

SOCIO-CULTURAL MODELS AS AN IMPORTANT ELEMENT OF THE SITE SELECTION PROCESS IN RURAL WASTE MANAGEMENT

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The problem of waste management in rural areas has not been the subject of detailed specific researches since most of the research has been directed towards the study of means, mechanisms and procedures of waste elimination in urban settlements. The reason for the reduced scope of research in this field lies in the fact that rural settlements cannot be considered as "grateful" subjects due to usual deficiency of specific data (population number, fluctuations, amount of waste, waste composition, methods of waste elimination, etc.). In addition, for several decades the villages have primarily eliminated waste spontaneously. This has proven difficult to research because of the variations of methods applied to each specific locale, as well as different environmental variables. These criteria are based on patterns of behavior, customs and habits of the local population, but they also insist on absolute participation of local stakeholders in waste management. On the other hand, although Serbia has a legislative frame which is fully harmonized with European laws, there is a problem within unclearly defined waste management system which is oriented mainly on rural areas. The reason for this is the fact that waste management in rural areas is the part of regional waste management, and does not operate independently from the system in "urban" areas. However, since rural areas require the construction of recycling yards, this paper will present a new methodology, which equally values techno-economic criteria and social criteria in determining waste elimination locations.

This paper will also point out varieties of actors in the process of waste elimination in rural areas, as well as the possibility of their participation.

Key words: waste management, rural settlements, multi-criteria analysis, participation, landfill location.

INTRODUCTION

The waste management problem as a part of environmental management system is one of the most important environmental parameters. This has necessitated the development of a particular scientific discipline – theory of waste management, through studies of the most prominent researchers in this field – (Tchobanoglous et al., 1993), (McDougall et al., 2003), (Mazzanti, Zoboli, 2008), (Aivaliotis et al., 2004), (Brunner, 1986), (Zamorano et al., 2008), (Redfearn, Roberts, 2002), (Rogoff, Williams, 1994), (Christensen et al., 1999) (Geneletti, 2010) etc. This theoretical discipline has been developed with the aim to define principles which would help prevent effects of irrational waste management on human health,

as well as promote reuse of waste material. It has been developed on paradigms of industrial ecology which considers the industrial (manufacturing) processes and their perspectives through product compatibility and environmental interactions (Pongracz et al., 2004). The reason for separating the theory of management into a separate scientific discipline lies in the fact that this aspect of ecological sciences, due to growing problems of waste management, also requires specific methodological and research frameworks derived from other scientific disciplines (Tchobanoglous et al., 1993) (location theory, ecological planning, ecological economics, etc.). Precisely because of the abovementioned fact, the theory of waste management uses instruments of different sciences and scientific disciplines adapting them to its own research framework (Pongracz, et al, 2004). However, the problem which occurs at the level of theory of waste

management lies in the fact that research is directed exclusively towards urban areas, without elaborating in more detail the determination of methods and selection of sites for waste management in rural areas (Nenковиć-Riznić et al., 2009).

SPECIFIC THEORETICAL RESEARCH

Recent theory and practice define new concepts of landfill location based on multidisciplinary and interdisciplinary research, analysis and definition of multi-criteria model approaches to site selection, based on previously established location

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criteria and parameters. However, these new concepts do not incorporate the local characteristics of individual settlements, as well as the social/cultural component, which is reflected through the habits and behavior of local population in rural waste management.

The researchers, who are in the world theoretical thought considered as theoreticians of waste management, deal only to a lesser extent with issues associated with the methods and sites for waste elimination in rural areas. The reason for such state of affairs lies in the fact that, on the one hand, theoretical assumptions associated with waste management in urban areas may also be directly used in researching this problem in rural areas and, on the other hand, in the fact that due to deficiency of statistical data, there are no good grounds for research in rural areas (Christensen et al., 1999). On the other hand, in smaller communities, such as rural areas, research on municipal waste disposal is much smaller in scope, or, like in Serbia, practically neglected. However, some research results associated with this problem in urban areas may be directly applied to rural areas (e.g. in the domain of determining certain criteria for selection of waste elimination site), but considering the theoretical and methodological grounds (as well as results of various world and European studies), it has been observed that there are also many specificities associated only with rural areas due to which the mentioned theoretical and methodological frameworks should necessarily be separated and improved.

Considering analyses of recent research activities in the field of waste management (Calvo et al., 2005), (Geneletti, 2010) (Kontos et al., 2005) etc., the impression is that in determining the manner of waste elimination, as well as in selecting the landfill sites, the criteria are mainly techno-economically oriented, i.e. they do not take into account a social aspect of waste management. Namely, for the purpose of obtaining a higher level of community participation in waste management, it is necessary to also take into account the affinities, behavioral patterns and interests of local population as highly ranked criteria for determining the methods for waste elimination, as well as criteria for the selection of waste elimination sites (recycling yards) in rural settlements, which are actually normally used as criteria for location of existing dumps.

Structural differences in demographic and economic features, behavioral model (behavioral models of local population/ villagers), as well as ecological premises in cities and rural areas, also require different parameters (inputs) in determining the methods and selecting

recycling yards sites. Due to long lasting and non-cost-effective quantitative and qualitative analyses of the total amount of waste in rural settlements (versus significant databases formed for cities), qualitatively much less data required for the formation of models for defining the methods and sites for waste evacuation are collected in these areas. Precisely out of this reason, it is more difficult for researchers to apply the previously defined model approaches realized for urban centers to rural areas. (Nenković-Riznić, 2007).

The composition of municipal waste significantly varies in rural and urban settlements, this being yet another reasons why it is has become necessary to define different methods of waste management relative to those determined for cities (landfills, big recycling centers, waste processing facilities), as well as to determine specific methods for waste elimination by locating the centers for waste evacuation (smaller transfer stations, smaller recycling yards and compost heaps if it is economically feasible) in rural areas. Above mentioned waste management approaches in rural areas vary depending on local conditions and local legislative framework of different countries (Kontos et al., 2005), (Hermann, 1999), (Parisakis et al., 1991), (Zamorano et al., 2008).

Methods of waste management do not depend solely on the settlement type, but are also directly conditioned by the number of inhabitants, age structure, employment structure, amount of generated waste, waste composition, but also by social circumstances, local economic conditions, as well as, to the greatest extent, by geographic features of the area (McDougall et al., 2003). Therefore, while determining and checking justifiability of the selection of a method or site for waste management (recycling yards), all previously mentioned parameters should be taken into consideration.

Checking justifiability imposes itself as a logical step because such type of investment might be unnecessary, particularly in villages where less amount of waste is generated which could be treated in some other manner (composting, on-site incineration, etc.).

Theoretical knowledge on methods of waste management and waste management sites has been used for the purpose of examining the specific problems of rural waste management (Tchobanoglous et al., 1993). In their study, these authors gave an integral overview of waste management, from determination of amount and percentage share of certain components in the total waste flows, definition of options for waste elimination in settlements, through the definition

of waste deposal sites, transfer stations, recycling facilities, etc., to the formation of specific organizational framework for implementation of waste management projects. What imposes itself as a major criticism of these research assumptions, and is the results of research on standpoints of other authors (Brunner, 1986), is the fact that they have addressed the problem of locating the facilities for waste management in a techno-economic way, disregarding the social factor (stakeholder participation in decision-making process) in the hierarchy of important criteria for selecting the methods and sites for waste evacuation.

Through a series of research activities², it has been concluded that it is also possible to check all mentioned theoretical assumptions on parcel polygons in rural areas in Serbia (locations of recycling yards in area that is inadequate in the social context) and European countries where wrong estimations may be found in waste management planning, primarily due to over-dimensioned capacities, but also in generating greater environmental and health repercussions for local population. All this leads to the conclusion that, in an economic and social sense, there was no need for their realization (Christensen et al., 1999). Namely, planning the waste elimination sites of greater capacity than required necessarily causes an increase in economic costs which could not be compensated in the period considered to be paid off. On the other hand, economic costs may also be increased due to pollution and environmental charges.

On the other hand, in Serbia, waste management in rural areas is regulated through legislative framework (Law on waste management and other similar regulations) and Waste management strategy 2010-2019. In Serbian rural areas, the existing waste management option is usually illegal dumping, since these settlements are not included in waste collection system. According to the Waste management Strategy, waste collection system will be expanded to cover rural areas as well. Also, Waste management Strategy provides that until 2019 waste management in rural areas will be the matter of Local waste management plans. In accordance with the regional orientation of waste management, rural areas will be covered with the system of recycling yards (extremely transfer stations) and subsequent waste evacuation from these sites to the regional landfill. Therefore, this paper will give methodological guidelines for determination of waste elimination locations.

² carried out by the author since 2003 through the reserach carried out for the needs of regional and municipal plans, but also urban plans

ELABORATION OF CURRENT METHODS

Recent methodology in spatial and urban planning suggests a contemporary concept of approach in researching the community-based waste management (in the domain of defining methods and sites for elimination of municipal waste) in urban and rural areas. This concept is based on multi- and inter-disciplinary research (versus previously one-sided deterministic concept), analysis and definition of multi-criteria model approach to waste elimination locations location, based on the previously determined location criteria and parameters.

Determination of waste management system directly depends on how much the local population is interested in participating in waste collection and separation processes, but also in generating the amount of waste sufficient for its cost-effective treatment. Therefore, in recent approaches to researching the methods and locations for waste disposal in rural areas, the accent, in addition to geographical, hydrological, climatic and other parameters, should also be placed on social factors, i.e. degree of acceptance of a new recycling yard site by local population (i.e. degree of harmonization of local population affinities with the site determined by developers). In this connection, previously applied methodology for determining sites for waste evacuation, which may be characterized as techno-economic and deterministic one, cannot be considered adequate so that it has been necessary to also form new approaches to selecting the locations for temporary waste storage (transfer/recycling yards if it is economically feasible) in villages.

Considering the analyses of recent research activities in the field of waste management (mentioned above in the present paper), the issue of including social aspect in this problem area has also been actualized taking into account affinities, behavioral patterns and interests of local population as a highly ranked criterion for the selection of methods and sites for waste elimination. Considering that the composition of municipal waste differs diametrically between rural and urban areas, this is yet another reason because of which a need has manifested itself for defining different waste management methods relative to those determined for urban areas (landfills, big recycling centers, waste processing plants), as well as for determining specific manners of waste elimination by locating the centers for waste evacuation in rural areas (smaller transfer stations, smaller recycling yards and compost heaps if it is economically feasible).

It is, after all, irrational to speak of defining the waste management system in a community if the local population is not interested in it, but also if

there is no sufficient amount of waste which could be treated.

The techno-economic methods previously used in multi-criteria analyses have mainly been based on determining a series of criteria associated with geological, hydro-geological, seismic, and climatic features of the site. However, new methodologies of multi-criteria analysis: AHP (Analytic Hierarchy Process) and the SAW (Simple Additive Weighting) methods combined with the GeoSpatial Analysis (GSA) within the GIS represent a new method in modeling and analyzing potential sites for recycling yards. They, in addition to the previously mentioned standard criteria, also incorporate social parameters in modeling, whose importance ranking depends on the degree of acceptance of the site by villagers.

Besides, for several decades, with the development of the GIS tools as a decision support system, many researchers (Kontos et al., 2002), (Komilis et al., 2005), (Parisakis et al., 2005) have used, in a single-sided and theory-based way, the GIS instruments as a main site selection tool. Criticism (Malczewski, 2004) addressed to this methodology is based on the fact that geospatial systems can only be used as an instrument in the analysis, but not as the only methodological framework in location analysis (Malczewski, 2004).

Analyzing the assumptions of contemporary theoreticians in the field of waste management, it may be observed that there are no studies (or they are not available) examining the effects of stakeholder participation in the site selection process. However, there are indications that certain authors (Guiquin et al., 2009) have carried out such research, which has partly been supported by the fact that they have used AHP methodology and methodological framework of the social multi-criteria analysis, but their studies have not shown a clear distinction between location models based on techno-economic analysis and those based on the additional social criterion (participation). Furthermore, none of the authors has included unplanned landfills (visual criterion, free place criterion, etc.) in equal site evaluation criteria.³

In addition, analyses of all available research studies in the field of rural waste management have shown that they have not provided a clear model of waste management organization which could be applicable only to rural areas. Certain organizational models consider this problem from a wider aspect so that they can also be

indirectly used for research in rural areas (Guiquin et al., 2009).

Further analysis of the existing theoretical and empirical considerations in the domain of waste management shows that there are no relevant sources that provide an overview of legislative framework in the area of rural waste management exclusively, either in the European Union or in Serbia. Although these normative documents are found in the EU database, more detailed considerations and explanations, particularly associated with rural areas, have not been found in the available literature.

In Serbian theoretical thought, certain authors have dealt with the issue of waste management in rural areas only through pilot research activities (Malobabić et al., 2004), (Josimović et al., 2009), strategic guidelines for local legislation changes, or through studying the rural waste management (Čanak, 1990). Although problems in rural areas could also be described or clarified based on these studies, there is a need to form a single methodological and research framework which would take into account only characteristics of rural areas. In addition, research on recycling yards placement, as well as adequate methodological recommendations and models, have not been elaborated so far in the local literature.⁴

Through further analysis of available studies for the needs of site determination, particularly determination of the method of waste evacuation, it has been found that there is a significant shortcoming of mathematically-based and empirically checkable methodology associated with determination of the capacity of facilities or containers for waste disposal. Some authors give the mentioned mathematical guidelines rather generally (Everett, 1998) and, based on preliminary research carried out for the needs of this paper, there is no impression that they are applicable to rural settlements. Namely, certain parameters (specific transportation costs, distances between blocks) used within this mathematical method can only be applied to urban areas, while it is not possible to adapt them to rural areas.

Based on all mentioned elaboration of contemporary theory of waste management and methodology of site selection for waste disposal, certain shortcomings can be observed, the so-called research niches, as well as certain inconsistencies in methodology, but also in specific research studies.

³ the mentioned criteria have been formulated based on year-long research by the author of this paper on different planning documents, as well as on the results of numerous surveys carried out in Serbia.

⁴ it is presumed that researchers have not had relevant statistical framework or access to data required for their research.

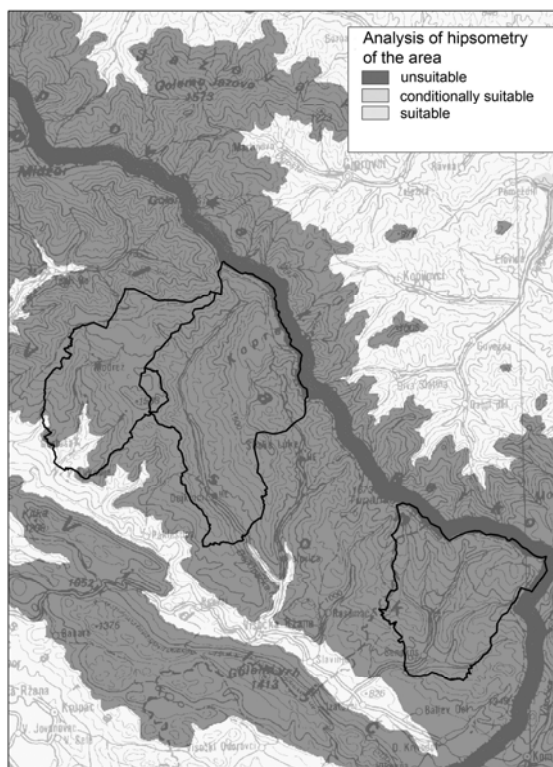


Figure 1. Analysis of hypsometry of the area

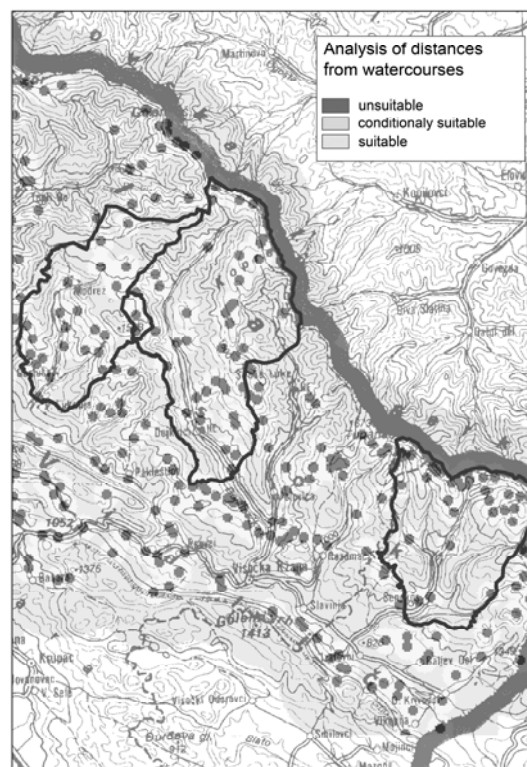


Figure 2. Analysis of distances from watercourses

NEW METHODS FOR SELECTING THE SITES FOR TEMPORARY WASTE STORAGE (RECYCLING YARDS, TRANSFER STATIONS) IN RURAL SETTLEMENTS IN SERBIA

For the purpose of defining the detailed method and system of municipal waste elimination in rural settlements in Serbia⁵, it is necessary to determine major input parameters made up of data on spatial coverage of rural areas (topographic characteristics, development of infrastructure, water resources and energy infrastructure, current waste management system, existing regional landfills nearest to the selected location, regional landfill planning), data on population (demographic structure and forecasts of population number, disposition of settlements), as well as the data on the existing methods of treating household waste and wastewater.

After forming a database on the mentioned parameters, it is also necessary to carry out their mapping through determining accurate locations of settlements, existing landfill spaces, existing and planned purpose of areas, possible existing and planned zones of

protected natural and cultural values, as well as possible geomorphologic/hydro-geological barriers (zones of protected water accumulations, infrastructure corridors, etc.) and spatial distribution of users of space (based on projected number of inhabitants/ tourists/users of space). All mentioned multi-criteria analyses are carried out using ARGIS (Spatial analyst) software package and based on previously mentioned methodologies, as well as studies (Kontos et al., 2002), (Komilis et al., 2005), (Parisakis et al., 2005) (Guiquin et al., 2009) (Josimović et al., 2008) (Herman, Osinski, 1999).

All mentioned parameters are needed primarily for defining the method for collecting waste in certain territory, but for the framework determination of sites and outlines of recycling yards/transfer stations and their capacities.

The research must include techno-economic, deterministic criteria which are used in waste disposal site selection (such as geological, hydro-geological, geomorphologic, seismic, and climatic criteria, the existing and planned ways of land use, ecological criteria, criteria for the protection of natural and cultural-historical values, the existing utility infrastructure, etc.). Based on all mentioned criteria, suitability classification of territories is carried out. In addition, each individual criterion is ranked differently relative to its importance in overall

valuation (as shown in figures 1 and 2).⁶ Eighteen different criteria have been determined for which, through the social cost-benefit analysis and by applying AHP (Analytic Hierarchy Process) methodology, the most suitable sites for the newly planned recycling yards in rural settlements have been determined, which have additionally been reevaluated using geospatial database, and then graphically represented (Nenković-Riznić, 2011).

The most suitable sites have been denoted by the lightest grey, the conditionally suitable ones by medium grey color, while unsuitable sites according to these criteria have been denoted by the grey color. Figures 1, 2, 3, 4 show analyses carried out for certain rural settlements situated in the pilot area of the Old Mountain Nature Park (which has three regimes for the protection of natural and cultural values).

Figure 1 shows suitability zones defined for the construction of recycling yards from the aspect of hypsometry of the area. Figure 2 shows sites evaluated relative to their distance from watercourses. These are, however, only some of the analyses (out of 18). The remaining analyses have comprised the suitability analyses relative to locations of the existing

⁵ harmonized with the adopted strategic guidelines given in the Waste Management Strategy, and here is further elaborated for the purposes of the polygon of three villages of Stara Planina.

⁶ the mentioned graphic representations are a part of more comprehensive research of the territory of three villages situated in the Stara Planina Nature Park, carried out for the needs of author's PhD thesis.

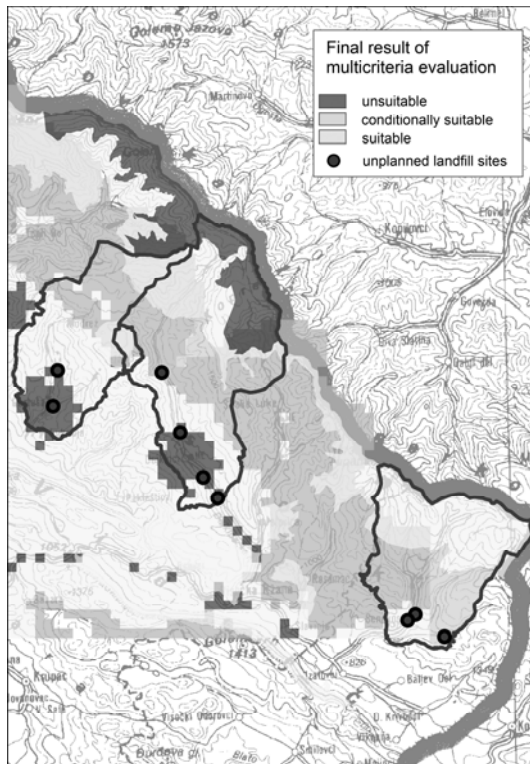


Figure 3. Final results of evaluation according to the techno-economic criteria using the ARCGIS software package

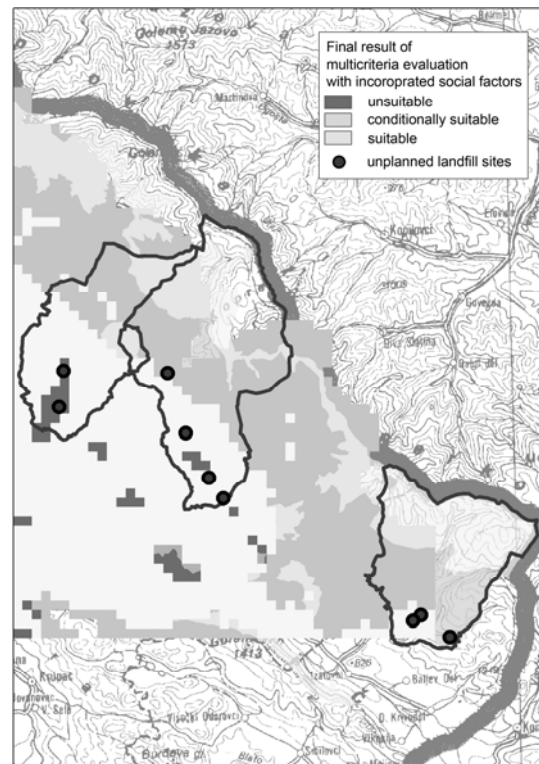


Figure 4. Results of multi-criteria analysis with added rank of social acceptance criteria for the site (with existing landfill sites entered)

rural settlements, climatic parameters, distance from the first and second category state roads, etc.

Sites obtained through analyses are a direct reflection of the previously defined techno-economic criteria, which can be determined with a high degree of accuracy through further detailed analysis (Figure 3).

Analysis results change depending on the inclusion and promotion of social criterion in overall criterion rank (as shown in Figure 4).

In order to prove initial assumptions on the importance of social criteria for the selection of recycling yards in rural settlements, an additional criterion, the social acceptance, has been incorporated into the originally realized techno-economic model, and a new set of sites considerably closer to sites of unplanned landfills has been determined through additional analyses (Figure 4).

Based on comparative representation of the existing unplanned landfill sites, as well as sites for recycling yards obtained through model approach, it could be concluded that level of waste management performance through building the smaller transfer stations/recycling yards in rural settlements depends primarily on the level of inclusion of local population/tourists/users of space in decision-making process in the sense of taking into account their attitudes in decision-making

and, what is even more important, on the level of taking into account habits and behavioral patterns of local population in multi-criteria analysis. Although these parameters have not been analyzed in more detail, but have been taken into consideration as results of population surveys, they should be perceived as implications for planning and forming the model for locating any activities in space.

On the other hand, the selection of adequate waste treatment method also depends on local and regional waste management strategy for certain territory, provided that waste collection system (as the first phase in management process) is not directly conditioned by the method of waste elimination, but is carried out according to certain standards.

New combined methodology applied in this paper with some changes can also be used for determining the sites for other, potentially ecologically hazardous purposes. The research can achieve an even higher level of detail by changing the number of criteria and their ranks within the model.

CONCLUSIONS

Waste management in rural areas has not been considered in more detail either theoretically or methodologically by world researchers. Different situation is in Serbia, where main reason for this is the fact that rural areas are a

part of a bigger, regional point of view, since Serbia has a regional system of waste management. Although rural areas with their specificities have smaller requirements regarding municipal waste elimination, on the other hand, the system of municipal waste management is less complex and does not require greater technical interventions. However, regardless of this fact, and in accordance with Serbian strategies and legislation, it is necessary to establish a clear site selection methodology, for recycling yards in rural areas which would comply with behavioral habits, affinities and interests of local population (Nenković-Riznić, Pucar, 2010).

Through elaboration of basic theoretical and methodological assumptions and identification of their drawbacks, a new methodology has been established and presented in this paper which can be used to determine recycling yard sites in rural areas. Multi-criteria analyses have been carried out using AHP methods and GIS data processing. Thereby, the manner in which inclusion of local population can, through social parameters, influence a more accurate selection of sites for waste disposal, has been shown. It has been concluded that using only techno-economic criteria, i.e. spatial planning criteria, cannot produce valid results regarding the site suitability. Therefore, it is necessary to also take into account the site acceptance by local population.

Thus, it may be concluded that it is not sufficient only to meet all conditions associated with techno-economic criteria for recycling yards site unless there is an initial social approval (compatibility with people's views), considering that it is easier to change negative ecological, economic and natural circumstances than people's views. Thereby, general conclusion that can be drawn lies in the fact that there are significant differences between unplanned landfills and recycling yard sites selected through techno-economically generated approach. In this way, a specific methodological enhancement of location theory has been achieved, which has been used in current research in the field of location theory, as well as theory of waste management.

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