Waste Management 36 (2015) 331–342

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Multi-criteria evaluation in strategic environmental assessment for waste management plan, a case study: The city of Belgrade

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ARTICLE INFO

Article history:
Received 24 February 2014
Accepted 2 November 2014
Available online 25 November 2014

Keywords:
Multi-criteria evaluation
Strategic environmental assessment
Waste management plan

ABSTRACT

Strategic Environmental Assessment (SEA) is one of the key instruments for implementing sustainable development strategies in planning in general; in addition to being used in sectoral planning, it can also be used in other areas such as waste management planning. SEA in waste management planning has become a tool for considering the benefits and consequences of the proposed changes in space, also taking into account the capacity of space to sustain the implementation of the planned activities. In order to envisage both the positive and negative implications of a waste management plan for the elements of sustainable development, an adequate methodological approach to evaluating the potential impacts must be adopted and the evaluation results presented in a simple and clear way, so as to allow planners to make relevant decisions as a precondition for the sustainability of the activities planned in the waste management sector. This paper examines the multi-criteria evaluation method for carrying out an SEA for the Waste Management Plan for the city of Belgrade (BWMP). The method was applied to the evaluation of the impacts of the activities planned in the waste management sector on the basis of the environmental and socioeconomic indicators of sustainability, taking into consideration the intensity, spatial extent, probability and frequency of impact, by means of a specific planning approach and simple and clear presentation of the obtained results.

1. Introduction

The definition of Strategic Environmental Assessment (SEA) that describes it as a systematic process of evaluating the environmental consequences of the proposed policy, plan or program initiatives in order to ensure that they are fully included and appropriately addressed at the earliest appropriate stage of the decision-making process on a par with the economic and social considerations (Sadler and Verheem, 1996) can be considered the most general and the most comprehensive one. Since the 1990s, many authors (Maričić and Josimović, 2005; Nilssona et al., 2005; Nilsson and Dalkmann, 2001; Therivel and Partidario, 1996; Therivel, 1992; White and Noble, 2013 among others) have written about the role and importance of the SEA in creating policies in different spheres of social activities, as well as about its role in decision-making. The issue is therefore quite interesting, from both scientific and professional aspects, and is of great importance in creating any environmental policy. This is also supported by the fact that an increasing number of international financial institutions, such as the European Commission, World Bank, UNDP, UNEP and USAID, have developed instruments and imposed requirements for the implementation of the SEA for the purpose of checking and increasing the number of development initiatives in tune with the principles of sustainable development (Chaker et al., 2006; Dalal-Clayton and Sadler, 2005).

Strategic Environmental Assessment Directive 2001/42/EC prescribes the obligation to undertake SEA for plans, programs and framework documents[1] in different fields, thus also in the field of waste management. By carrying out an SEA in waste management planning, it is possible to consider the consequences of the proposed planning solutions and changes in space, while at the same time taking into account the needs of the users of the space and appreciating the subject environment. On the basis of this, adequate measures can be defined for the protection and monitoring of the potentially threatened elements of the environment, in addition to having public participation in all stages of the SEA process. In this context, SEA obviously contributes to the decision-making process for the waste

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[1] A framework document is a generic term for all kinds of documents and studies in the energy sector and in the fields of forestry, water management, waste management, agriculture, nature preservation, etc., representing a framework for future development projects.

http://dx.doi.org/10.1016/j.wasman.2014.11.003
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management planning (Arbter, 2005; Desmond, 2009; Josimović and Marić, 2012; Salhofer et al., 2007).

Compared to other methods which contribute to decision-making, such as the traditional "life cycle assessment" (Bjorklund and Finnveden, 2007; Bond et al., 2001; Laurent et al., 2013; Tukker, 2000), the SEA contributes to integrating the impacts at the strategic level of waste management (national, regional and, if necessary, international level). For the purpose of making good decisions regarding the sustainability of the solutions defined in the waste management plans, it is necessary to consider different aspects of the potential impacts. Multi-criteria analysis has been strongly advised by various authors with expertise in the energy sector (Finnveden et al., 2003), water management sector (Garfi et al., 2010) and in the SEA for waste management plans (Finnveden et al., 2003; Fischer, 2003; Jay, 2010; Salhofer et al., 2007; Wilson et al., 2004).

The subject of this paper is the application of the Multi-criteria Evaluation (MCE) method in carrying out the SEA. The MCE method developed in the early 1970s is now considered a well-developed scientific field, supported by abundant references (Ananda and Heralth, 2009; Figueira et al., 2005; Kangas and Kangas, 2005). When first developed, MCE was characterised by the methodological principle of multi-criteria decision-making (MCDM) with little or no participatory mechanisms included (Zionts, 1979; Zionts and Wallenius, 1976). The primary objective was to elicit clear preferences from a decision maker and then solve a well-structured problem by means of mathematical algorithms (e.g., to design an engine by taking into account its power, weight, and efficiency). Progressively, the ideas of procedural rationality (Simon, 1976) and the constructive or creative approach (Roy, 1985) led to the development of the multi-criteria decision aid (MCDA), in which the quality of the decision-making process became central. Research started to point out the need to include public participation in MCE (Banville et al., 1998; De Marchi et al., 2000; Proctor, 2004), thus fostering the emergence of participatory multi-criteria evaluation (PMCE) (Banville et al., 1998; Proctor and Drechsler, 2006) and social multi-criteria evaluation (SMCE) (Munda, 2005, 2008). In such a context, appropriate deliberation is a prerequisite to ensuring a quality outcome. Nowadays, the MCE method is often recommended as a convenient support in the decision-making process because of its capacity to point out in many ways multiple alternatives of development on the basis of assessing criteria related to the environment and socioeconomic aspects of sustainable development. (CL:AIRE, 2011; Linkov et al., 2006; Rosén et al., 2009, 2013; Sparrevik et al., 2011).

The MCE method was originally defined in a scientific research project themed "Method for Strategic Environmental Assessment in Planning" (2005–2007), and later developed through several still ongoing scientific research projects, all of which have been funded by the Ministry of Education and Science of the Republic of Serbia. The results obtained have been used in carrying out several strategic environmental assessments for strategically significant planning documents. This paper examines the possibility of using the said method in the SEA process for the Belgrade Waste Management Plan 2011–2020 (BWMP), by which a completely new, contemporary waste management system is being established in terms of both its functionality and its spatiality.

2. Initial position

An SEA was carried out for the purpose of the BWMP for the city of Belgrade, which comprises 14 municipalities. The city of Belgrade is a metropolitan area unique in Europe by its geographical and strategic position. It is geographically positioned at the contact point between two different geographical areas (the low Pannonian Basin to the north and the mountainous and hilly region to the south). Two large European rivers, both international waterways – the Sava and the Danube, run through the two said areas.

According to the Statistical Office of the Republic of Serbia for 2012, the population of the city of Belgrade is 1,621,396 and the estimated generation of solid waste in households approximately 1,801 tons per day. In the course of revising the waste management system before the implementation of the BWMP, several major waste management points and issues were raised (BWMP):

- out of 14 municipalities included in the BWMP, 11 municipalities dispose of their waste at the city's central landfill, while the remaining three have local landfills at their disposal;
- the city's central landfill does not fully comply with the Landfill Directive 1999/31/EC, while the municipal tips do not meet even minimum sanitary conditions for waste disposal, thus raising major ecological and social problems;
- there is no centrally organised recycling system, and so the recycling depends on individual initiatives;
- the waste is collected from around 80% of the territory and 90% of population;
- the institutional, organisational and financial aspects of the waste management in their present state cannot meet the requirements of an effective modern waste management system;
- the level of education for the public in the field of waste management is unsatisfactory.

The objective of the BWMP is to establish a completely new, sustainable and integrated waste management system to replace the old one, which is unsustainable, uneconomic, dysfunctional and inconsistent with the principles of environmental protection. This objective is to be achieved through the following eleven general priorities:

1. to widen and strengthen the administrative capacities of the city in the area of waste management;
2. to widen the territory from which the waste is collected to 100% before 2019;
3. to establish an efficient system of waste separation, its reuse and recycling;
4. to build a waste management centre and close and remediate the existing municipal landfills;
5. to build communal waste treatment facilities in Belgrade;
6. to build a green waste composting facility;
7. to build a facility for recycling waste from construction sites;
8. to build an animal waste treatment facility;
9. to build a biogas production facility;
10. to develop a system for financing waste management at the local level;
11. to raise public awareness of the importance of waste management.

The aim of carrying out the SEA for the BWMP was to direct the planning process towards the goals of sustainable development, i.e. towards achieving the objectives set in the SEA related to environmental protection and socioeconomic aspects of development. The results obtained served as a basis for decision-making on the sustainability of the BWMP and its adoption.

3. Methodological framework

An increasing number of theoretical studies in the field of environmental and waste management planning (Calvo et al. 2005; Christensen et al., 1999; Tchobanoglous and Kreith, 2002;

Tchobanoglous et al., 1993; McDougall et al., 2003) have been aimed directly at defining appropriate solid waste management systems and waste planning methods, primarily in urban centres and places with the high population density, such as the city of Belgrade. It seems that the methodological frameworks employed in the SEA process represent an important instrument for planning a sustainable waste management system (Salhofer et al., 2007). However, the concept of the SEA methodologies, unlike the diverse, precise, and highly operable tools used in environmental engineering or other science-based areas, is rather fuzzy (Liou et al., 2006). Some authors (Brown and Therivel, 2000; Partidario, 2000; Therivel, 1996) have argued that there is no generalized SEA methodology applicable to all plans. Moreover, in a straightforward sense, SEA techniques and methodologies should be treated as a set of tools in a "toolbox", out of which each user can choose their own tools depending on their particular needs (Brown and Therivel, 2000; Partidario, 2002). Based on the above considerations, SEA is becoming a blooming interdisciplinary cross-sector field, in which integration and teamwork are emphasized. Generally speaking, SEA techniques and methodologies derive from the traditional Environmental Impact Assessment (EIA) and policy appraisal/plan evaluation studies (Partidario, 2002; Sheate et al., 2001), ensuring that methodologies would not become a barrier for institutional promotion of the SEA (UNEP, 2002). A variety of possible techniques for conducting the different steps of SEA have been further analysed and discussed by others (DHV, 1994; Partidario, 2002; Sadler and Verheem, 1996; Therivel, 2004; UNEP, 2002). In addition, Marsden (2002) pointed out that, in terms of methodologies, SEA relies more on qualitative consideration and techniques than traditional EIA, and thus, expert judgment plays a more crucial role. 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 comparative studies of past schemes and applications (Liou et al., 2006).

The methodological framework for the SEA for BWMP is centered on a plan-based approach and the use of multi-criteria evaluation of the planned activities and strategic determinants in relation to the capacity of space as a basis for the valorization of space earmarked for sustainable development (Josimović, 2007). The procedure and methodological framework for the SEA are shown in Fig. 1.

As shown in Fig. 1, the task in the initial stage of the SEA process was deciding on its scope. Such a decision was reached with the

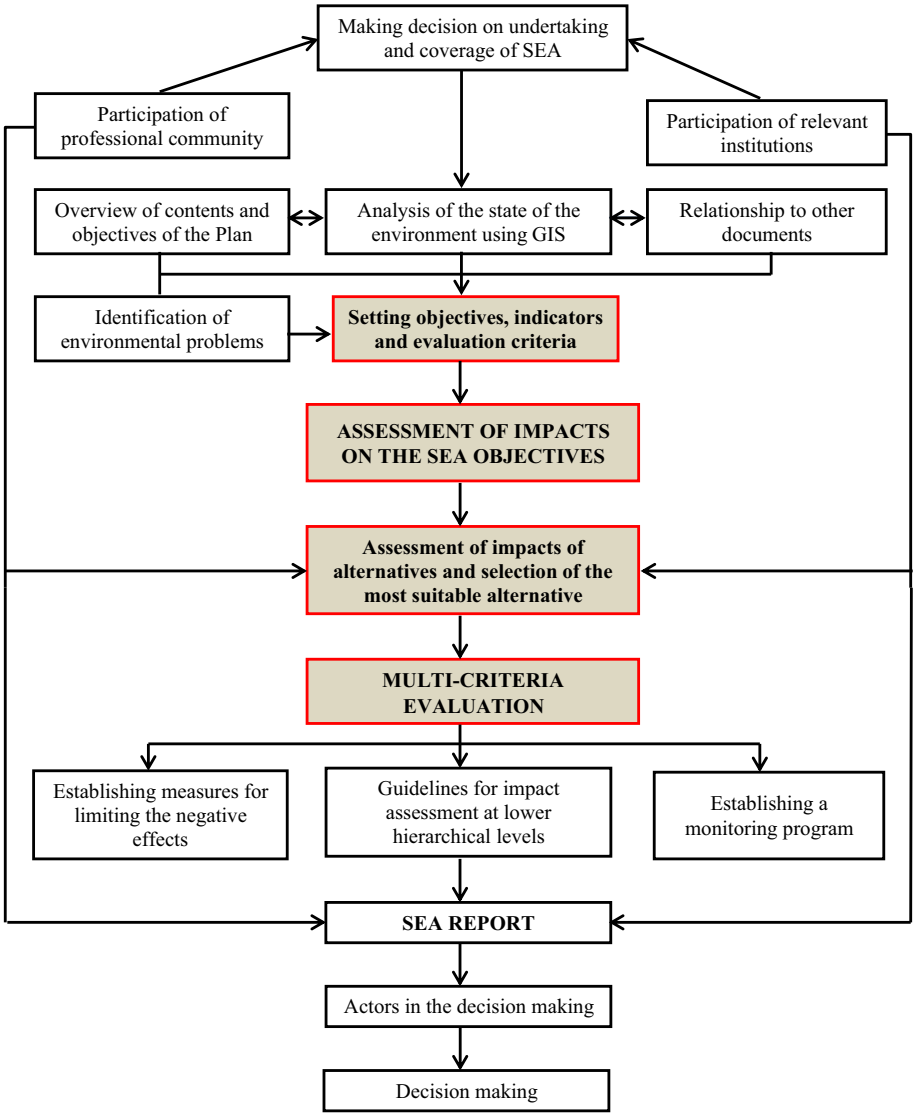
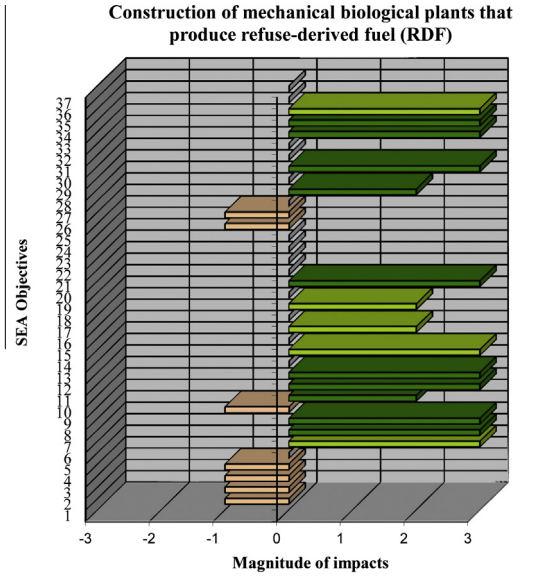


Fig. 1. Procedure and methodological framework for the SEA.

participation of the professional community and the relevant institutions. This stage was followed by an analytical strategic environmental assessment which included: an assessment of the planning documents, i.e. planning concepts and strategic guidelines; an analysis of the state of the environment by means of GIS tools (Calvo et al., 2005; Higgs, 2006; Josimović and Krunić, 2008); the assessment of its relation to other planning documents and strategies; and the identification of environmental issues. The next stage included setting the SEA objectives, relevant indicators and evaluation criteria, followed by an impact assessment procedure in which the first stage included the evaluation of alternative scenarios and the selection of the most suitable alternative. The alternative solutions were qualitatively evaluated by sectors of the BWMP according to the SEA objectives and criteria. The professional community and relevant institutions were again included in the process of choosing the most suitable alternative. Then, the process of multi-criteria evaluation (a semi-quantitative method) followed, representing the focal point of this paper. The role of multi-criteria evaluation is to identify the influence (both positive and negative) of the activities planned on the space in which they are being undertaken (the prediction of spatial influences) according to the SEA goals (environmental, social and economic). Measures aimed at limiting any negative consequences of the BWMP in the process of its implementation were based on the results of multi-criteria evaluation. The results stemming from the process are shown here in a manner comprehensible to all participants in the SEA process (Fig. 2). All the results of the SEA (including the opinions obtained through the public participation process) were presented in the SEA Report, which served as basis for the decision on whether to adopt, amend or reject the BWMP.

4. Case study: MCE method in the SEA for the BWMP

The multi-criteria evaluation of the activities and solutions conceived in the BWMP was a key stage in the SEA process. It was carried out for all the strategic planning solutions of the BWMP based on the SEA objectives and relevant indicators, and based on the evaluation criteria.



Designation (negative)	Spatial extent of impacts	Designation (positive)
R	Pegional	R
M	Municipal	M
L	Local	L

Fig. 2. Graphic overview of the impacts of strategically significant planning solutions.

4.1. Setting SEA objectives and indicators

Setting objectives and indicators was a delicate step at this stage. General and specific SEA goals were determined according to the requirements and purposes of environmental protection, as stated in other national plans and programs. The SEA goals were based on the Serbian Waste Management Strategy (2010), the National Sustainable Development Strategy (2007), the Spatial Plan for the Republic of Serbia – Waste Management Section (2010), the National Program of Environmental Protection (2010) and the Regional Development Strategy of the Republic of Serbia (2005). Setting the SEA objectives for the BWMP was also conditioned by the results and projections in the analytical strategic environmental assessment (as described for Fig. 1) by means of GIS tools (CORINE, 2006), which resulted in establishing 37 specific SEA objectives and 39 indicators against which the sustainability of the solutions proposed within the BWMP would be evaluated. The objectives were defined in relation to environmental receptors including all aspects of sustainable development. For each SEA objective, one or more relevant indicators were defined. The indicators were taken from the general set of UN Indicators of Sustainable Development, in line with the instruction issued by the Serbian Ministry of Science and Environmental Protection in April 2008. That set of indicators was based on the concept of "cause – consequence – response". The so-called cause indicators represented human activities, processes and relations influencing the environment; the consequence indicators showed the state of the environment, while the response indicators defined political and other actions aimed at changing the consequences to the environment. The selection of the SEA objectives is shown in Table 1.

4.2. Establishing evaluation criteria

Based on an analysis of the possibility of primarily considering the spatial aspect, as well as the problematic aspect of potential impacts, four sets of criteria with a total of 16 individual criteria were defined.

The criteria used in the multi-criteria evaluation of the planning solutions were related to: the magnitude (intensity) of the impact; the spatial dimension of the impact; the impact probability; and the frequency of the impact (impact duration) (Table 2). This evaluation system was applied to both the individual impact indicators and the related categories by means of the aggregate indicators.

The evaluating criteria for the magnitude and spatial dimension of the impact of the planned solutions on the SEA objectives served as a basis for evaluating the importance of the identified impacts in achieving these objectives. The impacts of strategic significance for the BWMP were those with strong or greater (positive or negative) effect at a regional or municipal level (Josimović et al., 2010).

The assessment of the impacts of individual planning solutions on the strategic assessment objectives, as shown in Tables 5 and 6 above, served as a basis for the identification of significant strategic influences shown in Table 7.

4.3. Multi-criteria evaluation of the BWMP

The evaluation of alternatives and the selection of the most suitable one preceded the multi-criteria evaluation of the planning solutions, i.e. it was an introductory stage in the impact assessment for the BWMP. This stage included tracking the environmental trends which could be a consequence (a negative trend) or a result (a positive trend) of implementing the planning solutions. The positive and negative impacts of the alternative scenarios were

Table 1
The SEA objectives and indicators (the SEA for the Waste Management Plan of the city of Belgrade, 2012).

Environmental receptors	General objectives of SEA	Specific objectives of SEA
Water (surface water and groundwater)	Reduce surface water and groundwater pollution to the level that will not affect their quality	– Discharge of polluting matters derived from activities related to waste in water should be aligned with GVI (1) – Ensure that water quality downstream of waste facilities is not deteriorating (2) – Mitigate negative impacts of waste on hydrological regimes and quality of groundwater (3)
Air and climate change	Limit air pollutant emissions to the level that will not affect air quality	– Air pollutant emissions from activities related to waste must be aligned with GVI (4) – Increase volume of collected municipal solid waste (5) – Reduce uncontrolled disposal of waste (6) – Reduce the amount of waste disposed of to landfills (7) – Maximize waste-to-energy potential (8)
	Reduce greenhouse gas emissions	– Reduce emissions of SN_4 and SO_2 from waste facilities (9) – Meet national goals for waste management including the use of landfill gas (10) – Waste treatment prior to its disposal (11) – The use of renewable sources of energy (12)
Soil	Limit the use of agricultural land	– Surface area and quality of land used for activities related to waste per ton of waste should be in accordance with best practices (13)
	Reduce soil pollution	– Minimize the area that becomes polluted due to activities related to waste (14) – Remediation and recultivation of landfills (15)
Biodiversity	Reduce harmful effects on biodiversity	– Build new waste facilities on environmentally insensitive sites (16) – Provide measures for the compensation for any damages caused to habitats (17)
Landscape	Landscape protection and protected natural resources	– Protect landscapes by carefully selecting sites for new waste facilities (18) – Maximize the remediation of closed landfills to preserve landscapes (19) – Minimize inadequate waste management (20)
Cultural and historical heritage	Protect cultural heritage	– Safeguard unprotected and protected important cultural properties (21)
Transportation	Minimize environmental impacts of transportation of waste	– Reduce waste vehicle traffic by building the transfer stations for waste reloading and long-distance waste transport (22) – Use the proximity principle as much as possible (23) – Minimize the generation of waste to reduce waste transport (24)
Population, human health, socio-economic development	Human health protection	– Minimize the risk and impact of waste-related accidental emissions (25) – Minimize the level of environmental problems due to activities related to waste (26) – Establish criteria for landscape protection in selecting sites for waste facilities (27)
	Stimulate economic growth and employment in the region	– Stimulate job creation in waste management plants (28) – Stimulate the implementation of waste management system (29) – Meet national goals for recycling and reuse of packaging waste (30) – Create recycling centres (31)
	Improve knowledge, increase investment in human capital, equipment and infrastructure	– Enable acquisition of new knowledge at the level of the City Administration and institutions responsible for waste management (32) – Increase investment in developing the waste management system (33)
Strengthening institutional capacity in waste management	Improve the waste management and monitoring services	– Improve waste management system (34) – Improve monitoring of the environment and waste management (35)
	Improve the provision of information on waste management issues to the public	– Establish information system for waste management (36) – Create educational programs (37)

identified using the matrix method, in which the alternatives by sectors of the Plan were intersected with the SEA objectives based on the following criteria: overall positive impact (+), overall negative impact (−) and ambiguous or no direct impact (0) (Table 3).

Considering the fact that the BWMP did not offer more alternatives in the sectors of the Plan, the two alternatives envisaged by the Law on strategic environmental assessment (2004) were considered in this phase: the option to adopt and apply the BWMP, and the option to dismiss the BWMP. The results of the evaluation of the two alternatives pointed to the following benefits of adopting and applying the BWMP:

- the start of primary waste separation and the prohibition of disposing of untreated waste in the landfill;
- extension of the waste collection coverage to 100% of the territory;
- creation of the transfer stations network;
- closing down of the existing municipal landfills and construction of a regional waste management centre;
- drafting special waste flows plans and programs for specific type of waste;
- changes in financing of the waste management system and strengthening institutional capacities;
- systematic increase in the utilisation of recyclable material;
- recovery and complete sanitary reconstruction of the Vinča landfill;
- construction of a facility for the mechanical biological treatment of waste;
- construction of a cogeneration plant fuelled by refuse derived fuel, to produce electrical and heat energy;
- usage of landfill gas;
- construction of a bulky waste disassembling facility;
- construction of a recyclable waste separation line;
- construction of a new sanitary landfill in Vinča.

The location of the future city landfill, as the key planning solution (especially concerning the need for environmental protection), was also considered at this stage of the SEA. The BWMP analysed four potential locations for the future city landfill, all of them already degraded by the existing landfills (the city's central landfill and three municipal landfills). The potential locations were analysed by means of GIS tools. The analyses focused on locating the unsuitable areas and/or areas with the most suitable environmental and socioeconomic aspects for the development of the future city landfill (Map 1). The detailed methodological approach to this action is described in Josimović and Krunić (2008). The results of

Table 2
Criteria for the impact evaluation.

Type of impact	Description
Very favourable (+3)	Very strong positive impact with visible improvements in the environment
Favourable (+2)	Strong positive impact
Positive (+1)	Positive impact
Neutral (0)	No impact, no data or not applicable
Negative (-1)	Negative impact
Unfavourable (-2)	Strong negative impact
Very negative (-3)	Very strong negative impact (degradation of the environment)
Spatial dimension of the impact	
Regional (R)	Potential impact on the region
Municipal (M)	Potential impact on the municipality
Local (L)	Potential impact on a zone or micro-location
Impact probability	
Quite sure (Q)	Probability of the event 100%
Likely (Lk)	Probability of the event over 50%
Possible (Ps)	Probability of the event below 50%
Unlikely (U)	Probability of the event below 1%
Frequency of impact	
Temporary (T)	Temporary – occasional
Long-term (Lt)	Long-term – constant

Table 3
Environmental impact assessment of alternatives in relation to the SEA objectives.

Sector of the Plan	Scenario of development according to alternative	SEA objectives		
		1	···	37
1	Explanation of environmental trends for each alternative	+	–	0
⋮	⋮	⋮	⋮	⋮
n	···	+	–	0

the analyses pointed to the location of the city's existing central landfill because of its environmental and socioeconomic aspects of development, as well as its spatial capacity for waste disposal in the long run. The social aspect of the said location is especially beneficial, since the location is already accepted as a landfill by the local community, which is of extreme importance in the process of waste management planning in general.

The impact assessment of the alternatives and the projections of potential and positive environmental trends caused by the alternatives were followed by the selection of the most suitable alternative. The professional community and the institutions relevant to waste management were also included in this process. They stated their opinions on the results of the impact assessment in a public forum debate. The selection of the most suitable alternative was the first important contribution to the process of waste management planning since the alternatives potentially causing significant negative environmental impacts were eliminated.

The selection of the most suitable alternatives was then followed by the selection of the key and priority planning solutions to be included in the process of multi-criteria evaluation (Table 4).

A total of 23 planning solutions were singled out and their impacts assessed in relation to the objectives (37), indicators (39) and criteria (14) as shown below.

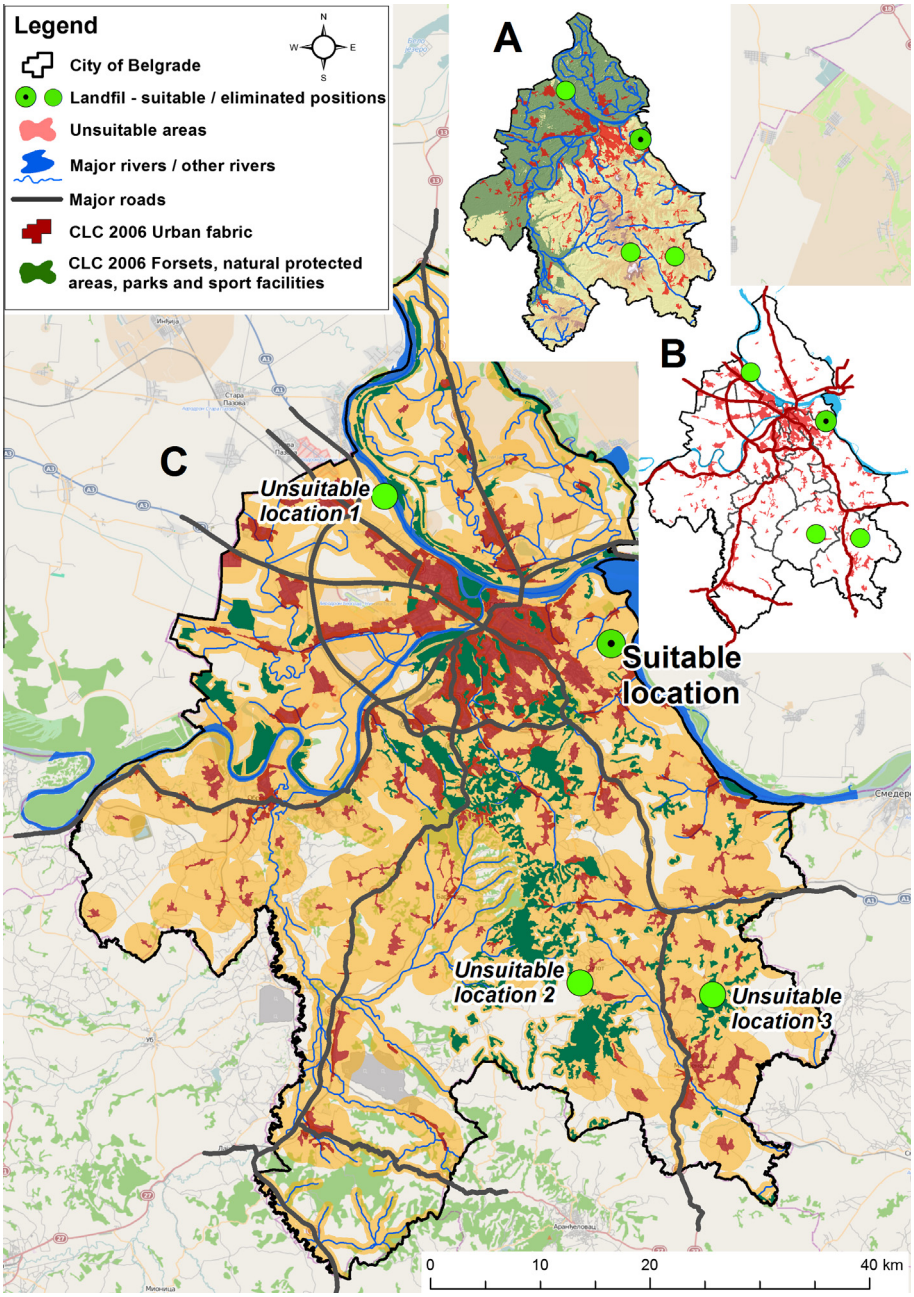
The matrices were formed at this stage under the same principle as in the impact assessment stage (Tables 5 and 6). All the planning solutions shown in Table 4 were intersected with the SEA objectives and evaluated by means of the first two sets of criteria shown in Table 2 – the significance/magnitude of the impact and the spatial dimension of the impact. Only the first two sets of criteria were presented in matrices as they were sufficient for the identification of strategically significant impacts, as explained in Section 4.2.

The evaluation of the planning solutions was semi-quantitative and carried out by the multi-disciplinary team of experts who conducted the SEA and the expert team who developed the Plan. GIS technology was used as a support to the evaluation in order to minimize subjectivity. Following the multi-criteria evaluation of the planning solutions, and on the basis of the results shown in the matrices, strategically significant planning solutions were identified (Tables 5 and 6) by synthesizing the key impacts of the Plan on the SEA objectives (Table 7).

The strategically significant environmental impacts identified are shown in tabular form (Table 7) – the mentioned strategically significant planning solutions are shown in the first column, the related SEA objectives in the second column, the environmental impact ranks based on the criteria given in Table 3 are shown in the third column, while an overview of the expected impacts is presented in the last column. An example of the strategically significant planning solutions identified can be seen in Table 7.

Since the process of multi-criteria evaluation was completely based on determining the "zero state" (in waste management and the environment), it is of no surprise that all the planning solutions implicate strategically significant positive outcomes. The development of the new city landfill in line with Directive 99/31 can serve as an example. The new landfill would be the central and only landfill for the city of Belgrade, instead of the existing four, which due to their only partial sanitary regulation have posed serious problems to the environment. Minor negative impacts, which due to their limited intensity and spatial dispersion were marked as strategically insignificant, can be put aside as the usual price to pay for development. Construction of the facility for the mechanical biological treatment of waste (MBT), producing refuse derived fuel (RDF), and/or the construction of the RDF-fuelled cogeneration plant for the production of electrical and heat energy, as envisaged in BMWP, can serve as an example. The technological processes used in these facilities can be the cause of pollution in the environment, but such pollution can be reduced to theoretical possibility if concrete measures for protection are defined, which the SEA stipulates.

In conducting the SEA for the BWMP, due to the participation of the public in the decision-making process, it was decided to present the strategically significant impacts not only in a tabular form, but also in a way easily comprehensible to the wider public, which was entirely in accordance with the principles of Aarhus



Map 1. Detailed GIS analyses of potential locations for the future central landfill of the city of Belgrade; A – Analyses of environmental characteristics; B – Analyses of the existing populated areas and infrastructure; C1 – Synthesis map of (suitable and unsuitable) locations for the future landfill.

Convention (UNECE, 1998). To that end, each of the strategically significant planning solutions identified is shown in the form of a graph, in which the positive and negative effects on the sustainable development goals, as well as their magnitude and significance, can be clearly identified (Fig. 2).

In addition to the strategically significant environmental impacts of the planning solutions, which can be clearly seen on the graph, other identified impacts are also noticeable, thus providing a complete insight into the effects of the planning solutions on environmental factors.

This completed the procedure of multi-criteria evaluation that was a basis for establishing appropriate measures for limiting the negative impacts, as well as for establishing the guidelines for impact assessment at lower hierarchical levels and monitoring programs. This was preceded by the consideration of cumulative and synergistic effects, taking into account that significant effects can occur as a result of interactions between numerous smaller impacts of the existing facilities and different planned activities in the area covered by the Plan (Stojanović, 2006).

5. Results and discussion

The Waste Management Plan (WMP) is a strategic framework for the implementation of policies and measures relating to the field of waste management. Possible implications for the environment that may arise as a result of the implementation of the Waste Management Plan (WMP) and participation of the public (NGO, population, expert groups, relevant institutions) in the decision-making process clearly indicate the need for a careful consideration of this aspect in creating waste management policies, either at the national, regional or local level. The reason for a significant public

Table 4
Planning solutions for the BWMP included in the multi-criteria evaluation.

Designation	Planning solutions
a	Introducing the primary sorting of waste and prohibiting the disposal of untreated waste to landfills
b	Extending the solid waste collection coverage to 100%
c	Waste transport
d	Construction of two transfer (reloading) stations
e	Construction of fourteen recycling centres
f	Closure and remediation of the existing municipal landfills – solid waste dumps
g	Remediation and improvement of sanitary conditions at the landfill in Vinča
h	The use of landfill gas
i	Construction of mechanical biological treatment (MBT) plant which produces RDF[a]
j	Construction of combined heat and power plant using refuse-derived fuel
k	Construction of bulky waste facility in which such waste is be broken down and disassembled
l	Construction of green waste composting facility
m	Construction of waste recycling plant
n	Construction of plant for biogas production from agricultural waste
o	Construction/reconstruction of facilities for the treatment of waste of animal origin
p	Plan of special waste flows
q	Programs for certain types of solid waste management
r	Measures for managing the waste generated during emergency situations
s	Changes in the method of charging for waste collection
t	Plan of capital investments in equipment and infrastructure
u	Education of population and employees in the public utility companies on the importance of waste management
w	Establishing the Waste Management Directorate of the City of Belgrade
x	Strengthening administrative capacities for establishing an integrated waste management system

[a] RDF (*refuse-derived fuel*).

interest in the waste management plans lies, on the one hand, in the nature of the planned activities and their potential impacts, and on the other, the significant coverage of the WMP. In this context, in addition to different studies on environmental protection made for individual facilities within the waste management system (e.g. the environmental impact assessment or the LCA), the EIA at the level of strategic planning is of particular importance as it should direct the planning documents towards sustainability goals in the early stage of waste management policy making. The SEA is precisely the instrument that meets all the specific requirements. This is supported by the fact that it is used to analyse the territorial (spatial) impacts of certain policies/plans/programs and can envisage the impacts of plans with a greater spatial extent, such as a WMP. In addition, the SEA process itself implemented as shown in Fig. 1 guarantees transparency in all its phases, especially in those relating to the key decisions in this process (the decision on the most suitable alternative phase and the phase of presenting the final results, i.e. deciding on the acceptability or unacceptability of the specific planning solutions). In the analysis and evaluation process, it is suitable to implement the MCE method, as shown in the case study presented here. Scientific literature extensively deals with this issue. A brief summary of it can be found in the Introduction and Methodological framework chapters of this paper.

The BWMP is specific because it establishes a completely changed waste management system as compared to the existing one, which has been assessed as unsustainable and environmentally unacceptable. In addition, the BWMP covers a metropolitan area with a high population density and complex physical geographic and socioeconomic characteristics. Due to this, the SEA carried out was specific in that it was necessary to create a symbiosis between all the existing phenomena and processes in the area and the projections of potential impacts of intended uses within the SEA itself. This helped in setting the SEA objectives and the associated indicators used in the evaluation of the alternatives and planning solutions of the BWMP. By using multi-criteria evaluation and the semi-quantitative method based on four sets of criteria (Table 2), as well as by presenting the results in the form of matrices and graphs, the results obtained were presented in a clear and unambiguous way for each strategically significant planning solution, including different aspects of impacts (significance, spatial extent, probability, frequency of impact). In this way, all the participants in the process of carrying out and adopting the SEA were easily able to draw conclusions on the positive and negative implications of all the identified impacts.

In comparison with a certain SEA oriented towards the identification of the "for" and "against" alternatives without seeking the best solutions (a prominent example is the SEA of the Replacement Midlands Waste Management Plan 2005–2010), in the SEA for the BWMP it was relatively simple to propose to the participants in the decision-making process the most suitable solution for implementing the BWMP. This was achieved through: a conceptually conceivable methodological approach; clear presentation of

Table 5
Assessment of significance of planning solutions impacts.

Planning solutions	SEA objectives																																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
a	0	0	0	0	0	+3	+3	0	0	+2	+1	0	+1	+2	0	0	0	0	0	+2	0	0	+2	+3	0	+1	0	0	+1	+3	+2	0	+1	+2	0	0	0
b	+2	0	+2	+2	+3	+2	0	0	0	0	0	0	+2	+2	+2	0	0	+2	+2	+2	0	0	0	0	+1	+2	0	0	+1	0	0	0	+1	+3	0	0	0
c	0	0	0	+1	+2	0	0	0	+1	+1	0	0	0	0	0	0	0	0	0	+1	0	+3	+3	0	0	+1	0	0	0	0	0	0	0	+2	0	0	0
d	0	0	0	0	0	+1	+1	0	0	0	0	0	+1	+1	0	0	0	0	0	+1	0	+3	+3	0	0	+1	+1	+1	+2	+2	0	0	+2	+3	0	0	+1
e	0	0	0	0	0	+1	+1	0	0	0	0	0	+1	+1	0	0	0	0	0	+1	0	+2	+2	+1	0	+1	+1	+1	+2	+2	+3	0	+2	+3	0	0	+1
f	+2	+2	+3	+1	0	+3	+1	0	0	+1	0	0	+2	+3	+3	0	0	+1	+2	+3	0	+1	0	0	+1	+3	0	0	0	0	0	0	+1	+3	0	0	0
g	+3	+3	+3	+3	0	+3	0	0	+1	+3	0	0	+2	+3	+3	+3	0	+3	+3	+3	+2	0	0	0	+2	+3	0	0	+3	0	0	0	+2	+3	+3	+3	0
h	0	0	0	+3	0	+2	0	+2	+2	+3	0	+2	0	0	0	0	0	0	0	+3	0	0	0	0	+3	+3	0	0	0	0	0	0	+2	+3	0	0	0
i	-1	-1	-1	-1	0	+3	+3	+3	-1	+2	+3	+3	0	+3	0	+2	0	+2	0	+3	0	0	0	0	-1	-1	0	+2	0	+3	0	0	+3	+3	+3	0	0
j	0	0	0	-1	0	+2	+2	+3	-1	+2	+3	+3	0	0	0	+2	0	+2	0	+3	0	0	0	0	-1	-1	0	+2	0	+3	0	0	+3	+3	+3	0	0
k	0	0	0	0	0	+2	+2	0	0	0	+2	0	0	0	0	0	0	0	0	+2	0	0	0	0	0	0	0	+1	0	+2	0	0	+1	+1	0	0	0
l	0	0	0	0	0	+2	+2	0	0	0	+3	0	0	0	0	0	0	0	0	+2	0	0	0	0	0	+1	0	+1	0	0	0	0	+1	+2	0	0	0
m	0	0	0	0	0	+1	+1	0	0	0	0	0	0	+2	+2	+2	0	0	+2	+2	0	0	0	0	0	+2	+1	+1	+1	0	0	0	+1	+1	0	0	0
n	0	0	0	+3	0	+3	0	+3	+3	+3	0	+3	0	0	0	0	0	0	0	+3	0	0	0	0	+2	+2	0	0	+2	0	0	0	+2	+3	0	0	0
o	0	0	+1	0	+1	+1	0	0	0	0	0	0	0	+1	0	0	0	0	0	+2	0	0	0	0	0	+2	0	+1	0	0	0	0	+2	+2	0	0	0
p	0	0	+2	+2	0	0	0	0	+1	+1	0	0	0	+1	0	0	+1	0	0	+2	0	0	0	0	+1	+2	0	0	+1	+1	+1	0	+1	+1	0	0	0
q	0	0	+1	+1	0	0	0	0	+1	+1	0	0	0	+1	0	0	+1	0	0	+2	0	0	0	0	+1	+2	0	0	+1	+3	+1	0	+1	+1	0	0	0
r	+1	+1	+2	+2	0	+1	0	0	0	0	0	0	0	+1	0	0	0	+1	0	+1	+1	0	0	0	+3	+2	0	0	+1	0	0	0	+1	+2	0	+1	0
s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	+2	0	0	0	+3	+2	0	0	0
t	0	0	0	0	+1	0	+1	+3	0	+3	+3	+3	0	0	0	0	0	0	+2	+2	0	0	+1	0	0	0	0	+2	+3	+3	+3	+1	+3	+3	+1	+1	0
u	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+3	0	0	+3	0	+1	0	+2	+3
w	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	+3	0	0	+3	+1	+2	+2	+2	+2
x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+3	0	0	+3	0	+1	0	+2	+3

Table 6
Assessment of the spatial dimension of the planning solution impacts.

Planning solutions	SEA objectives																																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
a						R	R			R	R		M	M						R			R	R		R			R	R	R		R	R			
b	M		M	M	R	O							R	M	O			M	O	R					M	M			R				R	R			
c				M	R				M	R										R		R	R			M								R			
d						O	R						M	M						R		R	R			R	M	M	R	R			R	R			R
e						R	R						M	M						R		R	M	M		M	M	M	O	R	R		R	R			R
f	M	M	M	M		O	R			O			M	M	O			M	M	M		M			M	M							R	R			
g	M	R	M	M		M			M	R			M	M	O	M		M	M	R	M				M	M			R				R	R	R	R	
h				M		M		R	M	R		R								R					M	M							R	R			
i	M	M	M	M		M	R	R	M	R	R	R		M		M		M		R					M	M		R		R			R	R	M		
j				M		M	R	R	M	R	R	R				M		M		R					M	M		R		R			R	R	M		
k						R	R				R									R								M		R			R	R			
l						R	R				R									R						R		M					R	R			
m						R	R							R	R	M			R	R						M	M	M	M				R	R			
n				M		M		R	M	R		R								R					M	M			R				R	R			
o			M		R	R								M						R						M		M					R	R			
R			M	M					M	R				M			R			R					M	R			R	R	R		R	R			
q			M	M					M	R				M			R			R					M	R			R	R	R		R	R			
r	M	M	M	M		M								R				M		R	M				R	R			R				R	R		R	
s																												R	R				R	R			
t					R		R	R		R	R	R							R	R			R					R	R	R	R	R	R	R	R	R	
u																													R			R		R		R	R
w																												R	R			R	R	R	R	R	R
x																													R			R		R		R	R

Table 7
Identification and evaluation of the strategically significant environmental impacts of the planning solutions.

Planning solution	Impact		Overview of expected impacts
	SEA objective	Rank	
Primary sorting of waste and prohibiting the disposal of untreated waste to landfill	6	R/+3/Lk/Lt	Strong long-term positive effects are expected in the entire area covered by the Plan including: reducing the uncontrolled waste disposal to landfills; reducing the amount of waste which is disposed of; meeting the national and local goals for waste management; minimizing inadequate waste management; meeting the recycling goals; increasing the investment in elements of waste management system
	7	R/+3/Lk/Lt	
	10	R/+2/Lk/Lt	
	20	R/+2/P/Lt	
	23	R/+2/P/Lt	
	24	R/+3/P/Lt	
	30	R/+3/Lk/Lt	
⋮	⋮	⋮	⋮
x	...	...	...

the obtained results, which allowed vast public participation in the critical stages of the SEA process (selection of the most suitable alternatives, identification of all the potential positive and negative impacts of the strategic planning concepts); the use of a semi-quantitative method in environmental impact assessment; and the use of contemporary information technology (GIS). On the other hand, the evaluation of planning solutions was carried out relative to the identified "zero state", which from the aspect of sustainability of the existing waste management system in the city of Belgrade is unsatisfactory. Having that in mind, it is no surprise that in the SEA for BWMP, predominantly positive strategically important impacts of the planning solutions were identified, which also had positive effects on the decision-making process.

As for the assessment of the actual planning solutions, based on the criteria listed in Table 2, a certain amount of subjectivity is perceived on the part of the experts involved in the process. The margin between the criteria marked as "−3" and "−2" or between those marked as "+3" and "+2" was rather small, so the choice of the criteria can easily be subjective. However, at the level of SEA at which the possible trends in space are followed, this disadvantage should not have significant consequences, bearing in mind the fact that at the hierarchically lower levels of the impacts assessment, which logically follows SEA, and which is carried out for individual projects (for example, the EIA, the ESIA, and similar), the predictions of the SEA are checked. Then there are detailed inputs and the possibility of utilisation of sophisticated mathematical models for assessing the impacts of projects and processes on the environment.

Although the susceptibility of the professional community to political influence is always a threat in decision-making, the conclusion is that the results of the SEA for the BWMP were difficult to deny, which was proven by the fact that the SEA Report was accepted, i.e. that the BWMP, which was in line with the results and guidelines of the SEA, was adopted. Based on the SEA procedure shown in Fig. 1, following the reception of the positive opinion from the relevant city institutions, the completion of the public participation procedure, and the reception of the Committee[2]

[2] The Belgrade city management appointed a ten-member Committee, consisting of representatives of the relevant city institutions and experts. The task of the Committee was to closely follow the draft of the BWMP and the SEA through all their phases, to coordinate the teams of participants in drafting the two documents, and to coordinate their work with the relevant city institutions interested in participating in the creation of the city's waste management strategy (various companies interested in placing their products and technologies in the waste management or waste treatment systems) and the work of NGOs. Another task of the Committee was to produce an opinion on the issues relevant in the decision-making process.

Report, the SEA and the BWMP were adopted by the Belgrade City Assembly. Due to the fact that the SEA and the BWMP processes run parallel to each other, all the necessary amendments/interventions/corrections of the BWMP resulting from the SEA were implemented in the plan in the course of its drafting. This allowed an integral approach to environmental planning and protection and to the preventive protection of the environment, which is in fact the greatest contribution of the strategic assessment in creating the city of Belgrade's waste management policy. Minor setbacks in the process of carrying out the SEA manifested in the opposition of some experts involved in the development of the BWMP to double-checking the impact of certain alternative solutions on the environment, as well as the socioeconomic aspects of development. To illustrate this, the SEA team insisted that all the locations marked as potential sites for the future regional landfill be checked for their acceptability, which was opposed by the BWMP creators. The issue was resolved through consulting the relevant institutions and participants in the decision-making process, and the location of the future landfill was checked and its acceptability confirmed in the SEA (Map 1).

What was perceived as a problem in the SEA process was public participation, though it was undoubtedly in line with current legislation. However, advertising the time and place of a public display of documentation or time and place of a public debate in the printed media usually passes unnoticed, as happened in this case, and consequently the public participation was rather poor. This raised the issue of the lack of transparency, considering the importance of the waste management policy. It did not come as a surprise that public participation was reduced to answering queries received from the institutions concerned, while the participation of the local communities, which would be directly influenced by the planning solutions, was virtually non-existent. This aspect of the SEA process should be improved by adopting some of the procedures common in the Environmental Social Impact Assessment (polls, questionnaires, etc.) so that the wider community can be included in the decision-making process when it comes to creation of waste management policy.

The disadvantage of the BWMP is that it does not stipulate a sufficient number of alternative solutions to be checked in the SEA process. Although that disadvantage cannot be ascribed to the SEA itself, it certainly limited the possibilities of the SEA to influence the process of the city of Belgrade's waste management policy-making more significantly, and consequently diminished the contribution of the SEA.

6. Conclusions

This paper examines the use of the MLE method in drafting the SEA for BWMP. The MLE method was used as an evaluation tool for the possible effects of the defined planning concepts upon the SEA objectives and/or environmental and socioeconomic elements of sustainable development. To be precise, the approach adopted in this case study allowed the analysis of trends in the environment (and space in general), i.e. the notification of the consequences (negative trends) or the results (positive trends) of the planning solutions stipulated in the BWMP.

The specific features of the approach lie in the identification of the SEA objectives and the associated indicators based on the analysis of a complex symbiosis between environmental quality and the activities planned in BWMP. The objectives and indicators resulting from such an approach served as a basis for the assessment of the complex implications of the activities planned in the area and the potential interactions between different sectoral commitments to the elements of sustainable development. This was defined by the adoption of the MCE method in drafting the SEA, which turned out to be convenient for the identification of strategically significant impacts of the BWMP. The MCE method served as a defining tool for the type of impact, its spatial dimension, probability and frequency, and by means of the criteria defined in Table 2, helped in identifying the strategically significant impacts of the BWMP on the environment and the elements of sustainable development. The results of the evaluation were presented in a clear matrix-based way, which turned out to be especially convenient for presenting the results of the multi-criteria evaluation. This proved very important in the phases of the SEA process involving the public.

The approach presented here shows the way in which it is possible to carry out environmental assessment without the use of different mathematical methods such as, ARAS – Additive Ratio Assessment (Chatterjee and Bose, 2013) or AHP – Analytical Hierarchy Process (Ismail and Abdullah, 2012), which due to insufficient technical input are often inapplicable to strategic planning documents such as BWMP. The methodological approach shown is potentially widely applicable, not only in drafting waste management plans but in planning in general, with the provision that it requires the definition of specific objectives, indicators and evaluation criteria. The results of the SEA for BWMP are a good basis for establishing adequate guidelines, as well as for the use of the abovementioned methods at hierarchically lower levels of the impact assessment, i.e. in carrying out the EIA, which is in fact obligatory in carrying out the SEA. That said, this disadvantage should be taken conditionally, but should not be disregarded either in the SEA process, or in the process of decision-making. Carrying out the SEA for the BWMP in fact resulted in making appropriate decisions in the process of establishing a sustainable waste management system for the territory of the city of Belgrade. Any future research resulting from carrying out the SEA for BWMP, which in some parts surpasses the methodological approach presented in this paper, should be directed at reducing subjectivity in the evaluation process. Although the use of GIS tools increases objectivity in the process of analysis and evaluation, the use of the semi-quantitative method in expert decision-making still bears a certain level of subjectivity, which can be conditionally considered a disadvantage. In addition, it is necessary to develop an information system concerned with the environment and space in general, and to perform monitoring, so as to acquire inputs, as precise as possible, for defining the "zero condition" of the environment and the SEA objectives, and create optimum conditions for monitoring changes in the environment in the process of the SEA implementation. Finally, it is necessary to increase public participation in the SEA process by stimulating more active involvement in the SEA and WMP (BWMP) decision-making process.

Acknowledgments

This paper is a result of a research conducted as part of the scientific projects themed "Spatial, ecological, energy, and social aspects of settlement development and climate change – mutual impacts", TR 36035; and "Sustainable spatial development of Danubian Serbia", TR36016; both financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia in 2011–2014.

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