos, D., Bogaart, P.W., Hein, L., & Tuia, D. (2021). Social media and deep learning capture the aesthetic quality of the landscape. *Scientific Reports*, 11 (1). DOI: 10.1038/s41598-021-99282-0.

Jovanovska, D., Swetnam, R.D., Tweed, F.S., & Melovski, L. (2020). Assessing the landscape visual quality of Shar Planina, North Macedonia. *Landscape Ecology*, *35* (12), 2805–2823. DOI: 10.1007/s10980-020-01122-5.

Mäntymaa, E., Ovaskainen, V., Juutinen, A., & Tyrväinen, L. (2018). Integrating nature-based tourism and forestry in private lands under heterogeneous visitor preferences for forest attributes. *Journal of Environmental Planning and Management*, 61 (4), 724–746. DOI: 10.1080/09640568.2017.1333408.

Mäntymaa, E., Tyrväinen, L., Juutinen, A., & Kurttila, M. (2021). Importance of forest landscape quality for companies operating in nature tourism areas. *Land Use Policy*, 107, article No. 104095. DOI: 10.1016/j.landusepol.2019.104095.

Martin, B., Arce, R., Otero, I., & Loro, M. (2018). Visual landscape quality as viewed from motorways in Spain. *Sustainability (Switzerland)*, 10 (8), article No. 2592. DOI: 10.3390/su10082592.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Wellbeing*: Synthesis. Island Press. Washington, DC

Niedermayr, A., Schaller, L., Mariel, P., Kieninger, P., & Kantelhardt, J. (2018). Heterogeneous preferences for public goods provided by agriculture in a region of intensive agricultural production: The case of the Marshfield. *Sustainability (Switzerland)*, 10 (6), article No. 2061. DOI: 10.3390/su10062061.

Pickering, C., & Byrne, J. (2014). The benefits of publishing systematic quantitative literature reviews for PhD candidates and other early-career researchers. *Higher Education Research and Development*, 33 (3), 534–548. DOI: 10.1080/07294360.2013.841651.

Price, C. (2013). Subjectivity and objectivity in landscape evaluation: an old topic revisited. In van der Heide CM, Heijman WJM (Eds.). *The economic value of landscapes* (pp. 53–76). London, Routledge.

Pueyo-Ros, J., Ribas, A., & Fraguell, R.M. (2018). Uses and Preferences of Visitors to Coastal Wetlands in Tourism Destinations (Costa Brava, Spain). *Wetlands*, 38 (6), 1183–1197. DOI: 10.1007/s13157-017-0954-9.

Senes, G., Fumagalli, N., Ferrario, P.S., Rovelli, R., & Sigon, R. (2020). Definition of a land quality index to preserve the best territories from future land take. An application to a study area in Lombardy (Italy). *Journal of Agricultural Engineering*, 51 (1), 43–55. DOI: 10.4081/jae.2020.1006.

Solecka, I., Rinne, T., Caracciolo Martins, R., Kytta, M., & Albert, C. (2022). Important places in landscape – investigating the determinants of perceived landscape value in the suburban area of Wrocław, Poland. *Landscape and Urban Planning*, 218, article No. 104289. DOI: 10.1016/j.landurbplan.2021.104289.

Sottini, V.A., Barbierato, E., Bernetti, I., Capecchi, I., Fabbrizzi, S., & Menghini, S. (2019). Rural environment and landscape quality: An evaluation model integrating social media analysis and geostatistics techniques. *Aestimum*, 74, 43–62. DOI: 10.13128/aestim-7379.

Sowińska-Świerkosz, B., & Michalik-Śniezek, M. (2020). The methodology of landscape quality (LQ) indicators analysis based on remote sensing data: Polish national parks case study. *Sustainability (Switzerland),* 12 (7), article No. 2810. DOI: 10.3390/su12072810.

Swetnam, R.D., & Tweed, F.S. (2018). A tale of two landscapes: Transferring landscape quality metrics from Wales to Iceland. *Land Use Policy*, 76, 565–576. DOI: 10.1016/j.landusepol.2018.02.037.

Swetnam, R.D., Harrison-Curran, S.K., & Smith, G.R. (2017). Quantifying visual landscape quality in rural Wales: A GIS-enabled method for extensive monitoring of a valued cultural ecosystem service. *Ecosystem Services*, 26, 451–464. DOI: 10.1016/j.ecoser.2016.11.004.

Ungaro, F., Häfner, K., Zasada, I., & Piorr, A. (2016). Mapping cultural ecosystem services: Connecting visual landscape quality to cost estimations for enhanced services provision. *Land Use Policy*, 54, 399–412. DOI: 10.1016/j.landusepol.2016.02.007.

Vannoppen, A., Degerickx, J., & Gobin, A. (2021). Evaluating landscape attractiveness with geospatial data, a case study in Flanders, Belgium. *Land*, 10 (7), article No. 703. DOI: 10.3390/land10070703.

Wartmann, F.M., Frick, J., Kienast, F., & Hunziker, M. (2021). Factors influencing visual landscape quality perceived by the public. Results from a national survey. *Landscape and Urban Planning*, 208, article No. 104024. DOI: 10.1016/j.landurbplan.2020.104024.