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TERRITORIAL ANALYSIS AS SUPPORT TO THE STRATEGIC ENVIRONMENTAL ASSESSMENT PROCESS FOR AGRO-WASTE MANAGEMENT PLANNING

Nikola Krunić[1], Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia
Boško Josimović, Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia
Aleksandra Gajić, Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia
Marina Nenković-Riznić, Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia

Strategic Environmental Assessment (SEA) for waste management planning (WMP) has been applied around the world for fifteen years now. In addition to identifying potential trends in space and the environment by means of WMP, the SEA process contributes to involving the general public in issues relevant to the environment. In turn, the endpoint of the SEA process is a set of results that enable appropriate decisions to be made related to WMP. Bearing this in mind, it is necessary for all the segments of the SEA process to be supported by specific spatial analyses and presentations enabling visual monitoring of the results. In this context, an important role is played by GIS tools, since they offer support to the SEA process and give it a new quality, which, in addition to visualizing the results, also increases objectivity in the evaluation of the planned solutions. This paper presents the deployment of GIS tools in spatial analysis and the support they provide for the SEA process during the development of the Agro-Waste Management Plan for Oplenac Vineyard in Serbia (AWMP). The results indicate the possibility of applying GIS tools to increase objectivity in the Multi-Criteria Evaluation (MCE) of the planned solutions in the SEA process.

***Key words*: territorial analysis, GIS, Strategic Environmental Assessment, waste management plan.**

INTRODUCTION

Strategic Environmental Assessment (SEA) is one of the most important instruments for directing the planning process towards achieving environmental protection goals and decision making in alignment with the principles of sustainability. Its main application lies in strategic planning, which also includes waste management planning. Applying SEA makes it possible to identify the benefits and effects of the proposed spatial changes, taking into account the capacity of the space in which the planned activities are carried out, and, based on that, it is possible to make decisions on the suitability of the proposed spatial changes (Josimović *et al*., 2015). The role and importance of SEA in policy-making in different domains of social action, as well as the role of this instrument in the decision-making process, have been discussed by a number of authors (Therivel, 1992; Therivel and Partidario, 1996; Nilsson and Dalkmann, 2001; Nilsson *et al*., 2005; Maričić and Josimović, 2005; White and Noble 2012; Josimović and Crnčević, 2012; Josimović *et al*., 2016, and others). In this context, the exceptional importance of the topic at hand from a scientific and professional standpoint can be seen in developmental policy making, affirmed by the fact that an increasing number of international institutions, e.g. the European Commission, UNDP and UNEP are introducing the instruments and requirements for the application of SEA, with a view to increasing the number of developmental initiatives in line with environmental protection and the principles of sustainable development (more details in Dalal-Clayton and Sadler, 2005; Chaker *et al*., 2006; Biehl *et al*., 2019).

SEA contributes to integrating the impacts at the strategic level of planning. For the purposes of making good decisions regarding the sustainability of the solutions defined in the plans, it is necessary to consider different aspects of the potential impacts. Multi-criteria analysis has been strongly recommended by various authors (Partidário and Coutinho, 2011) for this purpose.

[1] Bulevar kralja Aleksandra 73/II, 11000 Belgrade, Serbia
nikola@iaus.ac.rs

On the other hand, with the development of GIS tools as a decision support system, many researchers (Kontos and Halvadakis, 2002; Parisakis, 1991; Kontos *et al*., 2005; Geneletti, 2010; Gorsevski *et al*., 2012; Eskandari *et al*., 2012; 2015) are using GIS instruments as a major impact assessment tool in landfill site selection and waste management. The implementation of GIS technologies in waste management analysis involves the creation of geospatial databases used for spatial analysis, visualization and monitoring. The GIS combines spatial data (maps, ortho/satellite images, etc.) with qualitative and quantitative data (Kontos *et al*., 2005) in order to support Multiple-Criteria Decision Analysis (MCDA), which is necessary in the elaboration and implementation of waste management plans. GIS can be used as the most important instrument in landfill site selection, recycling plant site selection, and the spatial distribution, quantities and flows of waste, as well as the detection of waste sources in the field. GIS databases store all relevant data about waste sources, quantities and types of waste, and they include location criteria, which are then evaluated using predefined evaluation criteria. The results are presented in the form of maps based on all predefined parameters, and this data can be used in the relevant decision analysis for different types of waste management.

The NoAW project is based on the principles of a circular economy in the context of agro-waste removal. The initial phase in removing agro-waste is the creation of an AWMP, with the support of the SEA process as a key instrument for directing the planning process towards the goals and principles of a circular economy. As it has the highest production of wine and produces the largest quantities of waste in Oplenac Vineyard, Aleksandrović Winery was selected as the case study. As such, it constitutes a representative sample for research and data extrapolation at the regional level. It is for the reasons stated above that the Aleksandrović Winery is a partner in the NoAW project.

The main aim of this paper is to raise awareness of the NoAW concept in wine production in Serbia. The operational goals include searching for, identifying and visualizing geographic data, as well as its spatial selection, in order to facilitate the organization of the agro-waste flow in Oplenac Vineyard. For these purposes, GIS tools were used in spatial/territorial analysis as support to the WMP and SEA in wine production in Serbia. Geospatial data and locations were combined with information gathered in the field about the generation of biowaste in wine production. This geoinformation was used to calculate the amounts of biowaste (from pruning and from grape petioles, seeds and grape skin) in the past, and to predict these amounts in the future. The spatial data collected was then incorporated in the spatial geodatabase used for monitoring the generation and spatial distribution of agricultural waste, as well as for the implementation of the NoAW concepts in wine production in Serbia.

THE CASE STUDY AREA

Aleksandrović Winery belongs to the Šumadija Region, which is considered as a functional-wine region. This region has around 10 active bigger and a few smaller wineries in 9 municipalities. It is divided into several winery subregions (vineyards), with Oplenac Vineyard (where Aleksandrović Winery is located) as a special research interest (Figure 1).

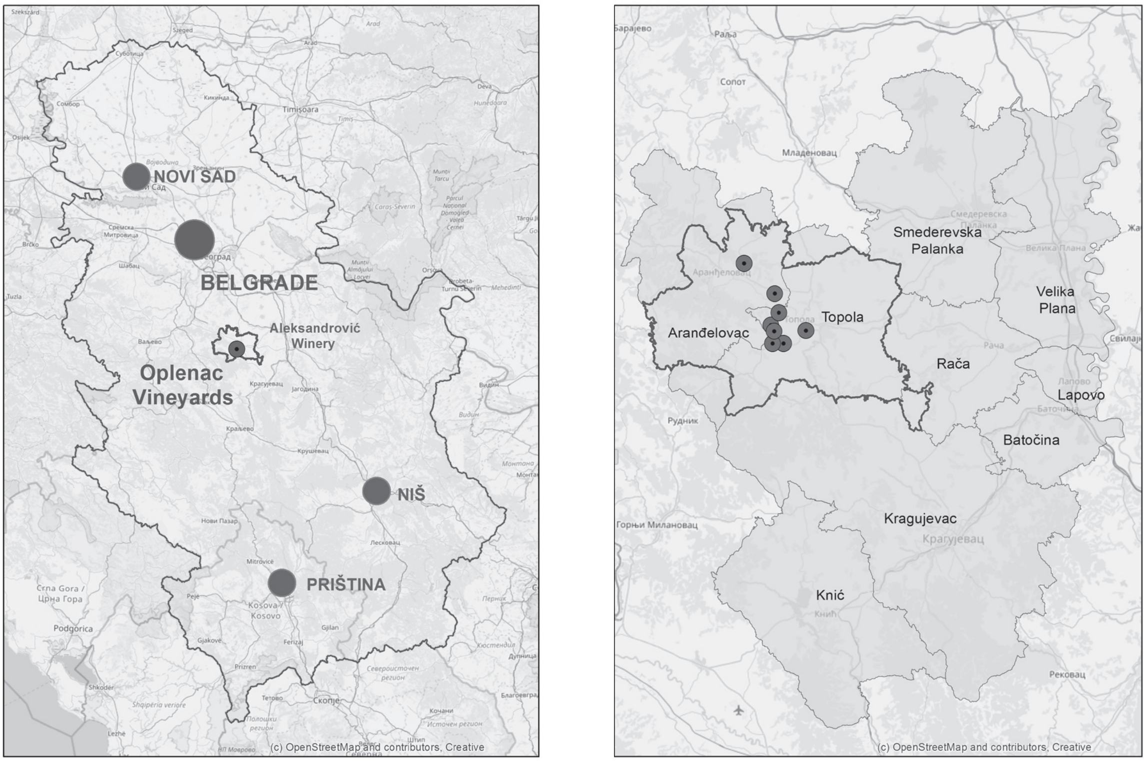

Figure 1. Position of Oplenac Vineyard and Aleksandrović Winery on the territory of Serbia (left)
Šumadija wine Region with Oplenac Vineyard (subregion) (right)
(Source: authors)

Aleksandrović Winery was selected as a representative case study because it is a leading winery according to the total area of its vineyards (75ha) and its wine production. Research was carried out and methodological concepts for the assessment of the territorial impacts of Aleksandrović Winery were applied to the wider territory of Oplenac Vineyard (8 wineries and 137 ha covered by vineyards) (Figure 2). By applying the principle 'Think regionally, act locally', the data collected from Aleksandrović Winery was extrapolated to the Oplenac Region, meeting thus, on the one hand, the prerequirement for regional waste management, and justifying the role of SEA as an instrument applied at the level of strategic planning (national, regional, subregional) in the initial phase of implementing the concept of sustainable waste management, on the other.

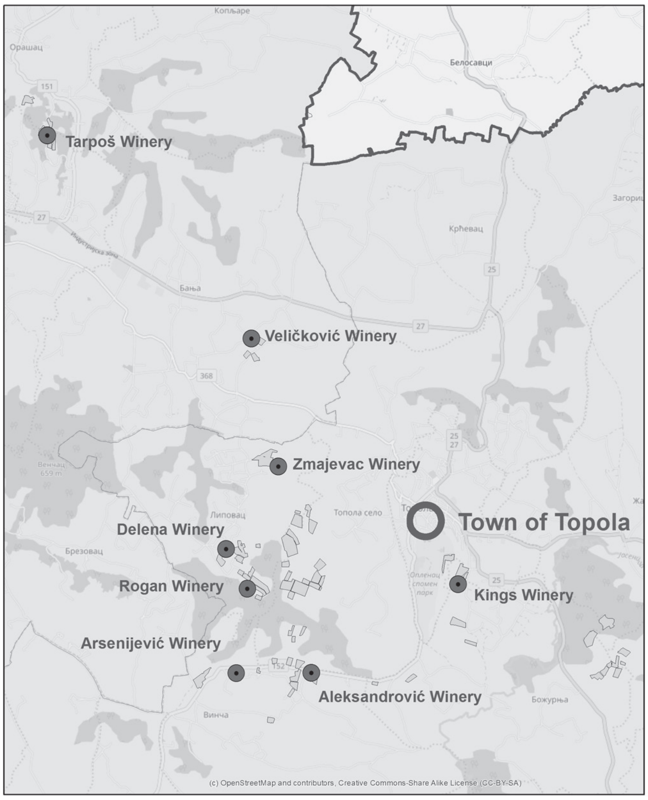

Figure 2. Oplenac Vineyard wineries (Source: authors)

METHODOLOGY AND DATA

In order to monitor agro-waste production in the wine industry, spatial data was collected on different territorial levels. Further, spatial analyses were conducted on the data provided from Aleksandrović Winery.

All spatial data necessary for the spatial analysis was included in the geodatabase on two hierarchical territorial levels – local and regional. At the regional level, data on 'Oplenac Vineyard', 'Regional Vineyards' and 'Wineries' was collected. Oplenac Vineyard was delineated by merging all the cadastral units which belong to that region: in administrative terms, the area belongs to the municipalities of Topola and Aranđelovac in Central Serbia. The Regional Vineyards layer contains polygon features associated with the position of wineries within Oplenac Vineyard. This layer contains the estimated amount of agro-waste (per ha, per year) for eight major wineries in the region. The Vineyards layer contains the features of winery production facilities. Data was collected in the field and provided by Aleksandrović Winery, and then combined with locations determined from satellite images.

Locally significant data relate to the vineyards belonging to Aleksandrović Winery. This layer consists of polygon features associated with the position of production facilities, vineyard distribution, the sort and number of vines in each vineyard, the planting date, etc. Aleksandrović Winery vineyards cover a total of around 75 ha (55% of all the vineyards in the region) and consist of more than 30 spatial units (parcels) and one production facility. All the data was provided by Aleksandrović Winery and used as a basis for calculating the amounts of agro-waste produced after pruning for the Oplenac Region.

In addition to this specific data, more general data was also used which is directly linked to agriculture, and specifically to wine production. This data includes 'Aspect', 'Slope', and 'Height' generated from the European Digital Elevation Model (EU-DEM, https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=metadata). Aspect identifies the compass direction that the downhill slope faces for each location. It is used for choosing the optimal location for planting vineyards. Aspect is represented at two levels – the first with 8 major geographic directions (N, NE, E, SE, S, SW, W and NE) and the second, generalized to "cold" (NW, N and NE), "hot" (SW, S and SE) and neutral directions (W and E). Slope identifies the steepness of the terrain at a certain location. If the slope value is low, the terrain is flatter, while a higher slope value means that the terrain is steeper. This is important for agricultural production since erosion processes are more prominent as terrain steepness rises. The slope values are in degrees and generalized into 4 classes. Classes refer to their suitability for wine production. The values are in the ranges 0–5, 5–20, 20–45 and over 45 degrees. Terrain elevations are grouped into height zones, and range in terms of the suitability for agricultural production in Serbia; they are defined as: up to 250m, from 250m to 500m, 500m to 750m, 750m to 1000m, 1000m to 1500m, 1500m to 2000m, and above 2000m. The optimum height of the terrain for vineyards should not exceed 500m. An overview of the datasets is given in Table 1 below.

The first part of the analysis included calculating and modeling waste production from pruning (per year) in Aleksandrović Winery, together with the total agro-waste produced from pruning (since the establishment of the winery). Accordingly, two assumptions were made:

- The total amount of agro-waste per vine/plant after pruning is 1.5kg. This value is used as an average, and it was measured in the field during the winter of 2017/2018. For further modelling and calculation, the observed values of agro-waste amounts are used for each vineyard and specific variety; and
- The above mentioned amounts can be achieved when the full plant vegetation potential is reached, which takes place in the third year after planting, on average. Accordingly, the agro-waste production for each vineyard is calculated with a three-year "delay" instead of immediately after planting.

Table 1. Basic metadata

Data	Data description	Reference scale	Attributes	Usage	Example
The Aleksandrović Winery vineyards	Locations/Parcels of *Aleksandrović Winery* vineyards *Topola, Serbia*	1:1000	Vineyard distribution, the sort and number of vines in each vineyard, the planting date	Calculating the amount of agro-waste production after pruning, Analysis of the spatial location, Accessibility	
Oplenac Vineyard	*Vineyard area, Central Serbia*	1:1000	Shape of the area		
Regional vineyards	Locations/Parcels of vineyards in Oplenac Vineyard	1:1000		Calculating the amount of agro-waste production after pruning, Analysis of the spatial location, Accessibility	
Wineries	Location/Position of wineries in Oplenac Vineyard	1:1000	Locations	Analysis of the spatial location, Accessibility	
Aspect	Aspect for each cell of a raster surface	1:25000	Aspect: N, NE, E, SE, S, SW, W and NE	Choosing the optimal location for planting the vineyards	
Aspect generalized	Aspect for each cell of a raster surface	1:25000	Aspect generalized to "cold" (NW, N and NE), "hot" (SW, S and SE) and neutral directions (W and E).	Choosing the optimal location for planting the vineyards	
Slope	Slope values for each cell of a raster surface	1:25000	Slopes in degrees generalized into 4 classes.	Estimation of agricultural production	
Height	Height values of each cell of a raster surface	1:25000	Height range in 6 classes: < 250m; 250–500; 500–750; 750–1000; 1000–1500; 1500–2000; > 2000m above sea level	Choosing the optimal location for agricultural production in Serbia	

The second part of the analysis included the estimation of waste from grape petioles, seeds and grape skin in the year 2018. This step included calculation of the total amount of grapes, performed by multiplying the number of plants by 1.2, which represents the projected yield per plant expressed in kg. The next step was to calculate the amount of waste from grape petioles. The amount of petioles counted as waste was fixed at 5% of the total amount of grapes, which was then subtracted from the total amount of grapes. In the next step, waste from seeds (fixed at 3%) and grape skin (fixed at 10%) was calculated for the remaining amount of grapes.

The third part included the extrapolation of the data obtained at the regional level. Therefore, the same methodology was applied for modelling the total agro-waste, agro-waste per year and agro-waste per hectare in Oplenac Vineyard for the year 2018. An overview of the results is given in Table 2 below.

According to the calculations made for Aleksandrović Winery, the same methodology was applied to estimating the amount of pruning waste for 7 additional wineries located in Oplenac Vineyard. These calculations were used for mapping and detecting the average agro-waste production per ha per year. These results served as input for identifying the current state of agro-waste management at the regional level, as well as being the basis for developing the AWMP.

The data collected in the field and the waste generation and treatment model developed here can be used in further research of the wine regions in Serbia and in the implementation of the NoAW concepts within them. Given their importance for wine production, the experiences gained in this research can be applied in the wine growing regions of the Danube Basin in Serbia, such as Fruška Gora and Negotin Vineyards.

Table 2. The average and total amount of agro-waste (AW) per vineyard for the year 2018

No.	Winery	Agro-waste (kg/ha				Total
		Pruning	Petioles	Grape seeds	Grape skin	Agro-waste (kg)
1	Aleksandrović	8 214	329	187	624	701 566
2	Rogan	7 554	302	172	574	120 428
3	Delena	6 810	290	166	552	39 088
4	Kings Winery	7 977	319	182	606	99 930
5	Zmajevac	7 313	293	167	556	66 620
6	Arsenijević	7 500	300	171	570	93 951
7	Tarpoš	7 650	306	174	581	87 118
8	Veličković	7 500	300	171	570	25 623
The Oplenac Vineyard (137 ha)		**7 910**	**317**	**181**	**602**	**1 234 325**

RESULTS AND DISCUSSION

Initial results show that the average amount of waste from pruning stands at around 1 083 608 kg, i.e. 7 910 kg/ha, which makes app. 88% of the total amount of agro-waste in Oplenac Vineyard. The waste from grape petioles, seeds and grape skin contributes significantly less to the total amount of agro-waste (around 12% altogether).

The vineyards of Aleksandrović Winery and other wineries in Oplenac Vineyard were located using GIS and spatial data. Each vineyard location is associated with many attributes important for its maintenance: parcel size, number of plants and planting age, variety, amount of pruning waste, etc. Waste quantities were estimated based on field measurements. This data is significant for the wineries, the region, and viticulture in Serbia, in a number of ways: a) attention is drawn to the annual production of waste that is constantly being generated but not properly treated; and b) estimates and calculations are provided, as well as specific locations where waste is generated, which is important for the rationalization of production in this winery, and also for the future development of the industry/service of wine production waste treatment.

The semi-quantitative approach usually applied in the SEA process is expert-knowledge-based and subjective. The subjectivity refers, among other things, to the group of criteria for determining the spatial dispersion of potential impacts of the planned solutions developed in the AWMP. The application of GIS tools and territorial analyses, as well as their visual presentation in the form of maps, makes it possible to determine with a high level of certainty the spatial dispersion of potential environmental impacts, making the process of evaluating the planned solutions more objective.

CONCLUSIONS

Generally speaking, the advantages of establishing a geodatabase are numerous: firstly, this approach allows the estimation, spatial modelling and monitoring of the amounts and flows of agro-waste; furthermore, it makes it possible to easily update and use different spatial data at various territorial levels.

GIS was used in full as a supporting tool in the multi-criteria evaluation method (MCE) in the SEA process, for the purpose of devising Agro-Waste Management Plans (AWMP). In addition, GIS was used as an analytical tool when the spatial data and data on waste production in the Aleksandrović Winery were collected.

The vineyards of Aleksandrović Winery and other wineries in Oplenac Vineyard were located using GIS and spatial data. Each vineyard location is associated with many attributes important for its maintenance: parcel size, number of plants and planting age, variety, amount of pruning waste, etc. Waste quantities were estimated based on field measurements. This data is significant for the winery, region, and for viticulture (wine growing) in Serbia, in a number of ways: a) attention is drawn to the annual production of waste that is constantly being generated but not properly treated; b) estimates and budgets are provided for quantities and specific locations where waste is generated, which is important for the rationalization of production in this winery, but also for the prospective development of the industry/service of wine production waste treatment; and c) the tourism potential of the wineries in the region is improved by GIS spatial analysis.

Although the starting point of this research was the analysis of data collected exclusively in Aleksandrović Winery, the concept ‘Think regionally, act locally’ was implemented by means of extrapolating the data collected in Aleksandrović Winery to Oplenac Vineyard, meeting thus the prerequirement for implementing regionalism in waste management. A similar, but more generalized, methodology was applied at the national level. However, for this level, the specific data that Aleksandrović Winery provided for Oplenac Vineyard was unavailable. This is why data available from the Agricultural Census was used in order to capture the main flows of agro-waste in Serbia.

In addition to the stated role of GIS in this research, the database created could have a significant role in creating an integral information waste management system, which would include all the data on waste streams and would offer support for the operation of the waste management system. The system would enable fast and high-quality waste management, monitoring, and updating data on waste, and would serve as a basis for planning the waste management strategy at the regional level.

The main contribution of this approach is the integration of spatial data and the data provided by Aleksandrović Winery (collected in the field), which can be an example of ‘good practice’ for implementation of the no-agro-waste concept in other wineries and wine regions in Serbia.

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Data availability

The data that support the findings of this study are freely available in ‘Spatial/territorial analysis as support to WMP and SEA for the selected case study area’, accessible at https://doi.org/10.15454/HOTPJB.

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