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Strategic Environmental Assessment and the precautionary principle in the spatial planning of wind farms – European experience in Serbia

Boško Josimović [a,*], Aleksandar Cvjetić [b], Danilo Furundžić [c]

[a] Institute of Architecture and Urban & Spatial Planning of Serbia, Bulevar kralja Aleksandra 73/II, 11000, Belgrade, Serbia
[b] Faculty of Mining and Geology, University of Belgrade, Serbia
[c] Faculty of Architecture, University of Belgrade, Serbia

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ABSTRACT

Spatial determination planning is at an initial and very sensitive step in the development of wind farms. On one hand, it is important to maximize the potential of wind in a particular area, and on the other hand, it is important to achieve environmental protection (including the human population and natural heritage) in the same space at the same time. With this in mind, it is important to balance all the requirements that are relevant for reaching the optimal solution when determining the micro-location of wind turbines at the earliest stages of the planning and development of wind power projects. In this context, planning is a key stage in finding sustainable solutions for the implementation of such projects, and an indispensable instrument in the planning process, offering support and control is Strategic Environmental Assessment (SEA). This paper presents the role of SEA in the planning process for wind farms. The place of the SEA process is identified in relation to other environmental impact assessment instruments, such as Environmental Impact Assessment (EIA) and Environmental Social Impact Assessment (ESIA), and a comparative analysis of these instruments is made, including their advantages and disadvantages. The results of the paper indicate the importance of applying SEA in the earliest stage of wind farm planning, so as to formally apply the precautionary principle and avoid problems, which in the later stages of the project, when EIA is usually used, can be disadvantageous both economically and in terms of environmental impact.

1. Introduction

Despite all of the benefits of wind farms in raising the quality of the environment on a global level, there are certain negative impacts that they have on the micro-level (site-specific) environment.

While a relatively small number of authors have published papers in leading international journals on the possibilities, importance and shortcomings of applying the SEA process in the sustainable planning of wind farms [1–6], much has been written in the past about the impact of wind farms on the environment and on socio-economic development, with many professional and scientific papers published on this theme.

Namely, a number of authors who have dealt with these issues so far have made a significant contribution to identifying the most relevant potential impacts that wind farms could have on the environment and on socio-economic factors, as well as defining measures and strategies for mitigating these impacts [1,4,7,8].]. In this context, some authors have made a significant contribution to the literature on the impact of wind farms on the environment [9].

Particularly important is the attention given to the social impacts of wind farms [10–18] and to overcoming possible conflict between their development and the populations of local communities. This theme has enormous significance, because the social problems highlighted could, in the worst-case scenario, jeopardize the implementation of a wind farm project.

Some studies suggest that social problems resulting from the development of wind energy can be solved by means of economic factors and highlighting the possible benefits to local communities [13,19]. However, this is more a theme to be addressed by economic instruments for analysis and evaluation than the SEA or EIA process, but the results of such studies can be integrated into the impact assessment process.

It is generally accepted that possible negative environmental and social impacts of wind farms exist, but that these impacts are negligible compared to the positive effects. However, they cannot and should not be ignored, as is partly indicated by EU Guidance on wind energy in

* Corresponding author.
E-mail addresses: bosko@iaus.ac.rs (B. Josimović), aleksandar.cvjetic@rgf.bg.ac.rs (A. Cvjetić), dfurundzic@gmail.com (D. Furundžić).

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accordance with EU nature legislation [20]. It is especially important to consider the dominant impacts of wind farms:

- impact on ornithofauna and chiropterofauna,
- impact of the increased noise intensity,
- impact of shadow flickering,
- impact on the viewshed,
- impact in the case of accident.

All of these impacts have their own spatial distribution, i.e., they cover specific space and can be considered using different instruments for impact assessment. Many different instruments are currently in use worldwide to assess the environmental impact of plans, programs, policies and projects.

Certain instruments, such as traditional Life Cycle Assessment (LCA), cover the entire development of a product (project) from raw material extraction, through material processing, production, distribution, use, repair and maintenance, all the way to disposal and/or recycling as the final stage, which is conducted after the exploitation period is over. The idea is to consider the energy consumed in the production of a product in relation to the time required for that energy to "return" to the working process, that is, the exploitation. If LCA is applied to wind farm projects, it means quantifying all of the impacts in the range of energy used to build a wind farm (cumulative effect) and the possibility of that energy being reproduced in the shortest possible time. The task of LCA is to show that the particular technology and project produces more energy than it uses, otherwise there would be no beneficial contribution from the wind farm to the energy system. The faster the energy return period, the better the LCA results. In such considerations, an inevitable segment would also be a comparative analysis with conventional fossil fuel based energy production systems, from which conclusions could be drawn on the advantages or disadvantages of using wind energy [21].

In addition to the all-encompassing approach characteristic for LCA, there are diametrically opposed approaches based on assessing the impact of individual environmental elements (water, air, soil, noise, viewsheds, etc.). When talking about wind power projects, these so-called partial[1] impact assessments can be carried out in the form of special impact assessments on specific environmental elements: noise, viewshed, risk of accident, ornithofauna, chiropterofauna or risk to the population.

'Global wind energy development is rapidly expanding. For this reason, much has been written in the scientific literature about the effects of wind farms on the environment or on specific environmental elements [22–32].

The authors of this paper, however, consider that the partial assessment of individual environmental elements is justified only if it is an integral part of a unified impact assessment within a framework that applies a holistic approach to assessing the environmental impact of wind farms. This is why we arrive at two environmental protection instruments which have the widest application at a global level of environmental impact assessment, not only for wind farms, but also for other development plans, policies and projects. These are:

Environmental Impact Assessment (EIA) – The history of the implementation of this instrument dates back to the late 1960s when a law was adopted in the United States relating to environmental protection policy. At the time, EIA was not formulated as such, but it was the adoption of this law that was the backbone for the development of this and other instruments for assessing the impact of various activities on the environment. Since that time, interest in developing environmental impact assessment instruments has continued to grow. One of the first definitions of EIA was formulated in the late 1970s [33]: *"the term environmental impact assessment describes a technique and a process by which information on the environmental effects of a project is collected, both by the developer and other interested parties, and it allows decision makers to assess whether a project is acceptable or not"*. Accordingly, this instrument helps to solve the environmental, social and economic problems that may arise from the implementation of public and private investment projects in a particular area. This instrument is an environmental management tool and is used at the level of specific projects. It contains a systematic, documented, periodic and objective assessment of how well pollution control and environmental management systems can be achieved in the functioning of a particular system [34]. EIA was introduced into European practice in 1985 with the adoption of EIA Directive 85/337/EEC [35]. Today EIA is one of the most widely used environmental impact assessment tools. Its application is planetary, since it is applied worldwide. More recently, it has also been formulated as Environmental Social Impact Assessment (ESIA), in accordance with the requirements of international financial institutions involved in the development of investment projects; and

Strategic Environmental Assessment (SEA) – Meeting the long-present need for legally regulated analysis of the impact of plans, policies and programs on the environment began at the end of the 1960s, when the National Environmental Policy Act (NEPA) was introduced in the US, laying out the basis of SEA. This law did not distinguish between plans, policies and programs, on the one hand, and projects on the other, or between the strategic and project levels of decision making, but rather it generally referred to actions [36, 37]. Based on the consideration of international experiences and its own practice of applying SEA, the World Bank considers SEA to be a "participatory approach for increasing the impact of social and environmental issues in the process of development planning, decision making and implementation at a strategic level" [37,38]. Today, SEA is one of the most important instruments for assessing the territorial impacts of a proposed policy on the environment, that is, for implementing a sustainable development strategy in the creation of spatial development policies (at the national, regional or local levels). The main purpose of SEA is to facilitate a timely and systematic consideration of possible environmental impacts, on the basis of which decisions are made on development policies at a strategic level and their acceptability in terms of sustainability [39]. The authors mentioned here are predominantly from the European continent, and so it is not surprising that the implementation of SEA in European planning practice and spatial development is given a great deal of attention. It has also been established through European legislation (European Strategic Environmental Assessment Directive 2001/42/EC [40] and Protocol on Strategic Environmental Assessment, 2003 [41], legally binding and adopted in 2003 at the Ministerial Conference "Environment for Europe" in Kiev, and developed as an adjunct to the Convention on Environmental Impact Assessment in a Transboundary Context – the ESPOO Convention). By applying SEA in spatial development planning through various development documents, today it is possible to consider the consequences of the proposed development concepts and spatial changes at the earliest stage of conceptualizing the planning propositions, while respecting the capacity of the space and not overloading it, and inevitably including the public at every stage of developing and adopting the SEA. In this context, SEA makes a significant contribution to the decision-making process regarding the future development of a space [42].

A characteristic of both instruments is the application of a holistic approach when considering the interaction between the existing and planned purposes for a particular space. The difference between the two instruments is in their purpose and methodological approach to impact

[1] The authors use the term "partial" for all assessments that analyze the impact of a particular project, e.g. wind power, focusing on only one environmental element (factor).

assessment and, most importantly, the point at which they are applied. A comparative analysis of these two instruments in the development of wind farm projects is presented in the continuation of this paper, focusing on the role and significance of applying the precautionary principle through the SEA process for the purpose of environmental protection, which is achieved by applying SEA in the earliest phase of developing a wind energy project.

The paper relies on particular (not all) results of the SEA process for the Košava wind farm project (105 MW), to the measure that it was sufficient to indicate and illustrate the inclusion of specific key aspects of the SEA process in order to determine the potential spatial impacts on environmental elements, without burdening the study either in terms of volume or the amount of information provided.

2. Comparative analysis of SEA and EIA in the implementation of wind farm projects

A significant number of authors have written about the role of EIA/ESIA and SEA in the development of wind farms, emphasizing the importance and role of one of these two instruments, but without making a comparative analysis between them [1,3,43–45].

One of the key differences between EIA and SEA, not only in the development of wind farm projects but in general, is the point at which they are carried out. When it comes to wind power projects only, SEA takes place at the very beginning of a project's development, while EIA is carried out after the SEA process (Fig. 1).

As seen in Fig. 1, after an investor begins an initiative to implement a wind farm project in a particular place, preparation of the relevant planning document is started. The planning document, which is the initial stage in the development of the project, formally and essentially considers the planned conditionality and correlation between the planned and existing activities in a specific space. An indispensable part of the planning documentation is the SEA report. Its role is in directing the planning process (including different alternative solutions) towards the goals of sustainable development (ecological and socio-economic), thus creating a prerequisite for sustainable planning solutions through the concept of the precautionary principle [46]. It serves as an instrument for making decisions about the future development in an area, that is, whether to accept (or not accept) a planning document [3]. The procedure is transparent to all stakeholders and institutions.

Following the decision to accept a planning document, the next stage in the development of a wind farm project is the design, which usually takes place in two phases: 1. preparation of the Preliminary Feasibility Study; and 2. Development of an EIA Feasibility Study (Fig. 1). In this phase, many solutions have already been concretized by the planning documentation, especially with respect to the spatial determination of the micro-locations for the wind turbine poles, which can by implication mean negative effects in the space and in the living and natural environment. It is characteristic for EIA to take place in the project development phase when precise and detailed data are available on the location and project (also including the type of wind turbine and the manufacturer). It is this level of detail and precision that sets EIA apart from other environmental impact assessment instruments. On the one hand, its holistic approach, and on the other hand, quantifying the results based on exact data (input) are the reasons why EIA has positioned itself globally as an indispensable instrument, and not only in the case of wind farm projects. Since its introduction, however, the EIA process has been the subject of criticism and adaptation with the purpose of solving issues arising in its widespread application. In this regard, one of the most active debates is focused on the need for a more serious analysis of the social impacts of implementing projects, which is why the

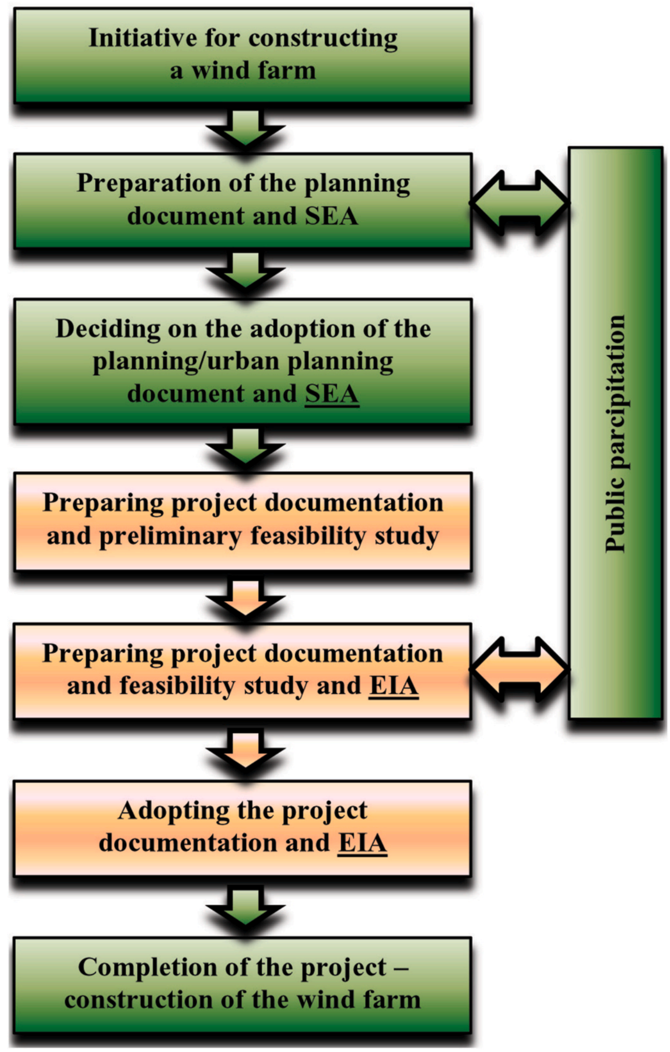

Fig. 1. A simplified scheme showing the place of the SEA and EIA processes in the development of wind farm projects (example from Serbia).

application of Social Impact Assessment (SIA) began in due course, but it has long been viewed as only one component, which is subordinate to the EIA process. As a continuation to this debate, Environmental and Social Impact Assessment (ESIA) has been used much more recently, for the purpose of addressing the environmental and social impact of development. Since its beginning, ESIA has been increasingly applied in cases where projects are funded by international institutions and private credit investors, given that within its framework it can integrally consider all the consequences of a project, and thus assess the degree of risk with its implementation [33]. In any case, since the beginning of this century trends have been moving towards the transformation of EIA into ESIA, that is, towards the integrated assessment of impact on the environment and on social development, in order to properly understand the interconnection of nature and society in the implementation of investment projects [43].

2.1. The methodology of SEA and EIA

In methodological terms, the approach to impact assessment in the SEA process is quite flexible in relation to the various precision mathematical and software tools used in environmental engineering and other fields, based on scientific postulates. A number of authors claim that there is no general SEA methodology that applies to all types of plans. Moreover, SEA techniques and methodologies should be treated as a set of different methods and tools, any of which can be selected by a user depending on the specific circumstances [47–49]. Marsden [50] pointed out that in terms of methodologies, SEA dominantly relies on a qualitative expert method of impact assessment as opposed to traditional Environmental Impact Assessment (EIA), and therefore expert assessment, which always entails a certain level of subjectivity, plays a decisive role [2]. The issue of selecting the appropriate assessment techniques and methodologies used in any specific case must be dealt with by referring to adequate implementation experiences accumulated through the comparative studies of past schemes and applications. A particularly important contribution of the SEA process is its consideration of the alternative solutions in the earliest phase of the planning process. In this way, the public and decision makers are introduced to the possible implications of the development options on the environment and on social factors. It is this segment of SEA that makes it stand out as an instrument which when applied is suitable for implementing the precautionary principle, as well as preventing potential conflicts (environmental and social) in space [46].

The methodological approach in EIA is technically oriented. It involves impact assessment at the stage of preparing the project documentation (feasibility studies at different stages). Given that most of the technical details of the project are already known at this stage, it is possible to apply different methodological approaches and methods due to the availability of the necessary inputs (MCA - Multi-criteria Analysis; MCDM - Multi-criteria Decision-Making; LM – Leopold Matrix, etc.); this has been and continues to be a study interest for a large number of authors [51–55]. The majority of methods are based on the application of sophisticated mathematical simulation methods, which make it possible to quantitatively and objectively express the expected effects (positive and negative) of a project on the environment. This principle makes it possible to know the relevant data: the types and quantities of materials, as well as energy and products and their movement in the construction and operation of a project, which are used as input in the given methods for environmental impact assessment within EIA.

On the other hand, SEA generally involves a very different methodology for impact assessment for the following reasons: plans are more complex than projects, they focus on strategic questions and contain less detailed information about the environment; plans are based on the concept of sustainable development, and apart from the environmental aspect, they mainly focus on the spatial distribution of impacts and social and economic aspects; because of the complexity of structures and processes and their cumulative effects, planning does not allow sophisticated mathematical simulation methods; decision-making processes have a greater spatial scope, including greater stakeholder influence, especially from the public, and therefore the methods and results of the assessment applied must be understood by the participants in the SEA process.

For these reasons, in SEA practice the expert methods are: checklists and questionnaires, matrices, multi-criteria analyses, spatial analyses, SWOT analyses, the Delphi method, assessment of the environmental capacity, cause and effect analysis, vulnerability assessment, risk analysis, etc. It is therefore possible to apply different methodological approaches and methods for assessing the environmental impact of wind farms within the framework of SEA [46]. The question of choosing the appropriate assessment techniques and methodologies to be used in any particular case must relate to the relevant implementation accumulated through comparative studies of previously applied methodologies that have shown good results in practice [39,56].

Given that a basic characteristic of qualitative expert methods is subjectivity, techniques and tools that achieve the highest possible objectivity in impact assessment in the SEA process need to be applied. It is certain that in SEA for planning wind farms, it is possible and also desirable to apply different qualitative expert methods in combination with the quantitative methods and modeling applied to partial impact assessments (such as modeling noise and flickering shadows, Figs. 2 and 3). In other words, because of the specificity of planning wind farm projects, it is also possible to have a desirable combination of a technical and planning approach in SEA, that is, the application of a semi-quantitative method of multi-criteria evaluation[2] [2].

The specificity of planning wind farms is seen in the availability of the technical data necessary for various types of modeling at the very beginning of the planning process. Therefore, it is possible to check the suitability of the spatial determination of wind turbine columns at the earliest stage of planning wind farms. After defining the initial positions of the wind turbines, they are aligned with the results of one-year monitoring of the biodiversity (with special reference to the monitoring of the ornithofauna and chiropterofauna that the windfarm could impact the most, Fig. 2) and with the results of partial assessments of the impact of the wind farm with regard to noise and shadow flickering (seen here in the example of Košava wind farm, illustrated in Figs. 3 and 4). Although the SEA also considers a whole series of possible impacts of the wind farm on the environment and social factors, only examples of impacts that are particularly significant from the aspect of space/territory are given here. Everything certainly highlights the impact of the planned wind farm on biodiversity, which is why the analysis of this aspect is conducted over several years. An additional elaboration on the consideration of biodiversity is given for Košava wind farm in the discussion and conclusion. In addition, the partial assessments serve as control instruments which determine the suitability of wind turbine locations in terms of their potential impact on the population (consideration of alternative planning solutions). After these checks, it is possible to reliably conclude which wind turbines do not have an optimal position, and then to correct their position in order to eliminate the negative impacts. In this way, potential negative spatial/territorial impacts are eliminated in the planning process and in SEA and confirmed in the relevant planning document. The precautionary principle thus achieves its full capacity, and the design and production of the EIA is then relaxed, especially for investors, with a focus on determining technical (not planned) protective measures and environmental monitoring.

Parallel with assessing the impact of wind farms on the basic elements of the environment, the possible social impacts on the local populations in which projects are implemented should not be neglected. Authors emphasize the importance of integrating social factors in the development of wind farms by highlighting the following: the integration of the social aspect in the SEA process [6,11,46]; analysis of the social acceptability of wind farm projects [10]; economic analyses and instruments for overcoming social problems [13,17,18]; the interdependence of social and institutional factors and their place in the operational process of planning wind farms [14]; and the development

[2] The Multi-criteria Evaluation (MCE) method was developed in the early 1970s and today is considered a well-developed scientific field supported by a large number of scientific references [57,58]. When first developed, the MCE method was characterized by the methodological principle of decision making on the basis of multiple criteria with or without modest public participation [59]. The primary goal was to obtain clear information on which to base decisions, and then to solve a well-structured problem using mathematical algorithms. Progressively, ideas of procedural rationality [60] and a constructive or creative approach [61] have led to the development of MCE methods to the level that the whole concept of application is directed to the process of making optimal decisions, which inevitably includes public involvement in the MCE process [62,63]. In this context, proper consideration is a prerequisite for ensuring a quality outcome for the process. Today the MCE method is often recommended as a suitable support in the decision-making process, because of its capacity to point out in many ways multiple development alternatives based on the assessment of criteria connected with the environment and socioeconomic aspects of sustainable development [39].

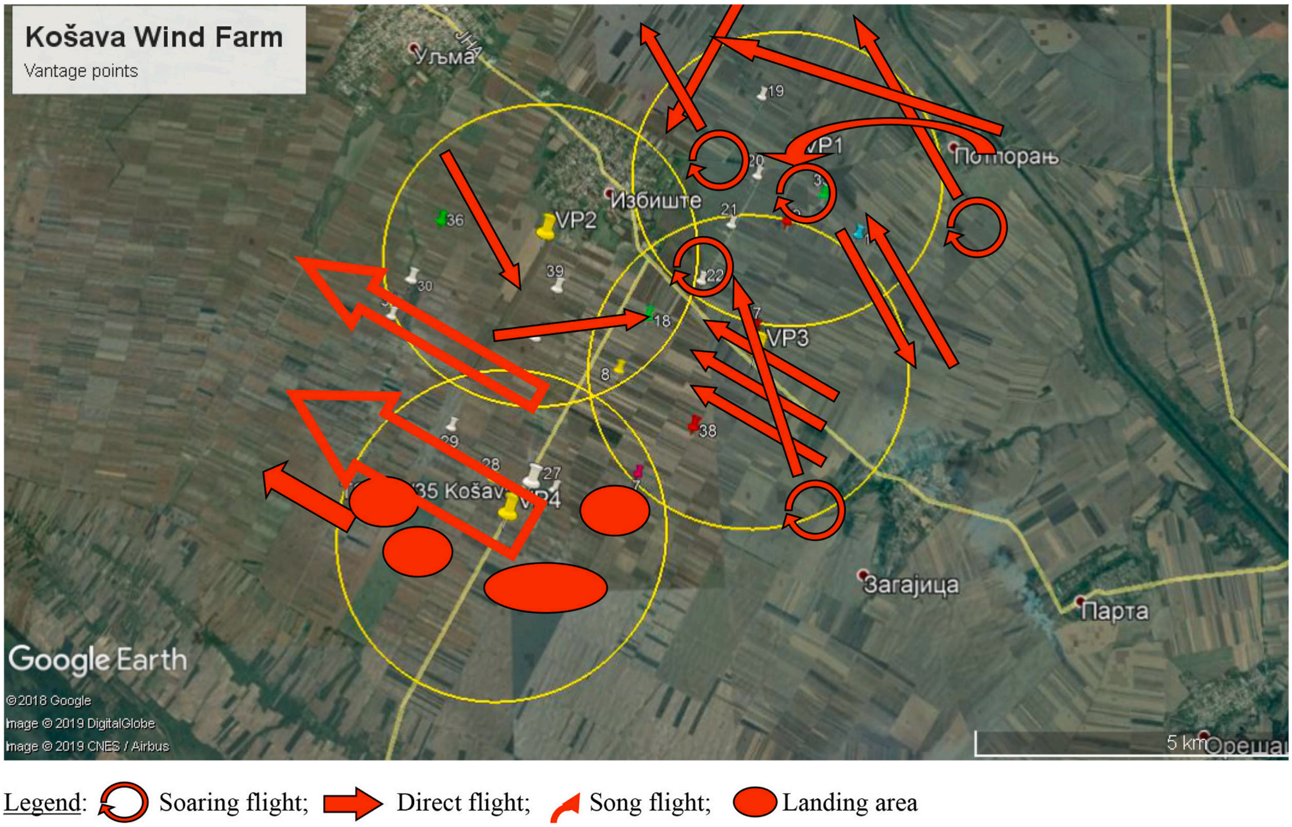

Fig. 2. Illustrative presentation of ornithofauna observations for the Košava wind farm for the target species *Haliaeetus albicilla* (from vantage points - VP).

of public awareness and education [16]. Bearing in mind the role of the SEA process in overcoming conflicts in space through the precautionary principle (which is also achieved through the alternative solutions), the significance of this aspect makes it indispensable in the SEA process when planning wind farms [46]. This by no means excludes social aspects from the ESIA process, which is a continuation of the SEA process, but it certainly eliminates most of the possible problems and conflicts in the later stages of project implementation.

A comparison between the application of SEA and EIA/ESIA in the Košava wind farm project in Serbia (Table 1) confirms the findings presented in this section. The key decisions that achieve the precautionary principle and prevent conflicts in space are made in the SEA process, thus reducing the risks in the project's development. What can be further concluded is that, if there is continuity in the development of these two documents, then EIA/ESIA is actually a verification instrument for the SEA process, supplemented with detailed technical data on the impact of the project that is methodologically adapted to international financial requirements. In addition, some of the results from the SEA process (such as observations of flying fauna, or the results of modeling noise and flickering shadows, for example) can also be used for EIA/ESIA and thus facilitate and speed up, i.e. shorten, the whole process of assessing the impact of the project on the environment and social factors. It has also been shown that making appropriate decisions on key issues related to environmental protection and acceptance of a wind farm project by the local community is facilitated when there is a continuous and transparent process that begins at the earliest stage of a project's development, namely, with the beginning of the SEA process.

3. SEA as an instrument for applying the precautionary principle in environmental protection in wind farm planning

Impact assessment in planning wind farms has its own specificities, which consequently result in specificities in the assessment of their environmental impact in the planning process. These specificities can be seen in the following facts:

- ➢ the planning document generally only covers one project (one wind farm);
- ➢ most technical details of the project are known in advance;
- ➢ although only one wind farm is usually planned, the space necessary for carrying out the project is significant, requiring extensive and complex spatial analyses.

These facts indicate that when planning wind farms there are elements that lead to the suggestion that it is sufficient to implement only EIA, and not SEA (one project – one location – known technical details of the project). This is of course always a tempting option for wind farm investors, who always want to save time. Going straight to EIA without implementing the SEA process seems like an excellent possibility [46].

However, there are two key arguments for carrying out SEA when planning wind farms:

1. application of the precautionary principle is only possible if, at the level of planning of wind farms through the SEA process, it affects the spatial determination of micro-locations for wind farm facilities, which is achieved through the analysis of different alternative solutions for spatial development; and
2. credit institutions providing funds to investors for carrying out wind farm projects pay particular attention to the environmental and social impact of the project (financial risk assessment), so it appears that application of the precautionary principle within the SEA procedure is the only correct way. Applying SEA in planning wind farms can make the possible environmental and social impacts of the projects acceptable to creditors (an economic argument is often crucial to choosing the right approach to carrying out projects).

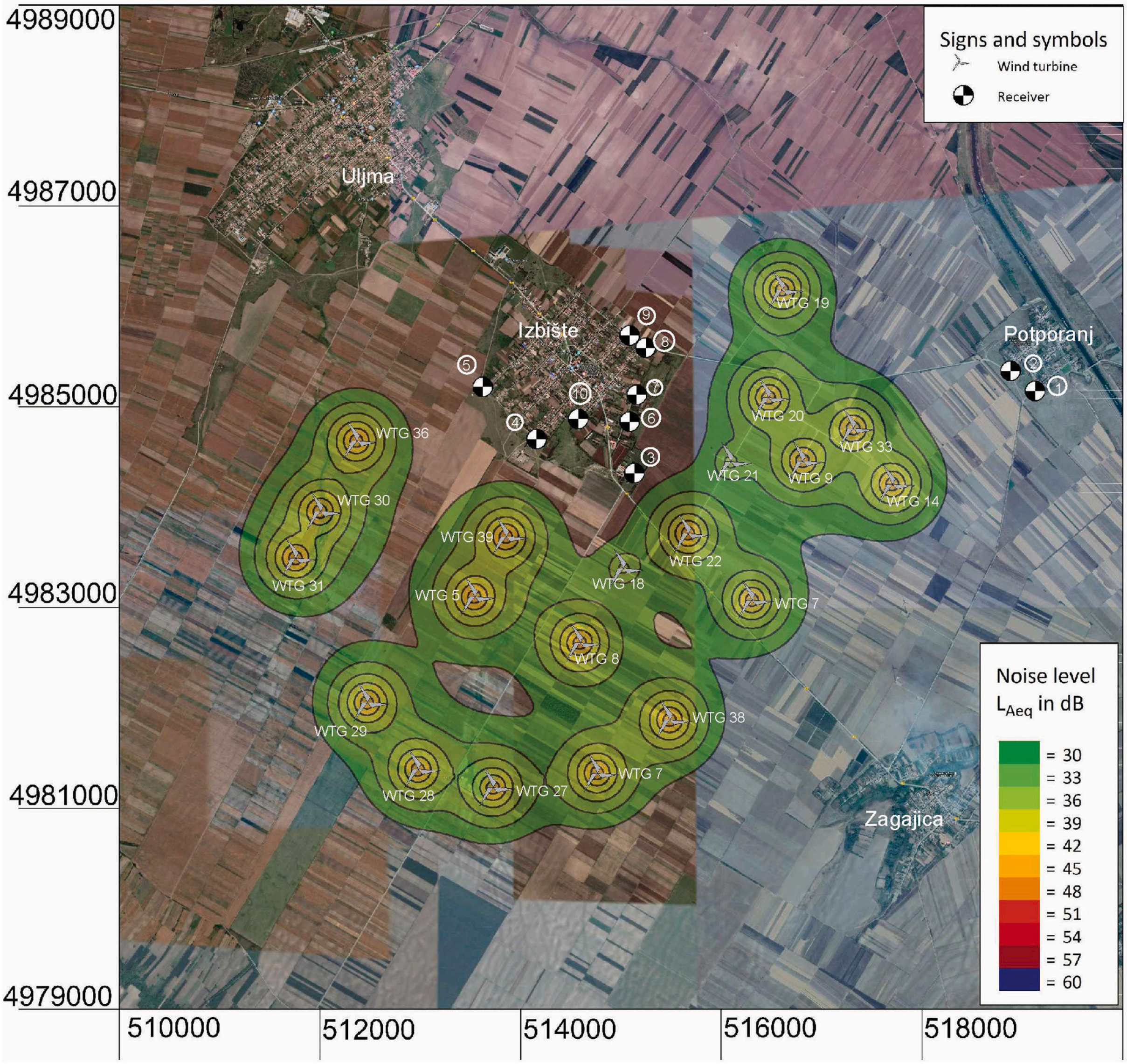

Fig. 3. Model of spatial noise distribution for the Košava wind farm in Serbia. a) At wind speeds of 8 m/s and b) at wind speeds of 20 m/s.

If, on the basis of the above facts, we accept that SEA is an indispensable instrument in planning wind farms and applying the precautionary principle with regard to environmental protection, an approach which the authors adhere to, then it is possible to analyze the possibilities in planning wind farms and the application of SEA in that process.

The first and most favourable circumstance is planning the development of the wind energy sector at the national or regional level. In this case, SEA can achieve its full capacity at the strategic planning level in such a way that it can consider the spatial capabilities of large or a large number of wind farms at the national or regional level, with all their possible implications for space and the environment. Using this approach, it is also possible to consider the cumulative and synergistic impacts of wind farms and their interaction, as well as their interaction with existing activities in the research area, which is traditionally a significant contribution of SEA. The results of SEA carried out in this way would be an outstanding contribution to determining the optimal number and distribution of wind farms at a national or regional level. Though it is not unusual in the world for a wind energy development strategy to be conceptualized at the national level, it is usually part of the national energy development strategy, or only individual spatial aspects are considered (e.g. *Spatial Planning for Onshore Wind Turbines – natural heritage Considerations, 2015*) [64], without any spatial analysis for locating wind farms. However, there are also cases in which the concept of spatial planning has been applied to the wind energy sector, but which are based on analysis of the relationship between the planned wind farms (which are not micro-location determined) and certain environmental elements (protected natural area, viewshed, etc.) without the use of SEA as a control instrument in the planning process [65,66]. This is not unusual, bearing in mind that the construction of wind farms depends on individual initiatives that are not known in advance to the creators of spatial developments at the national or regional level. Namely, it is difficult to know in advance the number of initiatives for constructing wind farms, and it is especially difficult to know the capacity of these wind farms, so this situation seems like only a good idea [46].

Another circumstance is planning wind farms at the local level, for the needs of a specific project (as in the case of the Košava wind farm), which is almost always the situation in practice. In this case, all of the circumstances for the application of SEA in planning are known (micro-location, capacity, number of wind turbines). Thus, the primary role of SEA in the planning process here is to determine the micro-location of individual wind turbines in relation to the spatial relationships,

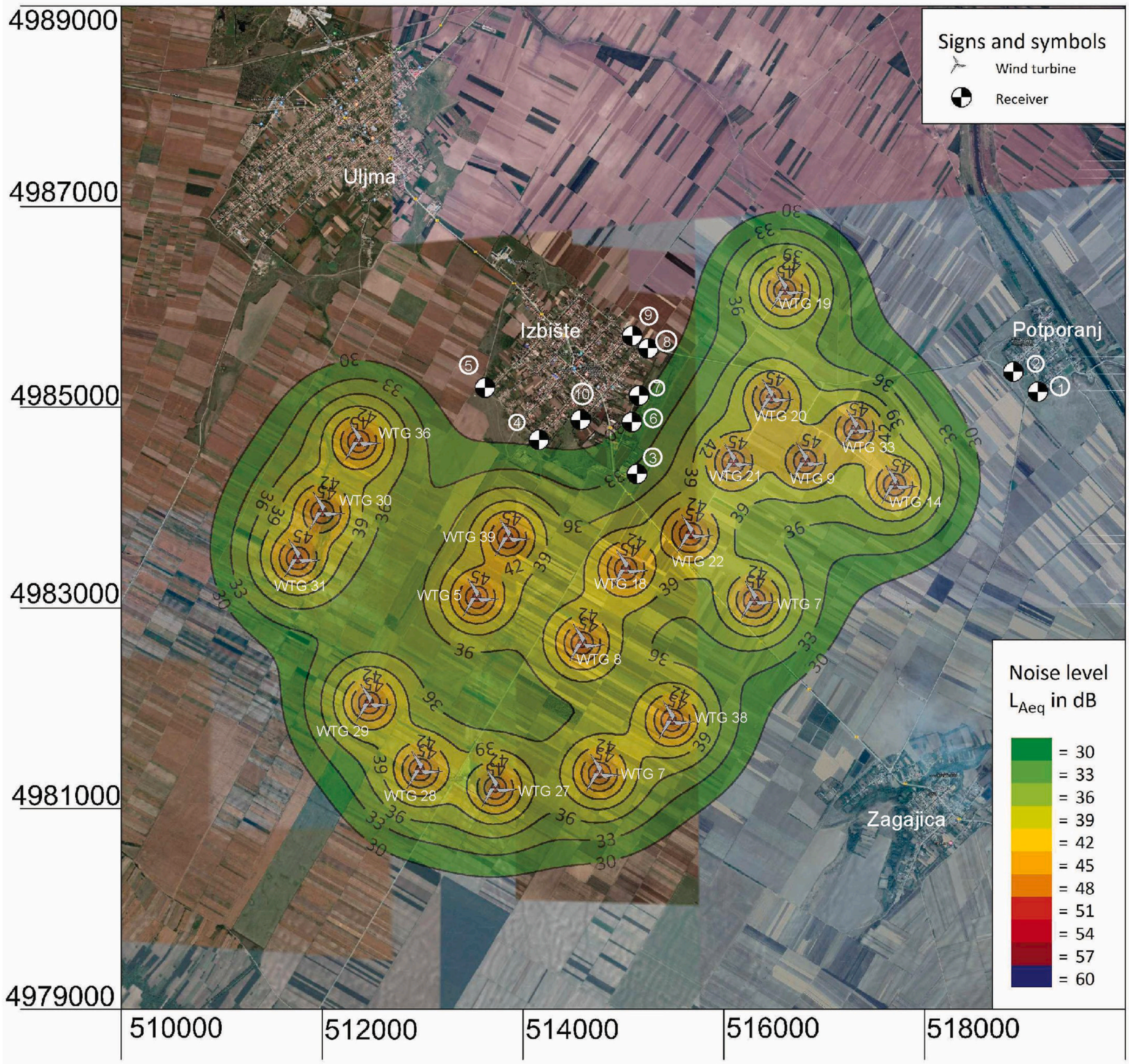

Fig. 3. (*continued*).

phenomena and processes at a particular location. Although it seems as if this second situation is limiting with regard to the application of SEA and its full contribution, the reality is actually different. Namely, by applying SEA in the planning of individual wind farms it is possible to cover all areas of the SEA, also including analysis of the possible solutions which in this case can relate e.g. to the number of wind turbines (larger number of smaller or smaller number of larger wind turbines) or the construction phase (which leaves space for the flora and fauna at the location to adapt to the new circumstances, so-called adaptability).

The application of SEA in planning wind farms, regardless of the given circumstances, is based on guidelines for selecting the best options for minimizing or completely preventing potential conflicts in space that may arise in the correlation between wind farms and environmental elements and the population of local communities (social aspects). The best options are sought in the analysis of the spatial relationships between wind farms and: ornithofauna and chiropterofauna; facilities, settlements, the local population (impact of noise, impact on the viewshed with the effect of shadow flickering, impact in case of an accident); and infrastructure (impact in case of an accident) (Table 2).

Table 2 shows the processing of key elements and activities in the SEA process for seven wind farms in Serbia in the period from 2007 (starting with the Bavanište project) until 2017 (when the SEA for Košava wind farm was carried out, the results of which are partially used in this paper). In terms of processing the elements and activities in the SEA process, it is evident that in the initial experience of applying SEA in the planning of wind farms in Serbia, not all aspects were processed through which the precautionary principle can be achieved. Certain aspects, such as the impact on ornithofauna and chiropterofauna, were processed only to respect the form, without proper observations being made. Therefore, the results cannot be completely representative, which reflects on the quality of the SEA process, and on the quality of the project itself. The focus was placed on assessing the impact of wind farms on basic environmental factors, and the use of software models for partial impact assessments did not exist at the time, but rather assessment was based on the literature and empirical data (without including the specifics of the location, topography, physical barriers, etc.). There was no analysis of social and economic aspects, nor were the potential benefits of implementing the project presented to the local community. All of this limited SEA from achieving its full contribution in the precautionary principle and preventing spatial conflict. Over time, after educating employees in local institutions, experts and the population, and then involving international financial institutions in the financing of

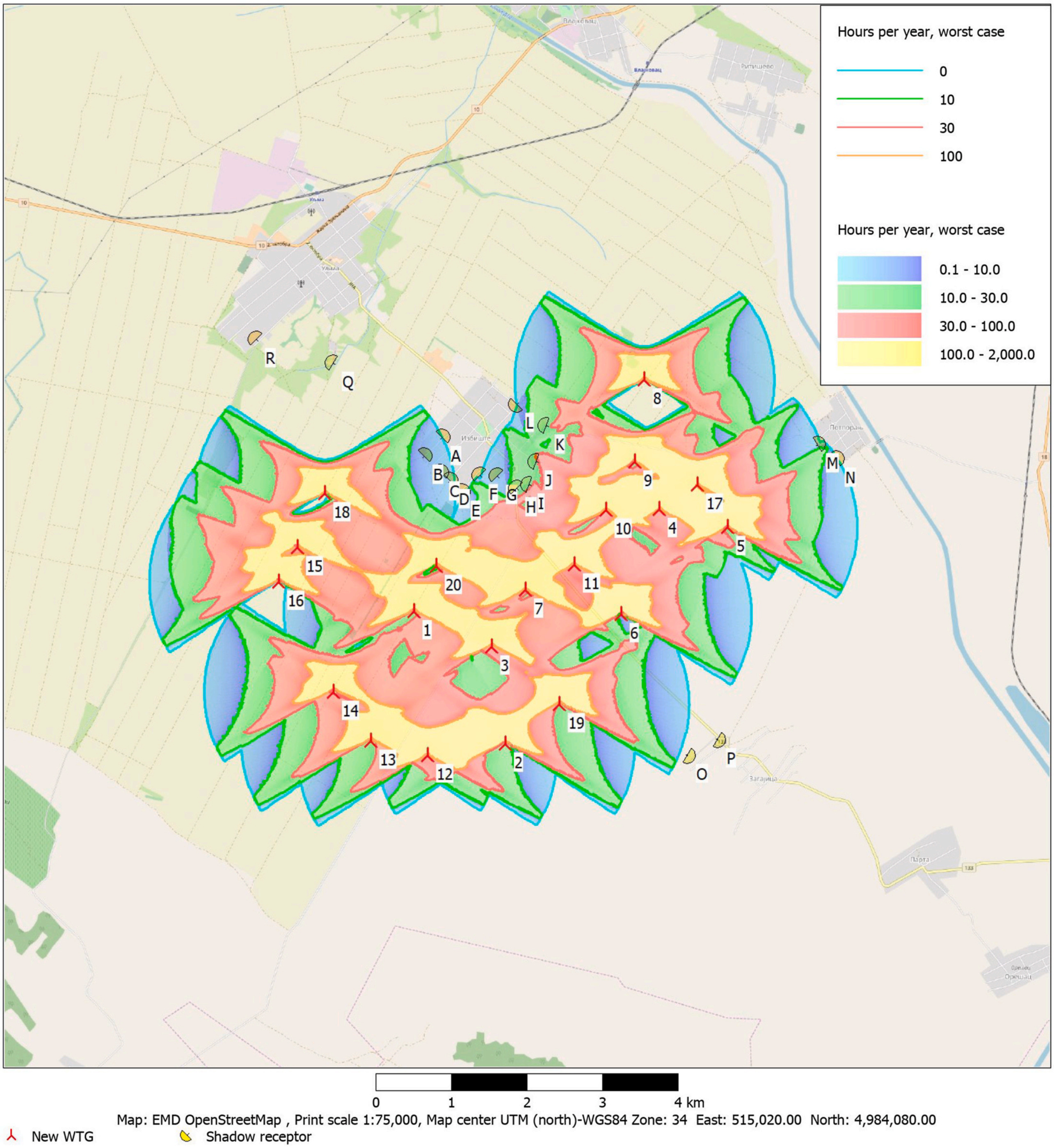

Fig. 4. Modeling the flickering shadows for the Košava wind farm in Serbia.

projects, the SEA process and its role in planning wind farms in Serbia began to achieve its full potential from 2013, in an expert, methodological, content and procedural sense. In this context, SEA, with its precautionary principle, stood out as an ideal instrument for assessing the spatial/territorial impacts of wind farms on the environment, that is, as an instrument for making optimal decisions on the sustainable development of wind energy in a specific space. Software models for determining territorial impacts on the environment were also applied to social factors, through the selection of optimal alternative solutions for the spatial disposition of wind turbines. The decision-making procedure became transparent at all stages of the SEA process, and for what initially posed a major challenge, namely, making the final decision on implementing the propositions from the planning and the SEA process, it was proved that in the case of private investment (which is the case for all wind farm projects in Serbia), decision makers unconditionally accept the word of experts. This is often not the situation when it comes to state/national development projects, when politics usually comes before the opinion of experts and it is possible for decisions to be made that are not optimal from the standpoint of environmental impact or social development.

4. Discussion and conclusions

Today there are a large number of different environmental impact

Table 1
Comparison of the elements and impact assessment methods in SEA and EIA/ESIA for the case study of Košava wind farm in Serbia.

PROJECT NAME	DOCUMENT NAME	KEY METHODOLOGICAL STEPS					
		Conducting one-year observations of flora and fauna with impact assessment	Analysis of the alternative solutions (precautionary principle)	Method used to present the assessment results	Analysis of cumulative and synergistic impacts	Analysis of the social impacts and the active role in preventing conflict	Transparency in the decision-making phase
KOŠAVA WF	**SEA**	One-year observations were carried out with impact assessment and the recommendation for new positions and the removal of other positions	The alternative solutions for the spatial disposition of the wind turbines were analyzed in line with the results of the observations of flora and fauna, which were harmonized with the results of modeling the spatial dispersion of noise and the effects of shadow flickering.	A semi-quantitative approach to the evaluation and presentation of the assessment results was used. The results based on software modeling have quantitative results, while other results are based on qualitative expert assessments of the probability, duration and frequency of the impact.	The cumulative or synergistic impacts were considered, which can occur as a consequence (negative impact) or a result (positive impact) of the interaction between planned and existing activities in the wider area.	A series of activities were carried out to prevent social impacts and possible conflicts during the SEA process. In addition to surveying the local population, SEA was one type of medium for proposing and finding the best options (primarily spatial-organizational and economic) for the implementation of the project.	Transparency was secured in all key phases of the SEA process (selecting the best alternative solution for the spatial organization of the wind farm, resolution of spatial conflicts, directing the planning process towards environmental protection goals and prevention of negative social implications, deciding on the acceptability of the planning document from the aspect of sustainability).
	EIA/ESIA	The data on the one-year observation was taken from the SEA, given that because of the continuity on the processing, there was no time vacuum that would call into question the accuracy of the existing data.	Verification was carried out for the alternative solution adopted for the spatial organization of the wind farm during the SEA process and planning of the wind farm (verification instrument)	A quantitative approach to the evaluation and presentation of results was used based on the results of modeling and exact technical data on the project.	The focus was on the project itself, without considering the interactions with the wider environment, i.e. without additional consideration of cumulative and synergistic impacts.	All potential social conflicts were prevented during the implementation of the SEA procedure, which is why they were not processed further, but rather the results of the SEA process for eliminating conflict were interpreted.	Complete transparency was secured in all phases of the EIA/ESIA process (decision-making phases on: the need for the process, the scope and content of the EIA/ESIA study, giving consent for the EIA/ESIA study and obtaining a construction permit).

assessment tools in use worldwide that can be applied to wind farm projects. Compared to other methods and instruments for environmental impact assessment that are mainly project oriented (EIA, ESIA, LCA, and others) and imply that the project development is near completion (there is no uncertainty with regard to determining the micro-location of the project), SEA represents a contribution towards integrating the impacts into the strategic level of planning. This enables the use of SEA to achieve the precautionary principle in the true sense of the word. Applying the precautionary principle is only possible in the phase preceding the design and implementation (construction) of specific investment projects, i.e., during the phase in which the spatial determination of the planned activities takes place, which is precisely the spatial planning phase and process of the development.

If the planning process takes place without SEA, then in that case EIA/ESIA is the first and last opportunity for implementing environmental protection policies in wind farm projects. It is then very difficult without risk to the project, or without financial consequences for the investors or the environment and local communities, to devise sustainable solutions if this is not done in the stage of producing the planning documentation. The reason is that in the design phase the project development has already gone a long way. On the other hand, EIA is a very functional instrument for controlling the technical (not planning) part of the project because at the level of project development all of the various inputs are available that are used for different modeling to determine the environmental impacts of wind farms (e.g. noise modeling or shadow flicker modeling) [56,65]. All of the above points to the need for continuous impact assessment at all stages of wind farm projects by implementing a preventive approach to protection using SEA at the earliest stage of project planning, and also after that, EIA for determining the technical measures of environmental protection during the development of project documentation.

The application of SEA in planning wind farms is based on guidelines for the best options for minimizing or completely preventing potential conflicts in space that may arise in the correlation of wind farms with environmental and social elements. The best options are sought in the analysis of the spatial relationships between wind farms and: ornithofauna and chiropterofauna; facilities, settlements, habitats, and the local population (impact of noise, impact on the viewshed with the shadow flickering effect, impact in the case of accident); and infrastructure (impact in the case of accident). In this context, SEA stands out as an ideal instrument for assessing the spatial/territorial impacts of wind farms on the environment and minimizing the risks involved in project financing for wind farms, which is of particular importance to the investors themselves.

In the case of the SEA for the Košava wind farm project, which stands out from Table 2 as a representative sample and an example of good practice, the results of which are partly used in this paper, special attention was given to considering the previously mentioned spatial impacts. Since some of the greatest potential impacts of wind farms are on flora and fauna, particular attention was paid to them during the development of Košava wind farm. Observations took place over the period of one year before the final definition of the spatial layout, which were then continued in the construction and operational phases of the wind farm. Based on the observations made for the SEA, it was

Table 2
Elements and activities in the SEA process for planning wind farms in Serbia.

PROJECT NAME	KEY ELEMENTS AND ACTIVITIES IN THE SEA PROCESS									DECISION-MAKING PROCESS		
	Environmental elements				Socio-economic aspects							
	One-year observations and the impact on flora	One-year observations and the impact on fauna	Impact on the viewshed and visibility	Impact on basic environmental factors (water, air, land)	Modeling of noise and shadow flicker in assessing the impact on the population	Impact on local population, buildings and infrastructure in case of an accident	Survey of population on acceptability of the project and land use change	Economic benefit for local communities	Economic benefit for landowners	Transparency of decision making on the alternative solutions	Transparency of decision making on the final planning solutions	Acceptance of recommendations from the SEA process
Bavanište WF (2007)	/	/	/	✓	/	/	/	/	/	/	/	✓
Čibuk WF (2010)	/	✓	/	✓	/	/	/	/	✓	/	✓	✓
Indjija WF (2011)	/	/	/	✓	/	/	/	/	✓	/	✓	✓
Kanjiža WF (2012)	/	/	/	✓	/	/	✓	/	✓	✓	✓	✓
Nikine Vode WF (2013)	/	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bela Anta WF (2016)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Košava WF (2017)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
legend	√ - processed in SEA			/- not processed in SEA								

concluded that the biodiversity in the location for the Košava wind farm was already significantly depleted. This was due to the space being completely anthropogenically changed through decades of active agricultural production, resulting in the flora, with the exception of agricultural crops, being very scarce. The situation with regard to flying fauna was different to an extent, which was confirmed by detailed and continuous monitoring of the ornithofauna (using the census method at observation points and, to a lesser extent, the limited transect method) and chiropterofauna (ultrasonic manual audio detection using the transect method and research of potential habitats used by bats). During 120 field days over a year, which were aligned with the dynamic of the SEA in their final phase, representatives of 106 bird species were identified, as well as two other genera that could not be identified up to species level. Representatives of many of the recorded species were present in extremely small numbers. Out of the stated number, 30 species are classified as targeted with regard to their national and international importance, as well as on the basis of their susceptibility to risk because of their specific bionomy, behavior, and manner and height of flight, and the possible destruction of their habitat due to the construction of the wind farm. Many of the species recorded did not belong to the research location sensu stricto, but rather their presence was a result of wetlands and aquatic habitats on the margins and around the location. In addition, it was determined that at least 16 species of bats were represented at the location.

The abundance of data resulting from the above observations was used in the SEA study for the Košava wind farm to assist in developing solutions for the spatial micro-locations of the wind turbines. The SEA process made a significant contribution to the application of the precautionary principle in the protection of flying fauna by eliminating three initially planned wind turbines (from a total of 35), and moving five turbines from their initially defined position to a location more suitable in terms of their impact on flying fauna. The results of modeling were also taken into account, i.e., the partial assessment of the impact of noise and shadow flickering, thus avoiding the elimination of one potential impact causing an increase in another impact. In this way, a holistic approach was achieved, which ensured the optimal spatial distribution of the wind farm facilities on the area of the planned Košava wind farm, with the minimum negative effects on the environment and on social factors.

In the context of considering social impacts within the SEA process for the Košava wind farm, various approaches and instruments were applied to overcome potential problems with the local community. The approaches used were those proposed in studies by authors who have focused on this aspect of the impact of wind farms [6,10,11,13,14,16–18,46], and SEA was used as the medium for finding the best options for all stakeholders. Surveys and the transparency of the SEA process played a significant role in this context, as well as being a support in finding the best economic options that would make social impacts acceptable to all stakeholders. The special value of the SEA process is its consideration of social impacts and the possibility of overcoming problems in the initial planning phase.

Methodologically, some of these instruments are comprehensive, such as: LCA, EIA/ESIA and SEA, and some are based on the partial impact assessment of individual environmental elements. When talking about wind farm projects, this so-called partial impact assessment can be done in the form of a special impact assessment on: noise, thw viewshed, accident risk, ornithofauna, chiropterofauna, etc. Partial impact assessment for individual environmental elements is justified, however, only if it is an integral part of a unified environmental impact assessment that applies a holistic approach. It is the SEA instrument that implements a holistic approach to the consideration of both considering the interaction between the existing and planned purposes in a particular space, and where it is possible and necessary to use partial impact assessments as parts of the overall impact assessment within the SEA process.This is also necessary in order to minimize subjectivity in the process of expert evaluation, which is characteristic of SEA. These facts additionally affect the quality of the SEA process in the planning and spatial determination of wind farms, and are thus significant when carrying out such projects. This experience was also confirmed in the practice of applying SEA in the planning of wind farms in Serbia.

Given that SEA is used at the strategic planning level, where it is possible to apply the precautionary principle through the selection of optimal alternative solutions, it seems that SEA is an ideal and indispensable instrument for effective environmental protection and preventing social conflicts with the local community in the planning and implementation of wind power projects. In addition its application also indicates the positive impacts of wind farms on the environment and social factors that have a broader context and go beyond the scope of a planning document, which is of particular importance for understanding the need to continue development trends in the field of wind energy.

A fact that can be put in a negative context with regard to SEA relates to the assessment of those environmental elements that cannot be carried out by partial assessment or by applying different models that are part of the universal semi-quantitative method of multi-criteria evaluation in SEA. There are two possible biases in this: 1. in impact assessment based on the subjectivity of expert opinions; and 2. in decision making based on the results of the SEA process. In this context, and given that the basic characteristic of qualitative expert methods is subjectivity, it is necessary within the framework of SEA to apply optimal techniques and tools by means of which the greatest possible objectivity will be achieved in assessing the environmental impact of wind farms (simulation models, GIS technologies, etc.). When it comes to subjectivity in decision making based on the results of the SEA process, it is beyond the reach of experts in this field and depends on political, financial and other aspects, which can certainly be a threat to the implementation of SEA proposals, but based on the experience from Serbia, it can be concluded that these threats are not expressed in the context of private investors (which is the case in wind energy in Serbia), unlike when decisions are made in relation to state/national projects.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Phylip-Jones J, Fischer TB. Strategic environmental assessment (SEA) for wind energy planning: lessons from the United Kingdom and Germany. Environ Impact Assess Rev 2015;50:203–12. https://doi.org/10.1016/j.eiar.2014.09.013.

[2] Josimović B, Pucar M. The strategic environmental impact assessment of electric wind energy plants: case study ’bavaniste’ (Serbia). Renew Energy 2010;35:1509–19. https://doi.org/10.1016/j.renene.2009.12.005.

[3] Diez-Rodríguez JJ, Fischer TB, Di Zio S. Introducing a group spatial decision support system for use in strategic environmental assessment of onshore wind farm development in Mexico. J Clean Prod 2016;220:1239–54. https://doi.org/10.1016/j.jclepro.2019.01.154.

[4] Gorayeb A, Brannstrom C, Jeovah A, Meireles A, Mendes JS. Wind power gone bad: critiquing wind power planning processes in northeastern Brazil. Energy Research & Social Science 2018;40:82–8. https://doi.org/10.1016/j.erss.2017.11.027.

[5] Thygesen J, Agarwal A. Key criteria for sustainable wind energy planning—lessons froman institutional perspective on the impact assessment literature. Renew Sustain Energy Rev 2014;39:1012–23. https://doi.org/10.1016/j.rser.2014.07.173.
[6] Vagiona D, Karapanagiotidou X. Strategic environmental impact assessment for onshore wind farm siting in Greece. Environments 2019;6:94. https://doi.org/10.3390/environments6080094.
[7] Dai K, Bergot A, Liang C, Xiang WN, Huang Z. Environmental issues associated with wind energy – a review. Renew Energy 2015;75:911–21. https://doi.org/10.1016/j.renene.2014.10.074.
[8] Brannstrom C, Gorayeb A, Mendes JS, Loureiro C, Jeovah A, Meireles A, Silva VE, Ribeiro de Freitas AL, Oliveira FR. Is Brazilian wind power development sustainable? Insights from a review of conflicts in Ceará state. Renew Sustain Energy Rev 2017;67:62–71. https://doi.org/10.1016/j.rser.2016.08.047.
[9] Saidur R, Rahim NA, Islam MR, Solangi KH. Environmental impact of wind energy. Renew Sustain Energy Rev 2011;15:2423–30. https://doi.org/10.1016/j.rser.2011.02.024.
[10] Shamsuzzoha AHM, Grant A, Clarke J. Implementation of renewable energy in Scottish rural area: a social study. Renew Sustain Energy Rev 2012;16:185–91. https://doi.org/10.1016/j.rser.2011.07.146.
[11] Juárez AA, Araújo AM, Rohatgi JS, Filho ODQO. Development of the wind power in Brazil: political, social and technical issues. Renew Sustain Energy Rev 2014;39:828–34. https://doi.org/10.1016/j.rser.2014.07.086.
[12] Carneiro FOM, Rocha HHB, Rocha PAC. Investigation of possible societal risk associated with wind power generation systems. Renew Sustain Energy Rev 2013;19:30–6. https://doi.org/10.1016/j.rser.2012.11.006.
[13] Varela-Vázquez P, Sánchez-Carreira MC. Socioeconomic impact of wind energy on peripheral regions. Renew Sustain Energy Rev 2015;50:982–90. https://doi.org/10.1016/j.rser.2015.05.045.
[14] Agterbosch S, Meertens RM, Vermeulen W. The relative importance of social and institutional conditions in the planning of wind power projects. Renew Sustain Energy Rev 2009;13:393–405. https://doi.org/10.1016/j.rser.2007.10.010.
[15] Enevoldsen P, Sovacool B. Examining the social acceptance of wind energy: practical guidelines for onshore wind project development in France. Renew Sustain Energy Rev 2016;53:178–84. https://doi.org/10.1016/j.rser.2015.08.041.
[16] Caporale D, De Lucia C. Social acceptance of on-shore wind energy in apulia region (southern Italy). Renew Sustain Energy Rev 2015;52:1378–90. https://doi.org/10.1016/j.rser.2015.07.183.
[17] Kim H-J, Kim J-H, Yoo S-H. Social acceptance of offshore wind energy development in South Korea: results from a choice experiment survey. Renew Sustain Energy Rev 2019;113:109253. https://doi.org/10.1016/j.rser.2019.109253.
[18] Brannstrom C, Gorayeb A, Mendes JS, Loureiro C, Jeovah A, Meireles A, Silva VE, Ribeiro de Freitas AL, Oliveira FR. Is Brazilian wind power development sustainable? Insights from a review of conflicts in Ceará state. Renew Sustain Energy Rev 2017;67:62–71. https://doi.org/10.1016/j.rser.2016.08.047.
[19] Dai J, Yang X, Wen L. Development of wind power industry in China: a comprehensive assessment. Renew Sustain Energy Rev 2018;97:156–64. https://doi.org/10.1016/j.rser.2018.08.044.
[20] European Commission. EU Guidance on wind energy in accordance with the EU nature legislation. 2010. http://ec.europa.eu/environment/nature/natura2000/.
[21] Al-Behadili SH, El-Osta WB. Life Cycle assessment of dernah (Libya) wind farm. Renew Energy 2015;83:1227–33. https://doi.org/10.1016/j.renene.2015.05.041.
[22] Al Zohbi G, Hendrick P, Bouillard Ph. Evaluation of the impact of wind farms on birds: the case study of Lebanon. Renew Energy 2015;80:682–9. https://doi.org/10.1016/j.renene.2015.02.052.
[23] Garcia DA, Bruschia D. A risk assessment tool for improving safety standards and emergency management in Italian onshore wind farms. Sustainable Energy Technologies and Assessments 2016;18:48–58. https://doi.org/10.1016/j.seta.2016.09.009.
[24] Gallo P, Fredianelli L, Palazzuoli D, Licitra G, Fidecaro F. A procedure for the assessment of wind turbine noise. Appl Acoust 2016;114:213–7. https://doi.org/10.1016/j.apacoust.2016.07.025.
[25] Lenchine V. Assessment of amplitude modulation in environmental noise measurements. Appl Acoust 2016;104:152–7. https://doi.org/10.1016/j.apacoust.2015.11.009.
[26] Zhang Y, Tang N, Niu Y, Du X. Wind energy rejection in China: current status, reasons and perspectives. Renew Sustain Energy Rev 2016;66:322–44. https://doi.org/10.1016/j.rser.2016.08.008.
[27] Maslov N, Claramunt C, WangaT Tanga T. Method to estimate the visual impact of an offshore wind farm. Appl Energy 2017;204:1422–30. https://doi.org/10.1016/j.apenergy.2017.05.053.
[28] Newson S, Evansa H, Gillingsa S, Jarretta D, Raynor R, Wilsona M. Large-scale citizen science improves assessment of risk posed by wind farms to bats in southern Scotland. Biol Conserv 2017;215:61–71. https://doi.org/10.1016/j.biocon.2017.09.004.
[29] Farfán M, Duarte J, Real R, Muñoz A, Fa J, Vargas J. Differential recovery of habitat use by birds after wind farm installation: a multi-year comparison. Environ Impact Assess Rev 2017;64:8–15. https://doi.org/10.1016/j.eiar.2017.02.001.
[30] Roemer C, Disca T, Coulonac A, Basac Y. Bat flight height monitored from wind masts predicts mortality risk at wind farms. Biol Conserv 2017;215:116–22. https://doi.org/10.1016/j.biocon.2017.09.002.
[31] Parisé J, Walker TR. Industrial wind turbine post-construction bird and bat monitoring: a policy framework for Canada. J Environ Manag 2017;201:252–9. https://doi.org/10.1016/j.jenvman.2017.06.052.
[32] Josimović B, Crnčević T. The development of renewable energy capacities in Serbia: case study of three small hydropower plants in the “Golija” biosphere reserve with special reference to the landscape heritage. Renew Energy 2012;48:537–44. https://doi.org/10.1016/j.renene.2012.06.015.
[33] Munn RE. Environmental impact assessment: principles and procedures/. for Scope by R. E. Munn, 1979 Bookmark: https://trove.nla.gov.au/version/45660346.
[34] Muralikrishna IV, Manickam V. Chapter Six – Environmental Impact Assessment and Audit. Environmental Management-Science and Engineering for Industry; 2017. p. 77–111. https://doi.org/10.1016/B978-0-12-811989-1.00006-3.
[35] EIA Directive (85/337/EEC). http://ec.europa.eu/environment/eia/eia-legalcontext.htm.
[36] Fischer T. Strategic Environmental Assessment in Transport and Land Use Planning. London: Earthscan Publications; 2002, ISBN 9781853838118.
[37] Dalal-Clayton B, Sadler B. Strategic environmental assessment: a sourcebook and reference guide to international experience. OECD, UNEP and IIED in association with Earthscan Publications; 2005.
[38] Mercier J, Ahmed K. EIA and SEA at the World Bank. Paper presented to Proceedings of the 8th Intergovernmental Policy Forum on Environmental Assessment in association with the IAIA. Vancouver: Canada; 2004.
[39] Josimović B, Marić I, Milijić S. Multi-criteria evaluation in strategic environmental assessment for waste management plan, A case study: the city of belgrade. Waste Manag 2015;36:331–42. https://doi.org/10.1016/j.wasman.2014.11.003.
[40] European Strategic Environmental Assessment Directive 2001/42/EC.
[41] Protocol on Strategic Environmental Assessment. UNECE; 2003.
[42] Geißler G, Köppel J, Gunther P. Wind energy and environmental assessments e A hard look at two forerunners' approaches: Germany and the United States. Renew Energy 2013;51:71–8. https://doi.org/10.1016/j.renene.2012.08.083.
[43] Smart DE, Stojanović TA, Warren CR. Is EIA part of the wind power planning problem? Environ Impact Assess Rev 2014;49:13–23. https://doi.org/10.1016/j.eiar.2014.05.004.
[44] Phillips J. A quantitative-based evaluation of the environmental impact and sustainability of a proposed onshore wind farm in the United Kingdom. Renew Sustain Energy Rev 2015;49:1261–70. https://doi.org/10.1016/j.rser.2015.04.179.
[45] Salhofer S, Wassermann G, Binner E. Strategic environmental assessment as an approach to assess waste management systems. Experiences from an Austrian case study. Environ Model Software 2007;22:610–8. https://doi.org/10.1016/j.envsoft.2005.12.031.
[46] Josimović B. Spatial aspects of the impact of wind farms on the environment. IAUS; 2020.
[47] Brown AL, Therivel R. Principles to guide the development of strategic environmental assessment. Impact Assess Proj Apprais 2000;18:183–9. https://doi.org/10.3152/147154600781767385.
[48] Balfors B, Wallström J, Lundberg K, Söderqvist T, Hörnberg C, Högström J. Strategic environmental assessment in Swedish municipal planning. Trends and challenges. Environ Impact Assess Rev 2018;73:152–63. https://doi.org/10.1016/j.eiar.2018.07.003.
[49] Unalan D, Cowell R. Strategy, context and strategic environmental assessment. Environ Impact Assess Rev 2019;79. https://doi.org/10.1016/j.eiar.2019.106305.
[50] Marsden S. Strategic environmental assessment: an international overview. In: Marsden S, Dovers S, editors. Strategic environmental assessment in Australasia. NSW7 The Federation Press; 2002. p. 1–23.
[51] Glasson J, Therivel R, Chadwick A. Introduction to Environmental Impact Assessment. Routledge; 2005.
[52] Jay S, Jones C, Slinn P, Wood C. Environmental impact assessment: retrospect and prospect. Environ Impact Assess Rev 2007;27:287–300. https://doi.org/10.1016/j.eiar.2006.12.001.
[53] Josimović B, Petrić J, Milijić S. The use of the Leopold Matrix in carrying out the EIA for wind farms in Serbia. Energy Environ Res 2014;4:43–54. https://doi.org/10.5539/eer.v4n1p43.
[54] Podimata M. Methodological approach to EIA due to gas pipeline failure after an earthquake. The case study of the Trans Adriatic Pipeline. J Nat Gas Sci Eng 2016;35:1200–6. https://doi.org/10.1016/j.jngse.2016.09.043.
[55] Kalnins SN, Gusca J, Pubule J, Borisov A, Blumberga D. Applicability of combined project evaluation methodology to EIA projects. Energy Procedia 2016;95:424–8. https://doi.org/10.1016/j.egypro.2016.09.052.
[56] Liu A. Review on wind turbine noise mechanism and de-noising techniques. Renew Energy 2017;108:311–20. https://doi.org/10.1016/j.renene.2017.02.034.
[57] Kangas J, Kangas A. Multiple criteria decision support in forest management the approach-methods applied, and experiences gained. For Ecol Manag 2005;207:133–43. https://doi.org/10.1016/j.foreco.2004.10.023.
[58] Ananda J, Heralth G. A critical review of multi-criteria decision-making methods with special reference to forest management and planning. Ecol Econ 2009;68:2535–48. https://doi.org/10.1016/j.ecolecon.2009.05.010.
[59] Zionts S, Wallenius J. An interactive programming method for solving the multiple criteria problem. Manag Sci 1976;22:652–63. https://doi.org/10.1287/mnsc.22.6.652.
[60] Simon E. From substantive to procedural rationality. In: Latsis JS, editor. Methods and Appraisal in economics. Cambridge: Cambridge University Press; 1976.
[61] Roy B. Méthodologie multicritere d' aide à la decision. Paris: Economica; 1985.
[62] Banville C, Landry M, Martel JM, Boulaire C. A stakeholder approach to MCDA. Syst Res Behav Sci 1998;15:15–32. https://doi.org/10.1002/(SICI)1099-1743(199801/02)15:13.0.CO;2-B.
[63] De Marchi B, Funtowicz O, Lo Cascio S, Munda G. Combining participative and institutional approaches with multicriteria evaluation. An empirical study for

water issues in Troina, Sicily. Ecol Econ 2000;34:267–82. https://doi.org/10.1016/S0921-8009(00)00162-2.
[64] Spatial Planning for Onshore Wind Turbines – natural heritage Considerations. 2015. https://www.nature.scot/sites/default/files/201910/Guidance%20%20Spatial%20Planning%20for%20Onshore%20Wind%20Turbines%20%20natural%20heritage%20considerations%20-%20June%202015.pdf.
[65] Baath LB. Noise spectra from wind turbines. Renew Energy 2013;57:512–9. https://doi.org/10.1016/j.renene.2013.02.007.
[66] Miler D, De Jong R, Morrice J, Horne P. Spatial planning of wind turbine developments in Wales. Macaulay Land Use Research Institute; 2002.