Feasibility Analysis for Improved Solid Waste Management in Municipality of Gevgelija

FINAL REPORT

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Abbreviations

€ – Euro (currency)

AHP – Analytic hierarchy process

EU – European Union

FA – Feasibility Analysis

GIS – Geographical Information System

MKD – Macedonian Denar (currency)

O&M – Operation and maintenance

PE – Public enterprise

SE – Southeast (statistical) region (in Macedonia)

SWM – Solid waste management

UN – United Nations

UNDP – United Nations Development Programme

VAT – Value Added Tax

1. Introduction

1.1 Project Background

A massive number of refugees and irregular migrants have transited through Macedonia in 2015. The refugees and migrants by and large originate from war-torn Asian and African countries, and are in search of safety, security and better prospects in the EU. During the summer months of 2015 an estimated 1,000 people crossed the southern border from Greece on a daily basis, seeking to transit the country to Serbia and move on to Germany, Sweden and other EU destinations. In mid-September 2015 the daily totals surged to 5,000-6,000 people. In October daily arrivals peaked at 11,000, before receding to 3,500 in November and December. Although precise numbers are scarce, it is estimated that over 900,000 people have made their way across the country during 2015, following the Western Balkan route to the north.

Although the refugee traffic through the country by and large has been a transit flow, it has proved to be a real test, in terms of funds, expertise and human resources, for the responsible Macedonian Government institutions and the two most-affected municipalities – Gevgelija and Kumanovo. The biggest municipal burden is faced by Gevgelija, since migrants need to spend at least several hours at the border for registration. Refugee reception centers have been established at the southern border at Gevgelija and the northern border at Tabanovce.

In response to the crisis throughout the year the UN has provided a multifaceted support to the country, addressing the needs of refugees and migrants, ensuring full respect for their human rights and helping to design, build, equip, staff and winterize the reception and transit centers in Gevgelija and Kumanovo. In addition, the UN has recognized that its support needs to go beyond humanitarian aid provision, i.e. towards support to national actors at all levels in enhancing their ability to manage the crisis and in building the resilience of local communities. This is of particular importance for both Gevgelija and Kumanovo, where local authorities need to find solutions and meet increased demand generated by the influx of refugees and migrants regarding waste management, water supply, power provision and other public utilities while delivering on existing responsibilities to local residents.

Municipalities in Macedonia have primary responsibility for provision of a number of public services, including for solid waste management (SWM). The extent of waste management service coverage in the country, in terms of covered area and population, varies considerably between municipalities. The service is mainly provided to the areas in and around urban centers leaving the majority of the smaller, rural communities without organized service at all. Further, every community (town and village) has its own landfill or dump, and most of them have several. Current landfilling practices in both in Gevgelija and Kumanovo municipalities are at a very low level. The additional waste quantities generated by the migrant/refugee crisis further exacerbate the situation, imposing an even greater threat to the environment and people's well-being.

Since 2008 the Southeast Planning Region (SE)[1] region has been involved in developing and realizing a strategy for improving the SWM service, based on up-to-date waste management practices – in particular regarding landfilling of wastes – and regionalization of the entire service. The concept includes the following: construction of a new regional sanitary landfill compliant with the pertaining EU Directives; the regional landfill will be located in the village of Dobrashinci (Municipality of Vasilevo), i.e. adjacent to the existing Strumica municipal landfill; collection and transport of solid

[1] The SE region in Macedonia includes the following 10 municipalities: Radovish, Konche, Valandovo, Strumica, Vasilevo, Bosilovo, Novo Selo, Gevgelija, Bogdanci, and Dojran.

waste from all 10 municipalities to the regional landfill on a daily basis; closure and reclamation of all existing municipal landfills and illegal village dump sites throughout the entire region; gradual introduction of recycling activities, as the national/local market for recyclables develops. Unfortunately, for a number of reasons the strategy for regionalization of the waste management service in the SE region has not yet been put into operation.

UNDP has initiated project activities that address high-priority, urgent needs of affected municipalities, particularly in the area of water and waste management, which are both crucial to refugee well-being and highly sensitive for local host populations. This report is a summary of feasibility analysis related to improvement of the solid waste management service in the municipality of Gevgelija.

1.2 Goals and Objectives of the Feasibility Analysis

The task is focused on identification, assessment and costing of a preferred practical and environmentally sound technical SWM solution that would meet both the increased demand imposed by the migrant/refugee crisis and the long-term needs of the local communities, particularly with regard to attaining improved sustainable SWM practices and increased resilience to crisis management. The specific objectives of the FA are to:

- Identify and assess possible technical solutions for improved SWM in Gevgelija municipality, and their conformity with the increased needs generated by the migrant/refugee crisis
- Assess required investment costs and future operating costs, as a basis for comparison and selection (cost-benefit analysis) of the preferred alternative
- Define any potential increase in operational costs for management of waste generated by the refugee crisis and other users, as well as propose practical mechanism for covering the costs. In addition, any necessary changes in current waste management policies at local/municipal level (such as waste tariff policy) as a result of the project should be assessed
- Identify key risk factors and the relative magnitude of project sensitivity on them
- Determine a financing and project implementation plan.

1.3 Methodology

The Feasibility Analysis for Improved Solid Waste Management in the Municipality of Gevgelija has been prepared by PointPro Consulting, Skopje. The analysis is primarily intended for use by the municipality of Gevgelija and the UNDP as a basic decision-making tool for further implementation of the project.

The tasks that were performed to assess the feasibility for improvement of the water supply service included:

- Phase I: Data Collection activities, including site visits, desk research, analysis of technical documentation, and conducting meetings with various project stakeholders
- Phase II: Analysis of Alternatives, which included activities focused on modelling, identification, assessment, ranking and selecting the most feasible location for a new sanitary landfill for Gevgelija
- Phase III: Feasibility Analysis, i.e. technical, financial, institutional, and risk analysis
- Phase IV: FS Report writing.

2. Project Description and Rationale

2.1 Gevgelija Municipality

2.1.1 Geographic location

Gevgelija is a municipality located in the very southeastern part of Macedonia, and is part of Southeastern statistical (administrative) region of the country. Gevgelija is also the name of the town where the municipal administrative seat is located.

The municipality is situated at the country's border with Greece, and extends along the E-75 highway that links Skopje with Thessaloniki and Athens in Greece.

Gevgelija municipality borders with four contiguous municipalities:

- To the north with municipality of Demir Kapija and municipality of Valandovo;
- To the east with the municipality of Valandovo and municipality of Bogdanci;
- To the west with the municipality of Kavadarci.

The Gevgelija municipality is characterized by a favorable geographical position:

- 160 km distance from the capital city of Skopje;
- 82 km distance from Thessaloniki (Greece);
- Located on the E-75 highway Skopje - Gevgelija – Thessaloniki.

2.1.2 Demographic profile

According to estimated based on the 2002 Macedonian census, Gevgelija municipality has population of 22,782, which shows a minor growth compared to the 2002. The structure of the population in the Municipality of Gevgelija by gender and age is shown on Fig. 2.1 below[2].

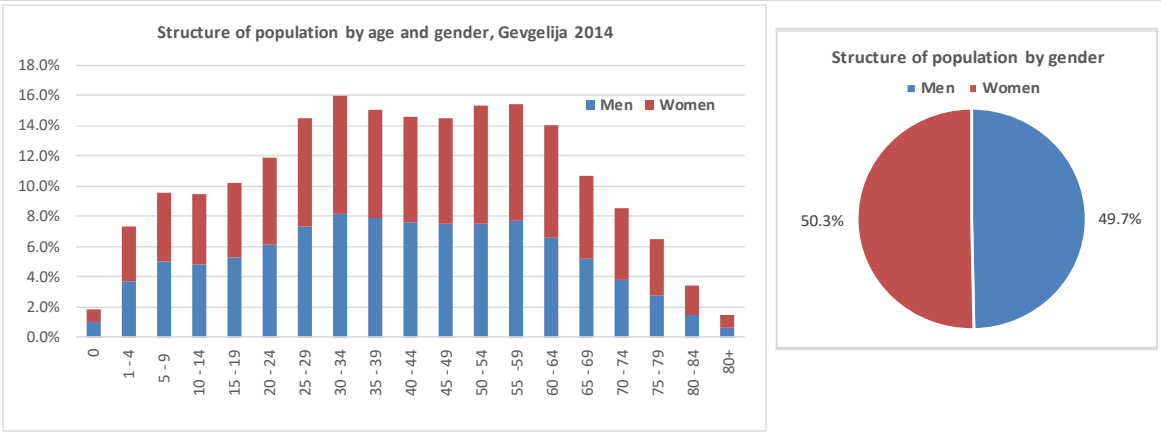


Fig 2.1: Structure of population by age and gender, Gevgelija 2014

[2] Source: State Statistical Office (2015).

2.2 General Project Description

2.2.1 Solid Waste Management in Gevgelija – current situation

The solid (communal) waste management service in municipality of Gevgelija is provided by the Public Communal Enterprise (PE) "Komunalec", Gevgelija. Besides waste management, the PE also provides other public services to the local population, such as: water supply, wastewater collection and discharge, maintenance of parks and greenery, etc.

The information presented further regarding the current status of SWM in Gevgelija is a summary of data gathered through a survey conducted under the project activities. The summary is based mainly on responses to a questionnaire and field visits.

It is important to note that the intent of this part of the report is not to criticize current management practices of the PE. This section is intended to document findings and to provide critical, independent assessment of the current operations of the waste management service provider and needs for improvement. The results of this chapter also form the basis for the development of project's technical concept.

Service coverage: For purposes of this report, municipal solid waste is assumed to include all the wastes generated in a municipality: from households, the commercial/institutional sector, street sweeping and park waste, with the exception of bulky industrial waste, construction and demolition debris and agricultural solid waste. The current extension of the service, i.e. number of served settlements and households in the municipality, is presented in Table 2.1.

Settlement	Service days	Number of households	Number of served households	Percent of served households
Gevgelija	Monday - Sunday	5,420	5,420	100%
Miravci	Tuesday	500	500	100%
Davidovo	Monday	100	100	100%
Bogorodica	Monday and Friday	270	270	100%
Moin	Thursday	100	30	30%
Negorci	Monday and Friday	550	550	100%
Mrzenci	Tuesday and Friday	180	180	100%
Prdejci	Monday and Friday	140	140	100%
Smokvica	Monday and Friday	100	100	100%
Miletkovo	Monday	30	30	100%
Novo Konjsko	Thursday	70	21	30%

Table 2.1: SWM service coverage in Gevgelija municipality, 2015

It can be concluded that the waste service coverage in Gevgelija is at a satisfactory level, with nearly 100% of the local population receiving waste collection and transport service on a daily basis in the urban areas (town of Gevgelija), and one to two times per week for the rural settlements.

Waste generation: It should be pointed out that the existing data regarding waste generation in the municipality of Gevgelija, as is the case elsewhere in the country, are on the whole unreliable. Currently used methods of estimating waste quantities are inadequate, hence there is no inclusive information concerning solid waste generation, neither regarding the total volume nor composition of the waste currently generated. The quantities of generated waste are based on the volume of waste transportation vehicles and average number of vehicle-trips to the landfill, which tends to overstate the waste quantities as the vehicles are frequently not full. Furthermore, there are no records on many illegal dumps in the region where the local population – especially the part of population not covered with the existing service – tends to dump solid waste indiscriminately.

Gathered information regarding the volume and weight of currently collected municipal solid waste in Gevgelija is summarized in Table 2.2 and Fig. 2.2 below; the weight in tons is calculated from values of collected monthly volume in m^3 given by the PE, and a ratio of uncompact waste of 300 kg/m^3.

	Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
m3	2013	2,932	2,908	3,062	3,087	2,809	2,876	2,890	3,008	2,891	3,090	2,886	2,980	**35,419**
	2014	3,073	3,170	3,112	3,207	3,098	3,171	3,300	3,331	3,218	3,379	3,116	3,199	**38,374**
	2015	3,216	3,029	3,373	3,328	3,249	3,516	3,663	3,649	3,601	3,633	3,802	3,746	**41,805**
	2015 + Migrants	3,216	3,029	3,373	3,328	3,249	3,516	4,033	4,139	4,209	4,782	4,987	5,004	**46,865**
t	2013	880	872	919	926	843	863	867	902	867	927	866	894	**10,626**
	2014	922	951	934	962	929	951	990	999	965	1,014	935	960	**11,512**
	2015	965	909	1,012	998	975	1,055	1,099	1,095	1,080	1,090	1,141	1,124	**12,542**
	2015 + Migrants	965	909	1,012	998	975	1,055	1,210	1,242	1,263	1,435	1,496	1,501	**14,060**

Table 2.2: Monthly and annual volume of waste generation in Gevgelija municipality, 2013- 2015

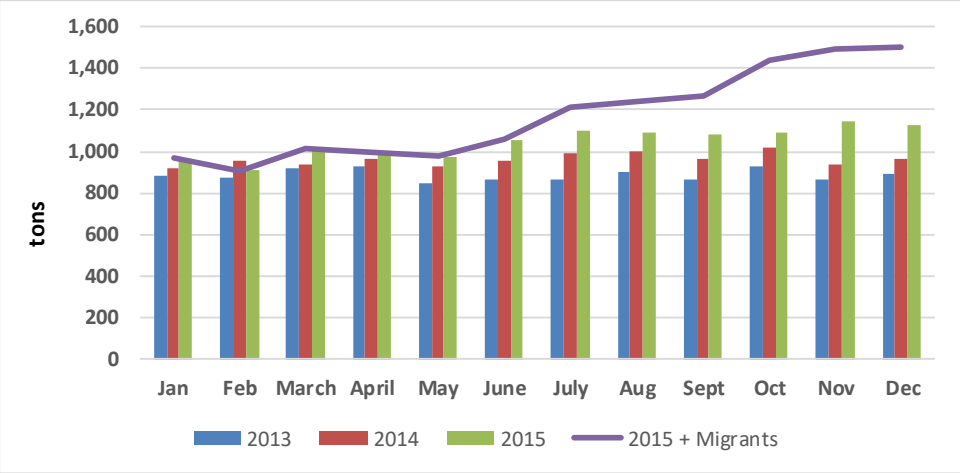


Fig. 2.2: Monthly and annual volume of waste generation in Gevgelija municipality, 2013- 2015

The increase of handled (collected and landfilled) solid waste as a consequence of the migrant inflow during the second half (July through December) of 2015 is evident. The increase ranges from 10% in July, as the migrant flow emerged, to nearly 35% in October and November when it picked.

Several typical unit waste generation rates for 2015, calculated based on information given by the PE, are shown in Table 2.3.

Unit rates	Value
t/HH/year	1.93
kg/HH/day	5.36
t/cap/year	0.55
kg/cap/day	1.53

Table 2.3: Unit waste generation rates

Waste collection and transport: The PE "Komunalec" provides mainly "curbside container", and to certain extent "door-to-door", waste collection service. The frequency of waste collection varies depending on the size of the town/settlement and the size of containers for waste collection. In the central parts of Gevgelija the frequency of collection is daily. In sub-urban parts waste collection is

carried out twice per week, while in smaller, rural settlements of the region the collection usually takes place once per week.

The PE uses two types of waste containers: 5 m^3 (#37) and 1.100 litters (1.1 m^3; #275) as well as small number of plastic bins of 120 liters. The 5m^3 and 1.1m^3 containers are mostly used in residential parts of Gevgelija dominated by multi-story buildings, while plastic bins are mainly used by private households; plastic bins are also placed in places where the migrants are concentrated – The railway station and the "Vinojug" refugee camp located near the border with Greece. The total waste collection volume/capacity (number of waste containers) for the municipality, based on the given information from the PE, appears as sufficient. However, a significant percentage of used containers, estimated roughly 50%, are damaged and need to be replaced.

As regards waste transportation vehicles, the PE uses modern compactor vehicles with volume of 24 m^3 and 26 m^3. In addition, the PE uses open skip trucks for transport of 5m^3 containers. By and large the vehicle fleets in use are obsolete, with majority of trucks being older than 15 years and by the end of their operational life, thus causing extremely high expenses for operation and maintenance.

Waste disposal: Collected waste from Gevgelija municipality region is deposited in an 'official' landfill located near the town of Gevgelija (Fig. 2.3). The landfill is operated by PE "Komunalec".

Fig. 2.3: Location of the currently used waste landfill near Gevgelija

Current landfilling practices are at a low level that cannot be classified as sanitary. The waste is commonly dumped over the edges of the sites. A bulldozer is used occasionally to compact the deposited waste and place cover material over a portion of the exposed waste. However, there does not appear to be an accessible amount of soil for creating a waterproof cap/soil cover, resulting in significant volumes of disposed of solid waste always opened to the atmosphere. No attempt is made to segregate residential, commercial or industrial recyclable wastes. The types and amounts of chemicals being disposed are also not known. There does not appear to be an alternative program for disposal of hazardous waste.

Furthermore, the landfill is located along the riverbed of Suva Reka and in very close proximity to the Vardar river, thus creating an enormous threat to surface- and underground-water pollution. Finally, the landfill is practically at the end of its lifetime, i.e. the space available for depositing additional waste at the current location, given the current waste generation rate, is estimated to be sufficient for less than a year.

Financial aspects: Waste fees and subsidies from municipal budget allocations are the two sources of funds for recovery of the expenditures for waste management in Gevgelija. Often also municipal capital investment funds and allocations from Central Government funds are used for various small-scale waste management-related investments, such as: purchase of waste equipment, closing or cleaning of illegal dumps, etc.

Waste fees currently levied are mainly set-up as flat monthly charges to households, businesses and public institutions. Information regarding the fees is shown in Table 2.4.

Households	Dwelling area	Home yard		
	1.8 MKD/m^2	28 MKD (flat)		
Businesses	< 20 m^2	20 - 40 m^2	40 - 80 m^2	> 80 m^2
	170 MKD	265 MKD	440 MKD	1.8 MKD/m^2

Table 2.4: Overview of waste fees charged by PE 'Komunalec', Gevgelija

In addition to the waste fees that are based on property size/area, the PE also has arrangement with some businesses for charging fees for collection of 1.1 m^3 containers. Such fees currently range from 350 to 400 MKD per container, based on the required transport distance.

2.2.2 Waste generation projections

As the volume of waste reported by the PE (Table 2.2) is not reliable as it is based on estimations only, the project team created a more realistic waste generation scenario. This scenario is based on the following assumptions:

- The period of analysis refers to a 10-year period (2016 – 2026)
- Unit waste generation rate for urban areas equals 417 kg/capita/year (1.4 kg/cap/day); for rural areas 347 kg/capita/year (0.95 kg/cap/day). These adopted rates are based on information from other/previous waste management studies carried out in the country that included analysis of current waste generation, following widely accepted and proven methodology
- Population growth for the region of 0.2% annually, assumption based on official statistical information
- The rural areas currently not covered with waste collection service will be gradually introduced into the system, starting from 2016
- For safety reasons the analysis takes into consideration that the refugee crisis will continue, thus the waste generated by migrants and 'support personnel' that will be present in Gevgelija due to the crisis is also included[3]. It is assumed that the crisis will take place over the first 3 year of the analyzed period (2016 – 2018). The average daily number of refugees in the municipality is assumed to equal 2,000, and 500 'support' personnel. Unit waste generation by the migrants and supporting personnel is estimated at 1.2 kg/cap/day.
- Extension of existing recycling activities carried out by the private and informal sectors[4],

[3] "Support personnel' refers to police officers, military, and representatives of humanitarian organizations dealing with the refugee/migrant crisis.

[4] The informal recycling refers mainly to recycling of scrap metals, carried out by owners of small-scale scrap yards and scavengers.

combined with initiation (to a minor degree) of formal recycling by the public sector, which will result in reduction of waste quantities to be transported and landfilled will start in 2018 with a 1% waste reduction in the first year, and will gradually increase to a maximum of 16% over a 5-year period.

- The following ratios are applied: weight of uncompact waste – 300 kg/m^3; weight of semi-compact waste (in transport vehicles) – 700 kg/m^3; weight of compacted waste (at landfill) – 1000 kg/m^3.

Summarized information regarding forecasted municipal solid waste generation in the region is given in Table 2.5 bellow. The detailed calculation spreadsheet is attached in Annex 1.

Municipality/Waste Generator	Unit	2016	2018	2020	2022	2024	2026
		0	2	4	6	8	10
Population growth rate		0.20%	0.20%	0.20%	0.20%	0.20%	0.20%
Waste Gevgelija URBAN + RURAL	**t**	9,151	9,661	10,001	9,506	9,978	10,328
Waste Refugees/Migrants	**t**	1,007	1,007	0	0	0	0
Total Gevgelija and Refugees	t	10,159	10,669	10,001	9,506	9,978	10,328
Cumulative Gevgelija and Refugees	000 m3	10	31	51	71	90	111

Table 2.5: Waste generation forecast

2.2.3 Summary of identified problems

Provided below is a brief summary of identified SWM problems:

- There is no organized and reliable waste generation measurement and monitoring
- Agricultural waste is not treated with the current SWM system
- Waste containers used are old; the number of 120 l waste containers is insufficient
- Waste transportation equipment/vehicles used is obsolete and expensive to operate and maintain
- Current waste disposal practices are at an extremely low level, causing significant threat to human health and environmental pollution
- There are no dedicated separation and storage, as well as appropriate disposal, of medical, hazardous and construction waste
- There are no waste recycling activities organized by the public sector.

The information gathered with the analysis current status with SWM in Gevgelija municipality points out the basic needs for modernization of the service, which could be summarized as:

(1) need for extending the coverage of the service to all currently not serviced settlements

(2) need for modernizing the waste collection and transport equipment

(3) need for upgrading of waste disposal practices in financially sound manner and according to modern environmental standards

(4) a specific, supplementary aspect is remediation or clean-up of the existing official landfill near Gevgelija and illegal dumps.

Given that the problem with disposal of communal waste is by far the most severe one, all further analysis in this report are focused on identification of potential sites for construction of a temporary landfill for Gevgelija, to serve the immediate needs until the strategy/project for regionalization of the waste service in the SE region takes place. Estimated size of the landfill, based on the waste generation projections, for an assumed 5 to 6-year period equals 1.2 to 2 ha (roughly 60,000 tons of compacted waste).

3. Applied Landfill Site Selection Methodology

Increase of the amount of generated waste is a growing and significant problem in context of environmental protection and health of the population, especially in developing countries, creating great pressure on natural resources. The impact of waste on the environment in Macedonia has multiple negative effects. The waste is disposed in illegal dump sites, there is obvious problem of insufficient tidiness/organization of official sites for municipal landfills, and low awareness of the citizens for need of environmental protection.

According to Waste Management Strategy of Macedonia (2008 – 2020) one third of the existing 51 landfills in the country is categorized according to the assessment of their environmental risk to the highest risk class and they need priority closure or remediation. One of those is the landfill located in Gevgelija, ranked as second.

The disposal of municipal waste in Gevgelija is one of the biggest problems in the region, and in particular the problem was exacerbated with the waste generated as a result of the migrant crisis. Therefore, the priority is to provide a new site for waste disposal due to absolutely unacceptable location of the existing landfill and its almost exhausted capacity.

3.1 Description of AHP methodology for landfill site selection

Positioning a landfill is a complex process because it has to combine social, environmental and technical parameters. The setting process aims to locate the areas that will minimize potential hazards to the public health as well as to the environment and will be economically efficient.

The methodology for the selection of a suitable location, which is applied is based on a combination of GIS (Geographical Information Systems) and AHP (Analytical Hierarchical Process) in order to define an appropriate space to locate the landfill site in the municipality/region of Gevgelija, and consists of the following steps:

1. Defining the Problem
2. Identification of key experts and stakeholders in the decision-making process and definition of specific criteria/factors for assessing the suitability of land for construction of a landfill
3. Collection and preparation of data (digitization, statistical analysis, etc.) and creation of raster data for each factor
4. Classification of data sets and forming the suitability map for each factor (criterion limit)
5. Establish a matrix of criteria for decision making and evaluation
6. Calculation of weighted factors of the criteria
7. Weighting of maps and their summing up in the map of suitability
8. Creation of map-factors constraints
9. Summing up the resulting maps by combining the suitability map with constrain map and getting the final map of suitability.

3.2 Identification of factors influencing the selection of the landfill site

The factors that have been identified as crucial in the process of selecting a suitable location for municipal (or sub-regional) landfill on the basis of expert knowledge and previous experience are divided into three types, based on the nature and the role they play in the decision-making process: criteria constraints (restrictions), and the dual nature of the factors (criteria and at the same time restriction). The factors are grouped into four basic factor groups: (1) Geo-natural factors; (2)

Environmental factors; (3) Social factors; and (4) Techno-economic factors. Bearing in mind that the process of identifying factors is imperative with respect to obligations and guidelines stipulated by the EU Directive and national legislation, the key recommendations of the EU Landfill Directive, the national Waste Management Act, the Regulation on waste disposal as well as extensive experience of expert groups in the design and construction of the landfill have been taken into account in the process of identifying factors and their evaluation.

Given that certain requirements related to locating a sanitary landfill site, such as distance from the border of the construction area, especially housing zone, distance from watercourses, and other agricultural and urban areas are not strictly defined by the EU Directive on landfills and the Regulation on waste disposal in landfills, the setting and evaluation of rules was carried out in accordance with recommendations of relevant international literature.

To each of the criteria a different score (rank) on a scale of 1 (Unfavorable locations for the siting of landfills) to 7 (Most suitable locations for siting landfills) was assigned in accordance with the legal limitations, the experience of experts involved in the evaluation and international literature [3].

The initial step of the methodology is definition of a hierarchical structure of the decision problem. Utilizing nine evaluation criteria, three levels of hierarchical structure have been chosen to be the appropriate scheme in order to decompose/analyze the multiple criteria problem of landfill risk assessment. The relative importance weights for the criteria in each hierarchical level are estimated using the Analytic Hierarchy Process (AHP) in GIS environment.

Factor group		Criteria		Distance	Grade
B1	**Geo-natural factors**	C1	Groundwater depth	<2	1
				2-5	4
				>5	7
		C2	Litho-structural	Gravels and sands	1
				Marl and flysch	4
				Schists, gneisses and serpentinites	7
B2	**Environmental factors**	C5	Land use (CORINE Land cover)	Forests	1
				Semi natural areas	4
				Agricultural areas (excluding permanent crops and irrigated areas)	7
		C6	Surface water streams	<500	1
			Dual factor	500-2000	4
				>2000	7
B3	**Social factors**	C7	Aspect (Direction of dominant winds)	N, NW	1
				SE, S, E	3
				W, NE	4
				SW	7
		C8	Settlements	500-1000	3
			Dual factor	1000-2000	4
				2000-25000	7
				>2500	1
B4	**Techno-economic**	C9	Terrain Slope	0-10	7

factors				
			10-20	4
			>20	1
	C10	Transport infrastructure	<500	1
			500-1000	4
			1000-2000	7
	C11	Energy infrastructure	<500	1
			500-1000	4
			1000-1500	7
			>1500	1

Table 3.1: Criteria scoring for landfill site identification/selection

- Groundwater depth and litho-structural factor: one of the main criteria when choosing a landfill site is the underlying ground to be impermeable and the depth to groundwater to be big enough to avoid contamination of groundwater.
- Land use: in the process of grading of land use, agricultural areas (excluding permanent crops and irrigated areas) got highest grade and forested areas got lowest grade.
- Surface water streams: the landfill must not be located near constant or intermittent watercourse, due to formation of leachate which can pollute the water.
- Aspect (Direction and intensity of dominant winds): landfills are a potential source of offensive odors that can create displeasure within communities, so the areas exposed to winds with high intensity got lowest grade.
- Settlements: the landfill site should not be placed near a residential or an urban area to avoid and to protect the general public from possible environmental hazards released from landfill sites.
- Terrain Slope: land morphology is a basic parameter for the construction of a landfill site. In the proposed methodology, land morphology was evaluated by the slope gradation, which was expressed in degrees. Sites with steep slopes are usually not technically suitable for landfill and too flat areas would affect the runoff drainage.
- Transport infrastructure: aesthetic considerations should be taken into account as well, and based on this principle landfills shall not be located very close to transport network. On the other hand, the landfill site should not be placed too far away from existed road networks, to avoid the expensive cost of constructing connecting roads.
- Energy infrastructure: landfills should not be constructed above gas pipelines, beside electric transmission lines, etc.

3.3 Evaluation of spatial criteria for the purpose of applying the AHP for creation of suitability map

The analytic hierarchy process (AHP) is a widely accepted decision making method, which is used to determine the relative importance of the criteria in a specified decision making problem. One of the most crucial steps in any multiple criteria problem is the accurate estimation of the relevant data. Although qualitative information about the criterion importance can be found, it is difficult to quantify it correctly. The AHP method proposed by Saaty is an effective approach to extract the relative importance weights of the criteria [4]. The AHP is based on pairwise comparisons, which are used to determine the relative importance of each criterion [5] (Table 3.2).

Intensity of importance	Definition	Explanation
1	Equal importance	**Two factors contribute equally to the objective**
3	Somewhat more important	**Experience and judgement slightly favors one over the other**
5	Much more important	**Experience and judgement strongly favors one over the other**
7	Very much more important	**Experience and judgement very strongly favors one over the other; its importance is demonstrated in practice**
9	Absolutely more important.	**The evidence favoring one over the other is of the highest possible validity**
2,4,6,8	**Intermediate values**	**When compromise is needed**

Table 3.2: The Saaty Rating Scale

These pairwise comparisons are carried out for all factors to be considered, and the matrix is completed (PCM-Pairwise Comparison Matrix). The next step is the calculation of the relative weights, importance, or value, of the factors, which are relevant to the problem in question (technically, this list is called an eigenvector). Saaty [4] proposes the estimation of the right principal eigenvector of the PCM which can be approximated using the geometric mean of each row of the PCM (by multiplying the elements of each row and then taking the nth root, where n is the number of criteria). This mode is known as multiplicative AHP and was used in the present work. Calculated geometric means are then normalized and the relative importance weights are extracted. The final stage is to calculate a Consistency Ratio (CR), i.e. to measure how consistent the judgements have been relative to large samples of purely random judgements. If the CR is much in excess of 0.1 the judgements are untrustworthy.

Based on the results shown in Table 3.3, it was confirmed that the Geo – natural and Social factors are less important factors in the selection of appropriate landfill site than Techno-economic and Environmental factors, which is fully in compliance with the EU Directives and the national legislation dealing with environmental protection and waste management.

	B1	B2	B3	B4	Eigen vector (weight)
B1	1	1/3	1/2	1/2	0.12
B2	3	1	4	4	0.53
B3	1	1/4	1	3	0.2
B4	2	1/4	1/3	1	0.15
Totals					1.00

Table 3.3: Matrix comparisons with rate value for factor groups and their weight (relative importance)

Values of degree of consistency, named as consistency ratio (CR) for all comparisons are calculated and have a value of less than 0.1, indicating the consistency of the obtained results.

Matrix comparisons and weight value elements are shown in Table 3.4 below and in the following order: Land suitability for the construction of the landfill (A) Factor group (B1 - B4), Criterion (C1-C9) and weight (W).

		Factor group		Criteria	Weight
A	**B1**	Geo-natural factors	C1	Groundwater depth	0.75
			C2	Litho-structural	0.25
	B2	Environmental factors	C3	Land use (CORINE Land cover)	0.25
			C4	Surface water streams	0.75
	B3	Social factors	C5	Aspect (Direction of dominant winds)	0.25
			C6	Settlements	0.75
	B4	Techno-economic factors	C7	Terrain Slope	0.574
			C8	Transport infrastructure	0.286
			C9	Energy infrastructure	0.14

Table 3.4: Criteria weight values

Through the analysis two types of factors and limitations were identified. The first group are factors that have a restrictive character, which means that in this zone locating a landfill is prohibited. This includes faults (with 1,000 m buffer zone), water supply sources (1,000 m buffer zone), cultural heritage localities (with a 500 m buffer zone), area where windmills are located (with a 1,500 m buffer), irrigated areas, inundating areas and the zone of the state border (with 2,000 m buffer zone). The second group consists of factor with a dual nature, i.e. factors that are both criteria and restrictions in the process of locating landfills. This group consists of three factors on the level of criteria: surface water (500m buffer zone), and settlements (with a 500m buffer zone); (Fig. 3.1; Annex 2).

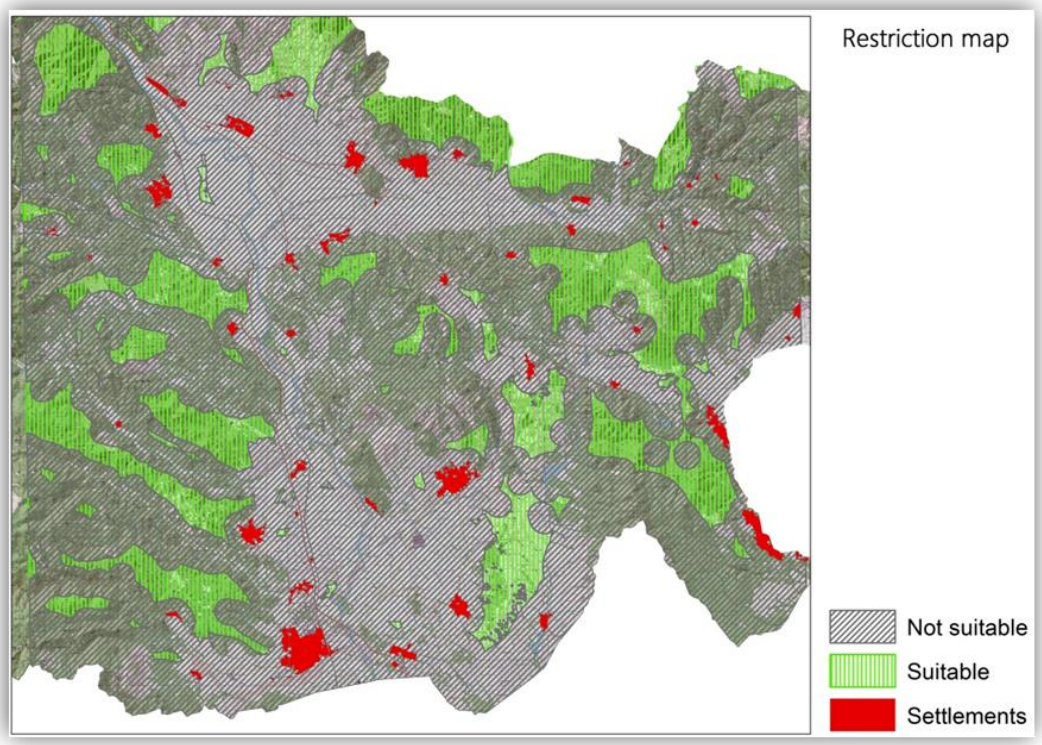
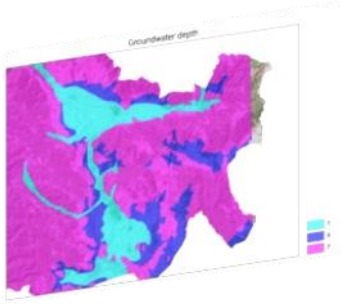
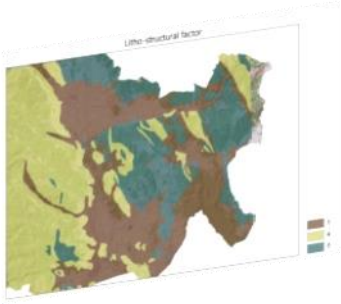


Fig. 3.1 Restrictions map

Maps (layers) showing Geo-natural, Environmental, Social, and Techno-economic factors of analyzed wider area for landfill site identification are shown of Fig. 3.2, 3.3, 3.4 and 3.5 respectively and Annexes 3 to 15. The concluding Suitability and Suitability with Restrictions maps of the analyzed area are shown on Fig. 3.6 and 3.7 and Annexes 16 and 17.



Groundwater depth



Litho-structural factors

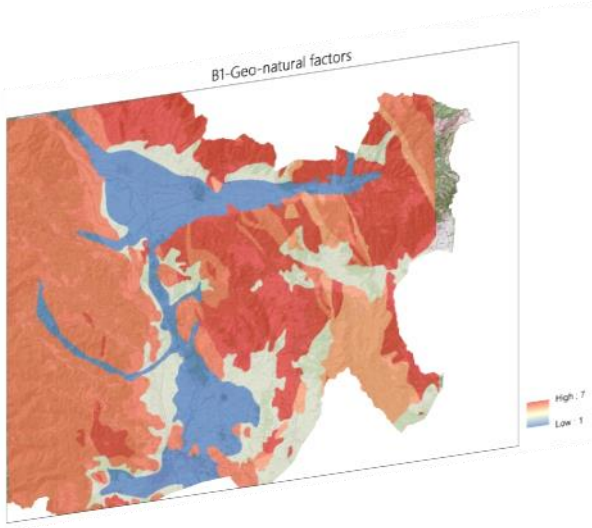
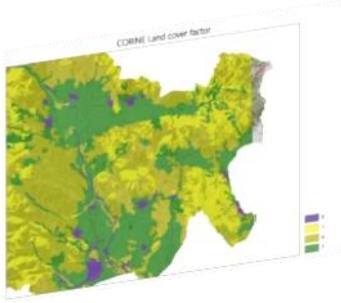
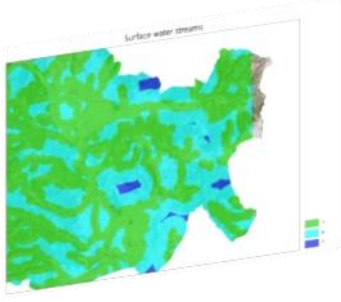


Fig. 3.2 Geo-natural factors



CORINE LC factor



Surface water factor

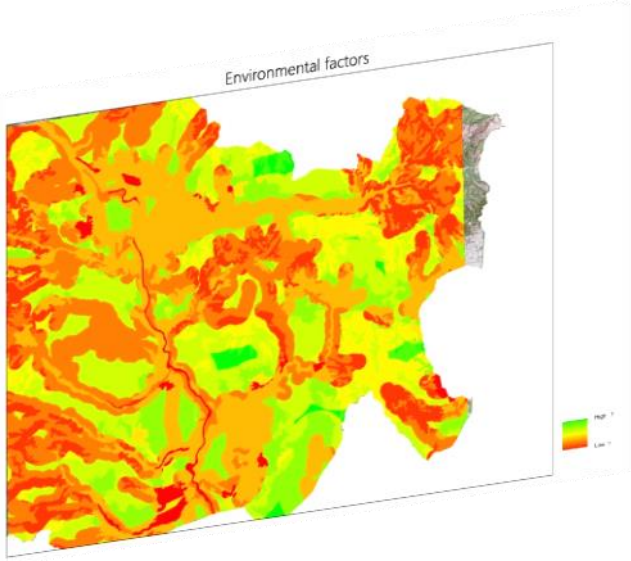
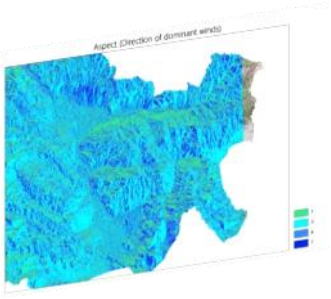
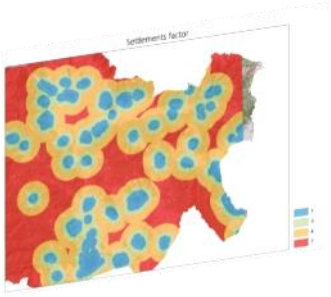


Fig. 3.3 Environmental factors



Direction of dominant winds



Distance from settlements

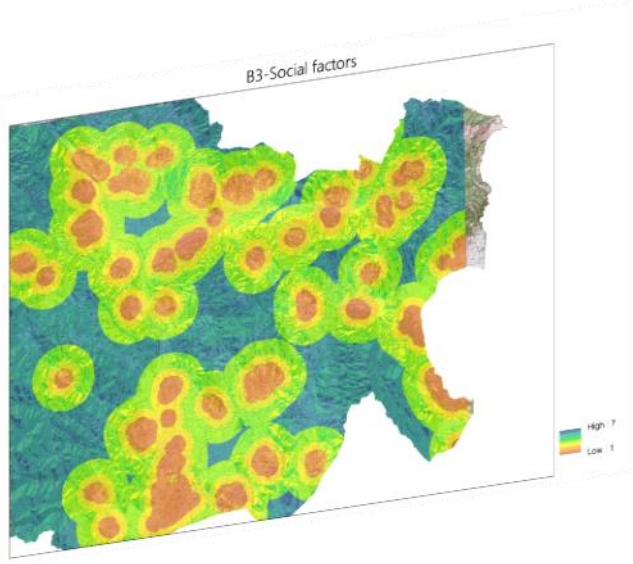
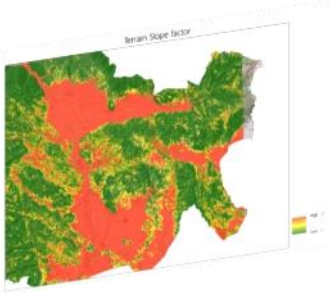
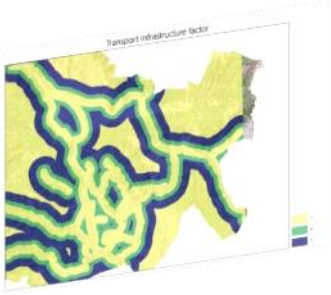


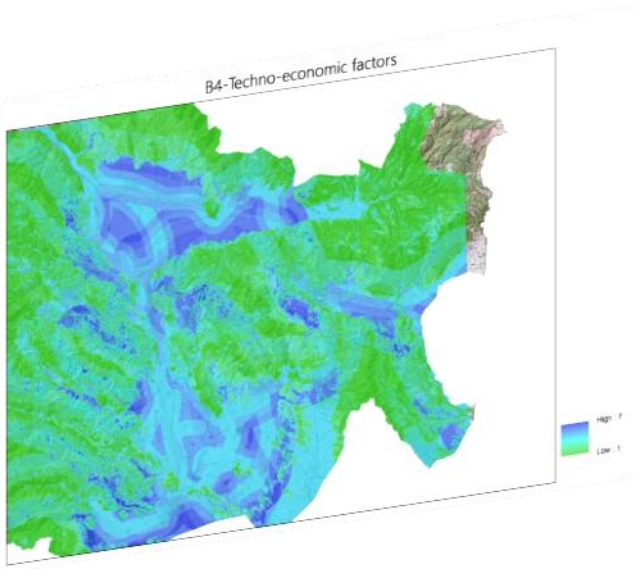
Fig. 3.4 Social factors

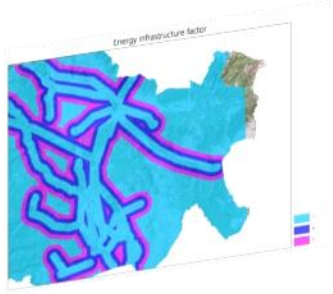


Terrain slope factor



Transport infrastructure factor





Energy infrastructure factor

Fig. 3.5 Techno-economic factors

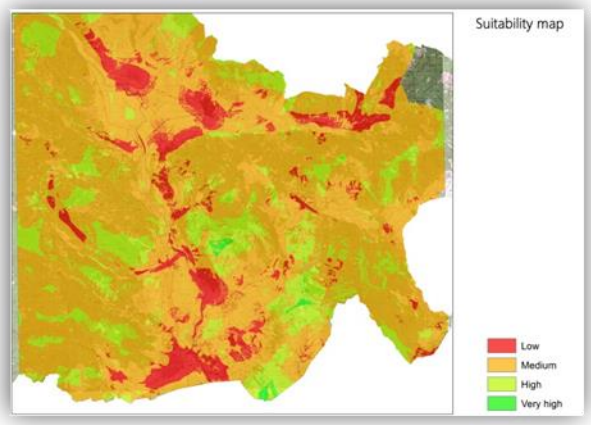


Fig. 3.6 Suitability map

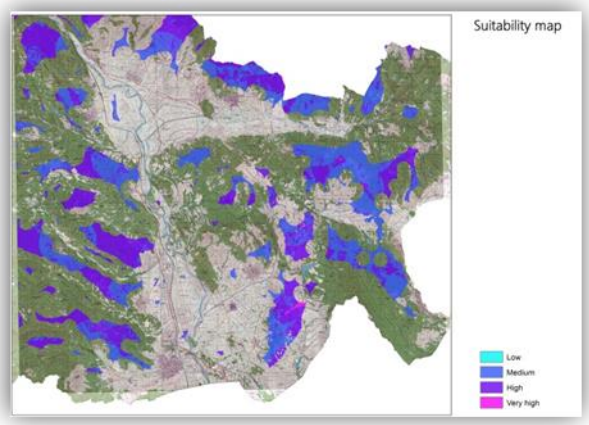
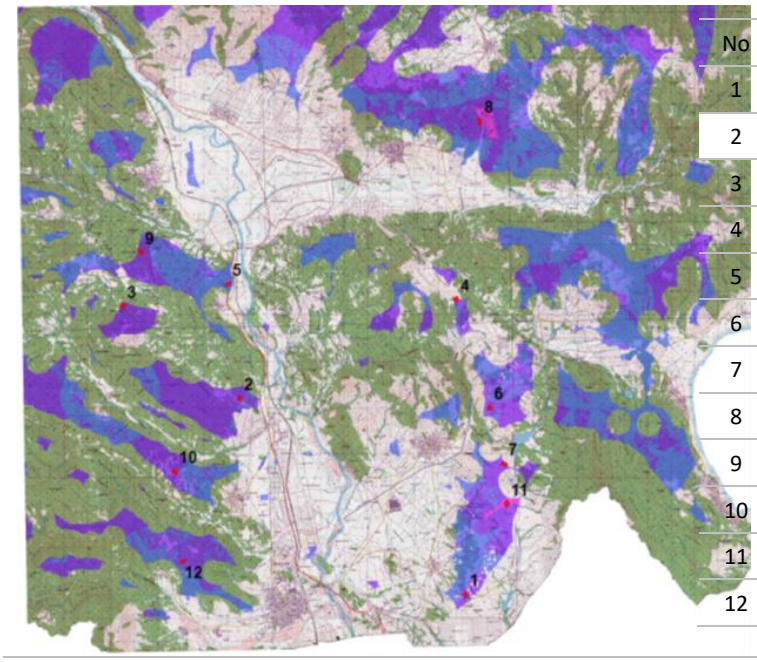


Fig. 3.7 Suitability map with restrictions

After identification of eligible macro location, or zone for the construction of landfills, from all suitable macro locations, 12 potential micro locations were selected for locating a temporary landfill, and average grade for each was calculated and is shown on Fig. 3.8 and Annex 18.

The methodology described is an efficient approach in a landfill siting process. The methodology combines the evaluation abilities of MCA methods and the analytical tools of GIS. The MCA was utilized to form the siting problem into a decision structure of three hierarchical levels, namely, the goal (suitability), evaluation criteria and spatial attributes. The AHP method was utilized to extract the relative importance weights of the evaluation criteria, in order to solve the landfill siting problem. GIS was exploited to create the spatial determination of the evaluation criteria and create the land suitability map.

In the process of finding the suitable location for landfill, factors that have a significant role in the selection of the landfill location were identified, on the basis of the relevant national legislation, EU Directives, and international literature. Unlike some methodologies which use a decision-making matrix to make the comparison of all criteria together, in this case the key factors in the decision making process for selection of optimal locations of landfill were divided into groups according to their nature and role in decision-making process. Finally, a comparison matrices are formed separately for each factor in order to avoid incompatibility of factors (e.g. comparing the depth of groundwater water with energy infrastructure).



No	KO	KP	Grade
1	Stojakovo	6165	3.79
2	Prdejci	617/1	3.85
3	Gabrovo	520	3.97
4	Kazandol	926/1	3.34
5	Smokvica	402	2.73
6	Bogdanci-vgr1	2921	4.08
7	Bogdanci-vgr2	4517	3.63
8	Rabrovo	24	3.53
9	Gabrovo	396/1	4.16
10	Negorci	228	4.02
11	Stojakovo/Bogdanci	658	5.03
12	Novo Konjsko	117	3.50

Fig. 3.8: Possible macro location/zones and micro locations with grades

However, presented GIS-aided siting methodology is flexible as far as the determination of criteria is concerned. Thus, it is quite easy to expand and improve the methodology by taking into account other or include more parameters.

From all identified macro locations or zones, 12 potential locations for temporary landfill were selected and graded.

4. Financial Analysis

4.1 Objective of the analysis

The main objective of the financial analysis as presented further is to identify the least-cost project alternative for construction of a new temporary sanitary landfill in Gevgelija. The analysis is carried out by comparison of the average operation and maintenance (O&M) costs for each of the 12 identified alternative landfill locations.

The second objective of the analysis is to provide an estimate of required investment costs for construction of the temporary landfill. It is expected that, given the nature of the landfill (temporary/small scale), the investment costs would not differ significantly from one alternative location to another, with the exception of costs for construction of access road which vary according to the terrain and other existing conditions referring to each alternative location. Thus, the investment value is estimated only for the proposed (most feasible) location.

4.2 Assumptions

The analysis of the considered project alternatives is based on the following assumptions:

- No sources of revenues were recognized in any of the alternatives, i.e. the analysis is based on least-cost assessment
- The number of employees for operation of the project refers only to technical personnel (employees) that will be responsible for its operation and maintenance on a daily basis
- The following categories of O&M expenses are taken into consideration: fuel cost (based on transport distance between the town of Gevgelija and analyzed localities), tire replacement costs, cost for replacement of vehicle spare parts, labor costs (wages) for the required number of truck drivers and loaders, costs for protective clothing, and annual vehicle license and insurance costs
- The alternative that provides the minimal average annual O&M costs is considered to be the optimal alternative

4.3 Analysis of considered alternatives

Summary information from the analysis of O&M costs for all analyzed alternative locations for the Gevgelija temporary landfill is presented in Fig. 4.1.

Landfill location	Negorci	Bogdanci 1	Rabrovo	Stojakovo	Prdejci	Smokvica	Gabrovo 1	Gabrovo 2	Bogdanci 2	Kazan dol	Stojakovo Bogdanci
Annual O&M costs	90,802 €	92,645 €	98,310 €	90,939 €	91,842 €	92,362 €	94,059 €	95,856 €	92,645 €	96,659 €	93,402 €
Ratio	0%	2%	8%	0%	1%	2%	3%	5%	2%	6%	3%

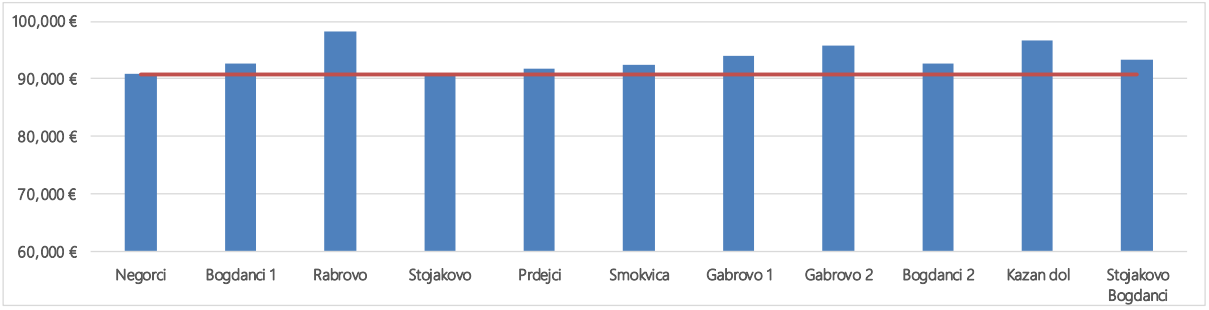


Fig. 4.1: Summary information from analysis of O&M costs

Evidently, there are minor differences in the O&M costs between identified alternative landfill site locations. The reason for this is the fact that major part of these costs are related to wages/labor (roughly 60%) and costs for vehicle spare parts (roughly 20%); fuel costs, which are directly related to the transport distances, are in the range of 8% to 10% (Fig. 4.2).

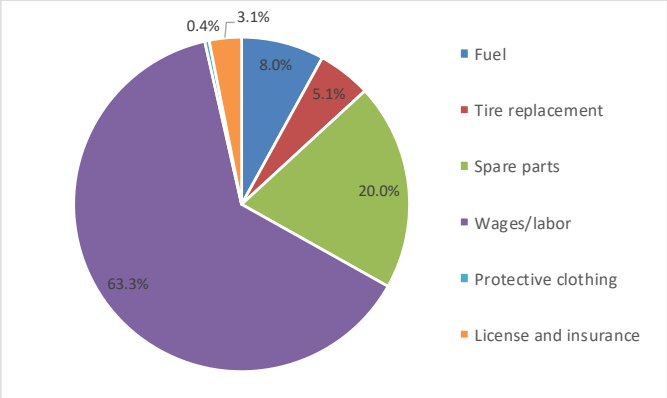


Fig. 4.2: Distribution of O&M costs, Novo Konjsko location

4.4 Investment cost estimate

Summary information from assessed investment value for construction of temporary sanitary landfill for Gevgelija municipality at the Novo Konjsko location is presented in Table 4.1 and Annex 20.

No	Description	Unit	Quantity	Unit price (euro)	Total price
Work connected with the landfill body					
1	**Excavation of landfill body**				**€ 11,966**
	Earth works for the landfill body				**€ 63,102**
1a.	**Geosyntetic system**				**€ 154,948**
2	**Gas wells (foundation part)**				**€ 5,990**
3	**Leachate concrete reservoir and pump system**				**€ 2,898**
4	**Access manholes** (foundation part)				**€ 202**
5	**Open reservoir for leachate**				**€ 25,688**
6	**PVC pipes for leachate collection**				**€ 2,332**
7	**Submerged pump for aggressive media**	unit	2	2480	**€ 4,960**
8	**Submerged pump for excavation draining**	unit	2	4960	**€ 9,920**
9	**Pipeline for pumping leachate**	unit	150	4.50	**€ 675**
10	**SBR Leachate treatment system** (detailed BoQ)	unit	1	92750.00	**€ 92,750**
11	**Stormwater open drain canal**				**€ 3,216**
	Total civil work for landfill body				**€ 378,647**

No	Description	Unit	Quantity	Unit price	Total price
Other Works					
12	**Landfill gas system**				**€ 167,127**
13	**Roads** (blanket & bituminous bearing courses only)				**€ 168,920**
14	**Truck weighing system**				**€ 31,023**
15	**Fencing**				**€ 18,961**
16	**Auxiliary building**				**€ 132,500**
17	**Tank for diesel fuel**				**€ 15,598**
18	**Outdoor water supply and sewerage**				**€ 82,743**
19	**Electric installations ans substation**				**€ 42,500**
20	**Monitoring system equipment**				**€ 3,000**
	Total other works				**€ 662,372**

	SUB TOTAL LANDFILL CONSTRUCTION COSTS	**€ 1,041,000**
	CONTINGENCY (15%)	**€ 156,000**
	TOTAL LANDFILL CONSTRUCTION COSTS	**€ 1,197,000**

Table. 4.1: Investment cost summary for construction of sanitary landfill for Gevgelija, Novo Konjsko location

The investment cost is estimated based on conceptual design drawings (Annex 19) and current unit prices for related construction works, installations and equipment I the country. The investment equals roughly €1,2 mill.

5. Conclusions and Recommendations

(1) A massive number of refugees and irregular migrants have transited through Macedonia in 2015. During the summer months of 2015 an estimated 1,000 people crossed the southern border from Greece on a daily basis, seeking to transit the country to Serbia and move on to EU destinations. In mid-September the daily totals surged to 5,000-6,000 people. In October daily arrivals peaked at 11,000, before receding to 3,500 in November and December. Although the refugee traffic through the country by and large has been a transit flow, it has proved to be a real test, in terms of funds, expertise and human resources, for the responsible Macedonian Government institutions and the two most-affected municipalities – Gevgelija and Kumanovo.

(2) In response to the crisis throughout the year the UN has provided a multifaceted support to the country, addressing the needs of refugees and migrants, ensuring full respect for their human rights and helping to design, build, equip, staff and winterize the reception and transit centers. In addition, the UN has recognized that its support needs to go beyond humanitarian aid provision. i.e. towards support to national actors at all levels in enhancing their ability to manage the crisis and in building the resilience of local communities. The UNDP has initiated project activities that address high-priority, urgent needs of affected municipalities, particularly in the area of water and waste management, which are both crucial to refugee well-being and highly sensitive for local host populations.

(3) The Municipality of Gevgelija is currently facing a very serious problem with disposal of communal solid waste generated by households, businesses and public institutions. The municipal landfill currently in use near the town of Gevgelija is located along the riverbed of Suva Reka and in very close proximity to the Vardar river, creating an enormous threat to surface- and underground-water pollution. Furthermore, the landfill is practically at the end of its lifetime, i.e. the space available for depositing additional waste at the current location, given the current waste generation rate, is estimated to be sufficient for less than a year.

(4) This feasibility analysis is focused on identification and assessment of potential sites for construction of a temporary landfill for Gevgelija, to serve the immediate needs until the strategy/project for regionalization of the waste service in the SE region takes place. Estimated size of the landfill, based on the waste generation projections, for an assumed 5 to 6-year period equals 1.5 to 2 ha (roughly 60,000 tons (m^3) of compacted waste).

(5) With application of a specific methodology based on combination of GIS and the AHP a total of 12 appropriate micro locations for the new landfill site in the wider Gevgelija region were identified. The wider region, besides the municipality of Gevgelija, includes also territories of the neighboring municipalities of Bogdanci, Valandovo and Dojran. The objective of the approach was based on assumed requirements to investigate possibilities for construction of a semi-regional temporary landfill that, in line with an ongoing project (strategy) for establishment of a regional waste management center for the SE statistical region in Macedonia, could serve the needs for one or more additional municipalities and even be converted into a waste transfer station once the waste service regionalization takes place. However, in the course of carrying out the analysis, based a series of meetings with the key stakeholders – Municipal authorities of Gevgelija and PE Komunalec – and following their development plans and requirements, it was decided to narrow the scope of the herein analyzed project to meet the SW disposal needs for Gevgelija municipality only.

(6) Based on further analysis, it is concluded that there are minor differences in the O&M costs between identified alternative landfill site locations. The reason for this is the fact that major part of the O&M costs is related to wages/labor (roughly 60%) and costs for vehicle spare parts

(roughly 20%); fuel costs, which are directly related to the transport distances, are in the range of 8% to 10%.

(7) It is recommended that the municipality of Gevgelija and PE Komunalec pursue with implementation of further activities for construction of a new temporary landfill at the Novo Konjsko location, with financial and administrative support by the UNDP. Proposed locality is highly convenient for the purpose:

i. It was ranked very positively with applied landfill site identification and selection methodology, which itself is based on strict criteria and a number of influencing factors grouped into four basic factor groups: (1) Geo-natural factors; (2) Environmental factors; (3) Social factors; and (4) Techno-economic factors.

ii. The locality is within the territory of Gevgelija municipality, making all further decision making activities efficient.

iii. The distance of the locality from the town of Gevgelija – the dominant waste producer in the municipality – equals roughly 7 km, which results in a minor increase of the current waste fees to cover the additional O&M costs.

iv. Required investment for establishment of the new landfill equal roughly €1.2 million.

v. Construction of a temporary landfill is in line with the Waste Management Strategy for Macedonia (2008 – 2020) [6] and the Law on Waste (Article 144/3) [7].

6. References

(1) “Waste Management Strategy of the Republic of Macedonia (2008 - 2020).” Mar-2008.

(2) “Градење на капацитетите за имплементација на ЕУ Директива за депонии -затворање на нестандардните депонии и инспекции.” 2011.

(3) “EPA Landfill Manuals, Manual on Site Selection.” Dec-2006.

(4) Thomas L. Saaty, “Decision making with the analytic hierarchy process,” Int. J. Services Sciences, vol. 1, 2008.

(5) Themistoklis D. Kontos, Dimitrios P. Komilis, Constantinos P. Halvadakis, “Siting MSW landfills with a spatial multiple criteria analysis methodology,” Waste Management, vol. 25, no. 8, pp. 818–832, Oct. 2005.

(6) “Предлог Стратегија за управување со отпад на Република Македонија (2008 – 2020)“; Влада на Република Мекедонија, 2008.

(7) “Закон за управување со отпадот“; Службен веснк на РМ. 2004.

(8) R. Macedonia, State Statistical Office: Statistical Yearbook 2014.

(9) “Guide to Cost-Benefit Analysis of Investment Projects”; European Commission, DG Regional Policy, Evaluation Unit. 2014.

Annexes