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2013

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MPRA Paper No. 61369, posted 18 Jan 2015 14:18 UTC

# Landfills – territorial issues of cities from North-East Region, Romania

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Received on <07-05-2013>, reviewed on <21-09-2013>, accepted on <26-10-2013>

## Abstract

Landfilling prevails in waste management options in Romania like others new EU members, being contrary to the concept of waste hierarchy promoted in recent years by EC. Waste disposal is done usually in non-compliant landfills and Government established a program to close these sites. This paper aims to analyse the transition from traditional waste management systems to an integrated system at national, regional and local scale. Assessment of landfills location based on buffer analysis (using GIS techniques) is made according to the proximity of five critical factors (CF) such as: residential area, industry & commercial units, agricultural lands, rivers & lakes, forest and protected areas, all these factors being sensitive to pollution. Thus, most of these old sites are badly or improperly located related to surroundings and only few have an acceptable location in the study area! Therefore, the proposed method can be a necessary tool in EIA studies of these environmental threats at regional scale.

**Keywords:** *landfill, urban area, GIS, multi-scale analysis, waste management*

## Rezumat. Depozite de deșeuri – probleme teritoriale ale orașelor din Regiunea Nord-Est, Romania

Depozitarea predomină în opțiunile de management al deșeurilor în România asemeni altor state noi membre, fiind contrar conceptului de ierarhie a deșeurilor promovat în ultimii ani de CE. Eliminarea deșeurilor se realizează de obicei în depozite neconforme, iar Guvernul a stabilit un calendar de închidere a acestor amplasamente. Această lucrare își propune să analizeze tranziția de la un sistem tradițional de management al deșeurilor către un sistem integrat la nivel național, regional și local. Evaluarea amplasamentelor acestor depozite bazată pe analiza buferelor (utilizând tehnici SIG) este realizată în funcție de proximitatea a cinci factori critici, cum ar fi: zona rezidențială, unitățile industriale și comerciale, terenuri agricole, râuri și lacuri, păduri și arii protejate, toți acești factori fiind sensibili la poluare. Astfel, majoritatea acestor amplasamente sunt rele sau necorespunzătoare față de împrejurimi și numai câteva au o amplasare acceptabilă în zona de studiu! Prin urmare, metoda propusă poate deveni un instrument necesar în studiile EIM ale acestor amenințări de mediu la scară regională.

**Cuvinte-cheie:** *depozite de deșeuri, zone urbane, SIG, analiză multi-scalară, managementul deșeurilor*

## Introduction

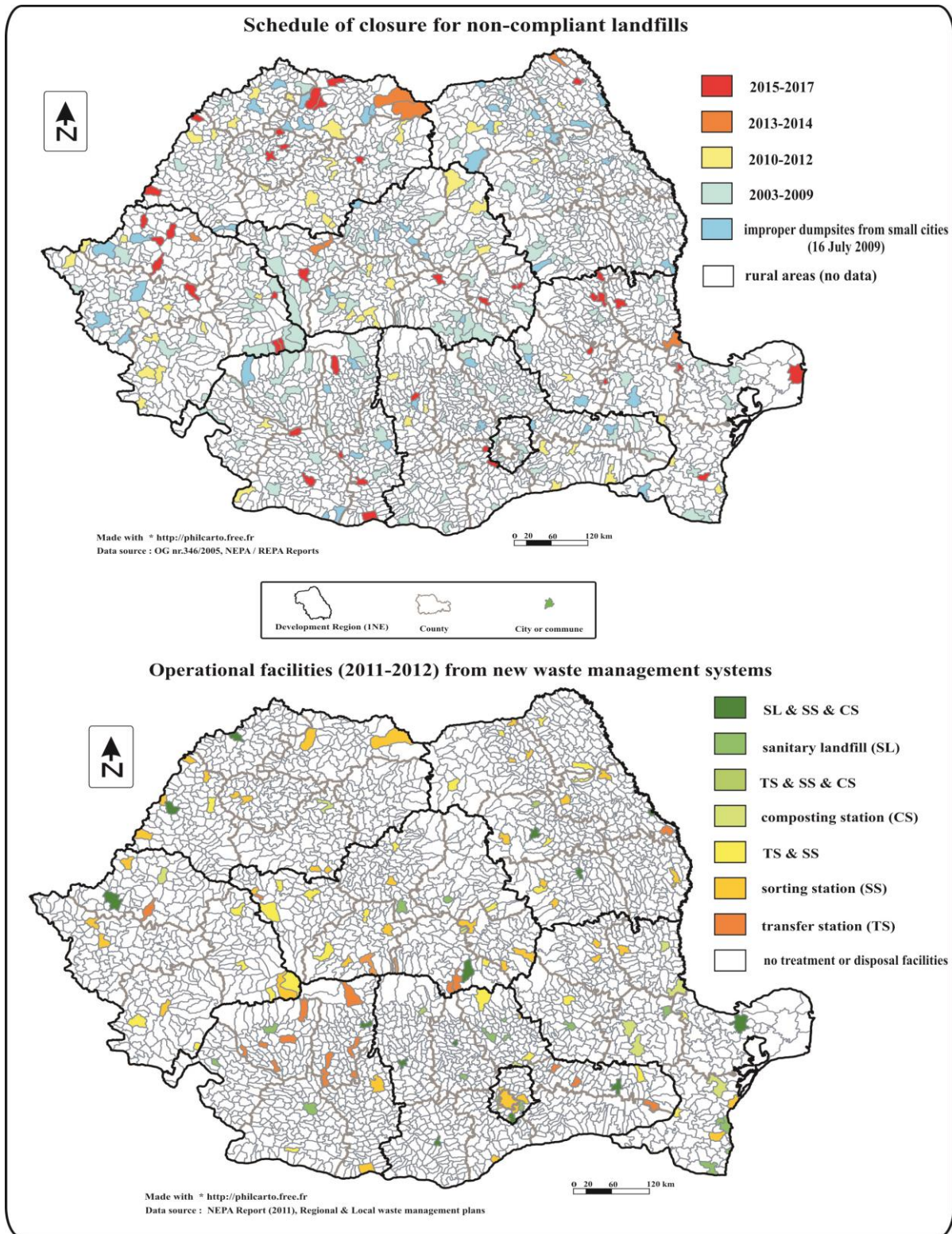
Landfills are the main option in urban waste management systems from new EU members despite recent improvements of infrastructure in this sector (Mihai and Apostol, 2012). Furthermore, most of these sites didn't comply the Landfill Directive (1999/31/EC) being scheduled to be closed. The improper location of non-compliant landfills in the proximity of urban areas led to complex pollution of surroundings. Urban waste collection services from Romania still did not cover the full population (Mihai et al., 2012, Mihai, 2012a) and on the other hand, these services are poorly developed in small towns, favoring the illegal dumping (Mihai, 2013; Mihai et al., 2011).

This paper examines the territorial and environmental implications of old and new waste management facilities at different scales highlighting the current disparities. GIS techniques are currently used in literature for EIA studies or to determine more proper sites of future landfills, combining with other methods such as multi-criteria analysis (Sener et al., 2010; Sauri-Riancho et al., 2011; Yashon et al., 2011; Moeinaddini et al., 2010; Sumathi et al.,

2008;). In the case of the existing ones, the buffer analysis of non-compliant landfills from Neamț County (North-East Region) reveals certain environmental issues on local landscape (Mihai et al., 2013a; Mihai et al., 2013b). Regional studies on waste management issue are necessary for a multi-scale assessment of EU targets and objectives related to geographical features at regional and local scale (D'Alisa et al., 2012, Passarini et al., 2011; Lin and Chen, 2009; Mazzanti et al., 2009). Also, spatial analysis of waste indicators are a necessary tool in assessment or monitoring of waste management sector (Keser et al., 2012; Pandey et al., 2012; Mihai, 2012b, Mihai and Lămășanu, 2013).

## Methods

In order to examine the current situation of non-compliant landfills at urban level and location of new waste management facilities, we consulted several reports of environmental authorities, regional and local waste management plans. Spatial analysis of indicators using thematic cartography reflects regional and local disparities (Fig. 1).



**Figure 1: The transition to a modern waste management infrastructure**

GIS techniques are used for mapping these old sites in the proximity of urban areas from North-East Region. This procedure was achieved using Google Earth images. The black polygons were overlaid on digital elevation model (DEM) on regional scale.

The DEM was performed based on digital datasets such as SRTM (Shuttle Radar Topography

Mission). Other vector layers such as hydrographic network and roads (classified by rank in European, national and county roads) were performed based on 1:25000 topographic map of Romania in Gauss-Kruger projection using as GIS software the TNTMips software 7.0. Built-up areas from ATU (Administrative-territorial units) of towns were

extracted from Corine Land Cover (CLC-2005). The aim of these maps is to analyze the territorial implications of dumpsites in a geographical context. Buffer area (2 km) shows the territorial implications of each site to surroundings (Fig. 2).

This analysis is more detailed at local scale (town), using the land use for each site (inside the buffer area of 2 km) extracted from CLC at regional scale. In order to examine the distance from landfill site to surroundings and to highlight the improper distances to critical factors (CF) such as, residential area (CF1- continuous urban area), industry & commercial facilities (CF2), agricultural land (CF3) rivers & lakes (CF4), forest and protected areas (CF5) buffer areas of 1 km were also delimited.

These factors are critical because they are sensitive to any environmental pollution threatening the human health and the local biodiversity. Proximity of a non-compliant landfill to these critical factors increases the vulnerability to complex pollution. The location and establishment of sanitary protection area must be determined by EIA studies following the procedure of Order no. 757/2004, otherwise, national regulations stipulates that such sites must not be located in the proximity of residential areas, rivers, protected areas at least at 1 km distance (Order no.536/1997). Based on buffer analysis at local scale (0.5/ 1 /2 km) there was developed an assessment method of landfill location.

Thus, for each critical factor identified on local maps inside the buffer area of 0.5 / 1/ or 2 km, a specific number of points correspond as shown in table 1.

**Table 1: Assessment of landfill location**

BA(km)	0.5	1	2	>2
CF1	0	0	3	5
CF2	0	1	3	5
CF3	0	1	3	5
CF4	0	0	3	5
CF5	0	0	3	5
Points				Max.25

The best scenario (max. value of 25) is when all these critical factors are located outside the 2 km buffer area from landfill site, but this scenario is more ideal. Each site is ranked according to the total sum of points accumulated from assessment table. Location of these old landfills from North-East may be good (20-25 points), proper (15-20), acceptable (10-15), improper (5-10) or bad (< 5) for urban environment.

This method may be complementary to current environmental impact assessments studies (EIA) that focus on in-situ analysis or to strategic environmental assessments studies (SEA). This approach is designed for regional scale including more than 10 sites from different counties in various

geographical conditions. In the case of more detailed studies at local scale, these factors may be completed with other ones. Also, the assessment table can be modified according to local features of the county.

## Discussion

Non-compliant landfills are scheduled to be closed in the period 2004-2017 (Fig. 1). This schedule is established following the G.Ono 349/2005 which transposed the Landfill Directive (1999/31/EC).

These sites are ordinarily located inside the administrative territorial units (ATU) of towns, increasing the impact on urban environment. Others are located on the range of periurban villages such as Albești (Mangalia town), Glina (serving Bucharest and other small towns from Ilfov County), Gălbinași (Buzău town), Tomești (Iași town) etc. Most of this old landfills exceeded the initial design capacity, increasing the toxic potential for local environment.

The closure of these sites does not solve the pollution issue. Lack of waterproofing systems will continue to favor the leachate infiltration into phreatic or surface waters in the proximity. On the other hand, this pollution will be diminished across the time, because there will no be others inputs in the landfill site. In this context, post-monitoring process plays an important role to reduce the potential threats. Some industrialized towns have started earlier to replace these old sites with controlled ones.

The first sanitary landfill for municipal waste was operational since 1995 disposing the amounts of waste generated from Ovidiu, Constanța and Năvodari towns (South-East Region). This site is located on the range of Ovidiu town and has eight cells with a design capacity for 1.600 000 m<sup>3</sup> (APM Constanța, 2003). Also, Brăila town has a sanitary landfill since 2002. In 2003, several urban landfills (Ploiești, Slănic, Băicoi, Sinaia) from Prahova County were closed being replaced by sanitary sites from following towns Boldești-Scăeni, Băicoi, Vălenii de Munte and Bănești village (near Câmpina town) and also by a transfer station in Bușteni (PJGD Prahova, 2008). In short time, these landfills have reached the storage capacity being closed earlier than the initial schedule.

The solution of some municipalities was the extension of these sites through the building of new cells. The majority of old sites were closed until 2012 in North-East Region and South Region, but several non-compliant landfills were scheduled to be closed after 2012 in other regions. In some counties, more than 3 non-compliant landfills will be operational until 2017 such as Sălaj, Maramureș, Arad, Vrancea, Olt due to lack of concrete

investments in this sector. Mixed waste collections have reduced the recycling capacity favoring landfilling and land consumption particularly for larger towns. These sites transformed important areas into degraded lands. Most of communes declared towns during the 2004-2006 period had no access to waste collection services, the household and similar waste generated being disposed in improper sites on surroundings.

This bad practice was widespread in these new urban areas, but these sites were closed and rehabilitated until 16 July 2009 using the same procedure as for rural dumpsites.

This environmental issue was not significant in some counties due to larger number of such towns (Suceava or Maramureş counties). In last years, on the one hand the old sites are replaced by sanitary landfills (serving a large town or as regional site at county level) and, on the other hand, by transfer stations equipped with sorting and/or composting facilities as shown in figure 1.

This new approach should stimulate the recycling programs and minimize the amounts of waste landfilled particularly for biodegradable fraction in accordance to EU targets. Also, sanitary landfills were built through ISPA projects in Piatra – Neamţ and Bacău towns (North-East Region), Aninosa, Titu (Dâmboviţa County – South Region) Râmnicu-Vâlcea (South-West Region), Galaţi (South-East Region). Several regional landfills as part of county integrated waste management systems are located outside the ATU of towns, in rural areas which serve both urban and rural areas such as Mavrodin (Teleorman county) or Albotă commune (Argeş county).

Transfer stations replace the improper sites from small towns through PHARE projects and several old urban landfills. New integrated urban waste management systems provide beside a sanitary landfill, separate collection, sorting and composting stations as in Piatra Neamţ, Bacău, Arad or Braşov towns. Every region and county developed regional and local waste management plans which analyzed the waste management sector and establish the major targets regarding the future of waste management systems. Local authorities, particularly county councils, develop projects regarding the implementation of an integrated waste management system at county scale.

These projects are submitted to SOP ENV programme for financial support. North-East Region is on top of Romanian regions regarding the closure of non-compliant landfills and also for investments in new waste management facilities. At regional scale, these facilities are more developed in the western part of the region (Suceava, Neamţ and Bacău) than in the eastern half. This fact is due to the ISPA and

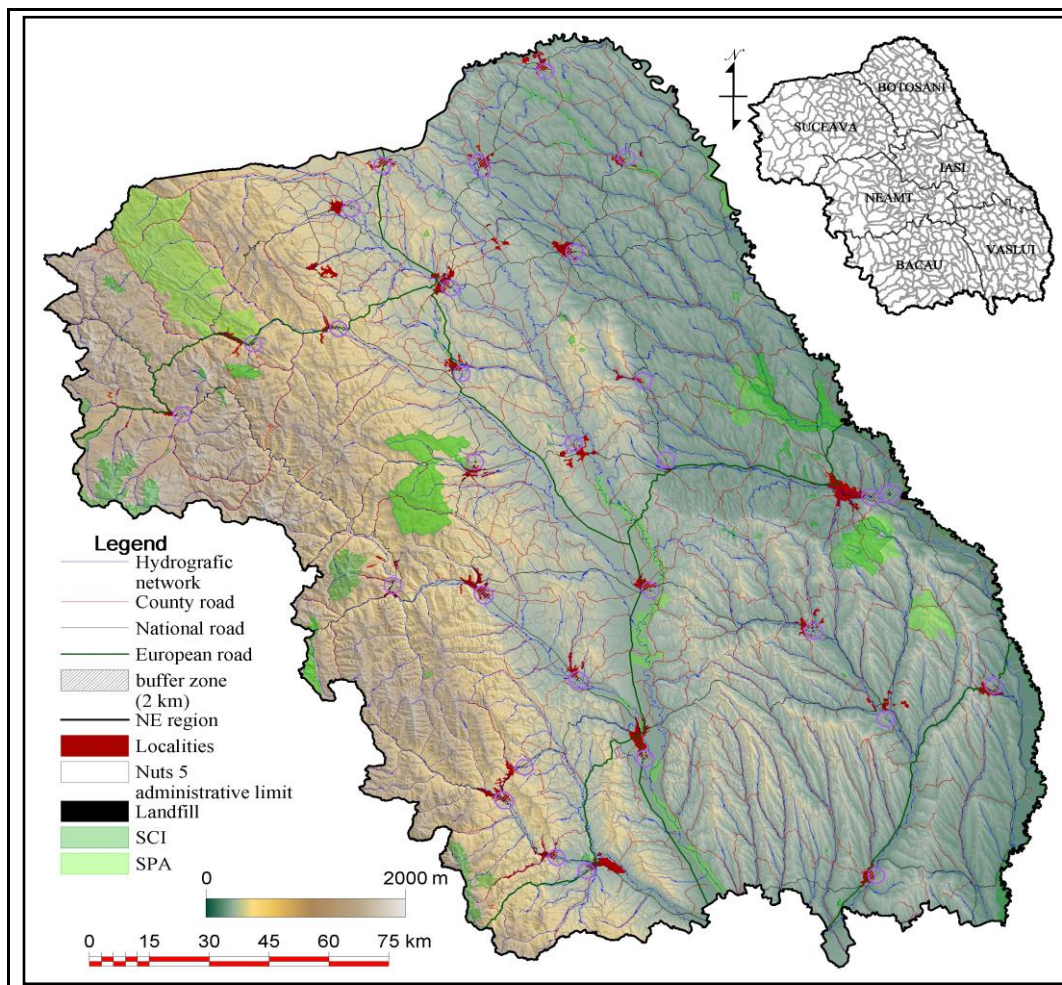
Phare projects which are already implemented in these counties. Since 2007, Piatra Neamţ town is a model concerning the waste management infrastructure at regional and national scale and also, an integrated waste management system for whole county was approved through SOP ENV. Moreover, Government funds supported the development an integrated urban waste management system in Iaşi town. These new facilities are necessary to be implemented in urban waste management systems because the old landfills were operational over 30 years in large towns from North-East Region such as county capitals (Iaşi, Piatra Neamţ, Suceava, Bacău) also occupied significant areas (>10ha).

Demographic features of the towns are reflected in the design capacity of landfills. Optimal life for a landfill site is minimum 15 years, but the lack of financial resources for building new sites have determined municipalities to extend the operational period of old landfills over even 45 years (Oneşti, Hârlău, Bicaz, Huşi, Gura Humorului). Waste disposal in small towns (< 20,000 inhabitants) was done in unsuitable sites which threatened the local environment even these dumpsites covered insignificant areas (often < 1ha) compared to more suitable sites from well-populated towns (Mihai, 2013).

The poor waste management facilities in the 2004-2009 period led to illegal dumping of household waste. Closure of these dumpsites (16 July 2009) and the non-compliant landfills from larger towns require the development of waste collection services (Fig. 3). Separate collection need to be compulsory in towns for recyclables fractions such as paper/cardboard, plastics or biodegradable waste. Other fractions are also collected from the economic sector, such as glass, metal, wood. Furthermore, Piatra Neamţ has two special centers in Mărăţei and Dărmăneşti neighborhoods where bulky waste, WEEE and hazardous municipal waste can be collected. In the proximity of sanitary landfill is located a crushing plant for demolition and construction waste.

These new facilities are the basic elements to achieve the transition from a traditional to an integrated waste management systems which focuses on separate collection, recycling, treatment and less landfilling. North-East Region is included in Balkwaste projects financed by LIFE07/ENV/RO/686 as case study for Romania.

The aim of this project is to establish a waste network for sustainable solid waste management planning and promotion of integrated decision tools in the Balkan Region along with Slovenia, Bulgaria and Greece.



**Figure 2: Landfills in the proximity of built-up areas of cities from North-East Region**



**Figure 3: Non-compliant landfills from study area**

This paper focuses on regional scale assessment of the location of old non-compliant sites in the proximity or urban areas. Such landfills are a source of complex pollution and this threat was facilitated by an improper location related to critical factors. Applying the assessment table for each landfill site from the study area (32 in total), it resulted that most of dumpsites are located in bad or improper sites (< 10 points), too close to the built-up areas of towns and on the other hand too close to the rivers, despite the national regulations that specify a distance at least 1 km to these critical factors. These old landfills were built during the communist period (1960-1990), disregarding the environmental issue. In this context, their location in the proximity of towns led to various implications on urban environment. Geographical barriers especially in the mountain areas reflect the low scores for landfill sites from following towns: Vatra Dornei, Câmpulung Moldovenesc, Gura Humorului (Suceava county), Bicaz (Neamț county) Comănești, Moinești and Târgu Ocna (Bacău county) (Fig. 4). These towns have no suitable or acceptable options for these facilities. Old landfills will be replaced by new transfer stations equipped with sorting and composting plants. Furthermore, small towns from mountain region as Broșteni, Frasin, Slănic Moldova disposed the municipal waste in open dumps or on river banks, just as rural communities.

The vulnerability of mountain rivers to waste dumping is significant in the proximity of localities (Mihai et al., 2012). Carpathian region should be avoided in territorial planning of new landfills. Beside critical factors which are difficult to avoid in this region, such as residential areas, rivers, forest & protected areas, the slope, climatic features and geomorphological processes are additional restrictive factors. Different geographical and social economic conditions reflect various land use patterns in the proximity of landfills. In this context, critical factors vary from case to case, particularly for CF2, CF3 and CF5. The urban landfills are often located on terraces or floodplains of major rivers such as the Bistrita (5 sites), Moldova (4 sites), Suceava (1), Trotuș (3), Bârlad (3) and Bahlui (2). Other sites are located in the proximity of their tributaries or streams. In this regard, only 2 landfills are located outside the 2 km buffer area (Onești, Hârlău) from rivers and others 5 dumpsites respect the minimum distance of 1 km (Siret, Bacău, Botoșani, Dorohoi, Tg. Frumos). Furthermore, there are 23 non-compliant landfills polluting for several years the major rivers in the proximity. Also, the new sanitary landfills (Piatra Neamț, Iași) are located inside the buffer area of 1 km from rivers in the proximity.

The new landfill site (two cells) from Piatra Neamț is located next to the old facility due to

economic reasons (Mihai et al., 2013b). This facility uses the existing infrastructure (road access, buildings etc) even this location is bad according to the assessment method. Also, all new facilities such as sorting & composting stations, crushing plant, leachate treatment, new administrative buildings are located in this perimeter to reduce the operational and transportation costs. On the other side, the new landfill complies with the EU regulations, reducing the potential threats to environment and recently the river sector in the proximity was dammed to protect the site in case of floods. Depending on other factors such as local landscape, infrastructure, economic and social features, the new sanitary landfills may be located near the urban areas, but detailed EIA or SEA studies are required. In another case, new sanitary landfill which serve the Iași town is located in Tuțora commune.

This site is more proper than the old site from Tomești locality but acceptable according to assessment location. The urban residential area is outside the buffer area (2 km), but other critical factors are in close proximity (rivers, arable land). Frequently, residential areas of old sites are in the buffer area of 1 km threatening the human health and only 3 landfills (Rădăuți, Iași-sanitary) are outside the 2 km, another 6 dumpsites respecting the minimum distance of 1 km: Vatra Dornei, Târgu Neamț, Bacău, Botoșani, Hârlău and Huși.

Industrial & commercial facilities (CF2) are exposed to landfills pollution particularly in larger towns such as county seats (Suceava, Piatra Neamț, Bacău, Iași, Vaslui) and agriculture land (CF3) is more significant in the Moldavian Plateau in the proximity of dumpsites from middle and small towns (Siret, Dărăbani, Săveni, Tg. Frumos, Negrești, Huși etc) (Fig. 5). Forest and protected areas as CF5 are more exposed in the proximity of mountain towns (Bicaz, Vatra Dornei etc).

A general overview shows that some sites from Târgu Ocna and Bârlad have accumulated no points (0!), representing the worst scenario. Most of the landfill sites are bad (12!) related to critical factors, 10 are improper, 9 are acceptable and no site is proper (> 15 points). Vaslui county has not an acceptable location (0/4) and the towns from Suceava and Neamț counties are the most vulnerable to landfills pollution.

The maxim values (13 points) are attributed to landfills locations from Iași county (Iași town - sanitary landfill, Hârlău, Tg. Frumos) and for Rădăuți. By rank classification, using only the undesirable categories (acceptable/ improper / bad), Iași county ranks first (3/2/0) followed by Bacău (2/2/2), Botoșani (1/3/1), Suceava (2/1/4), Vaslui (0/2/2) and Neamț (0/1/3).

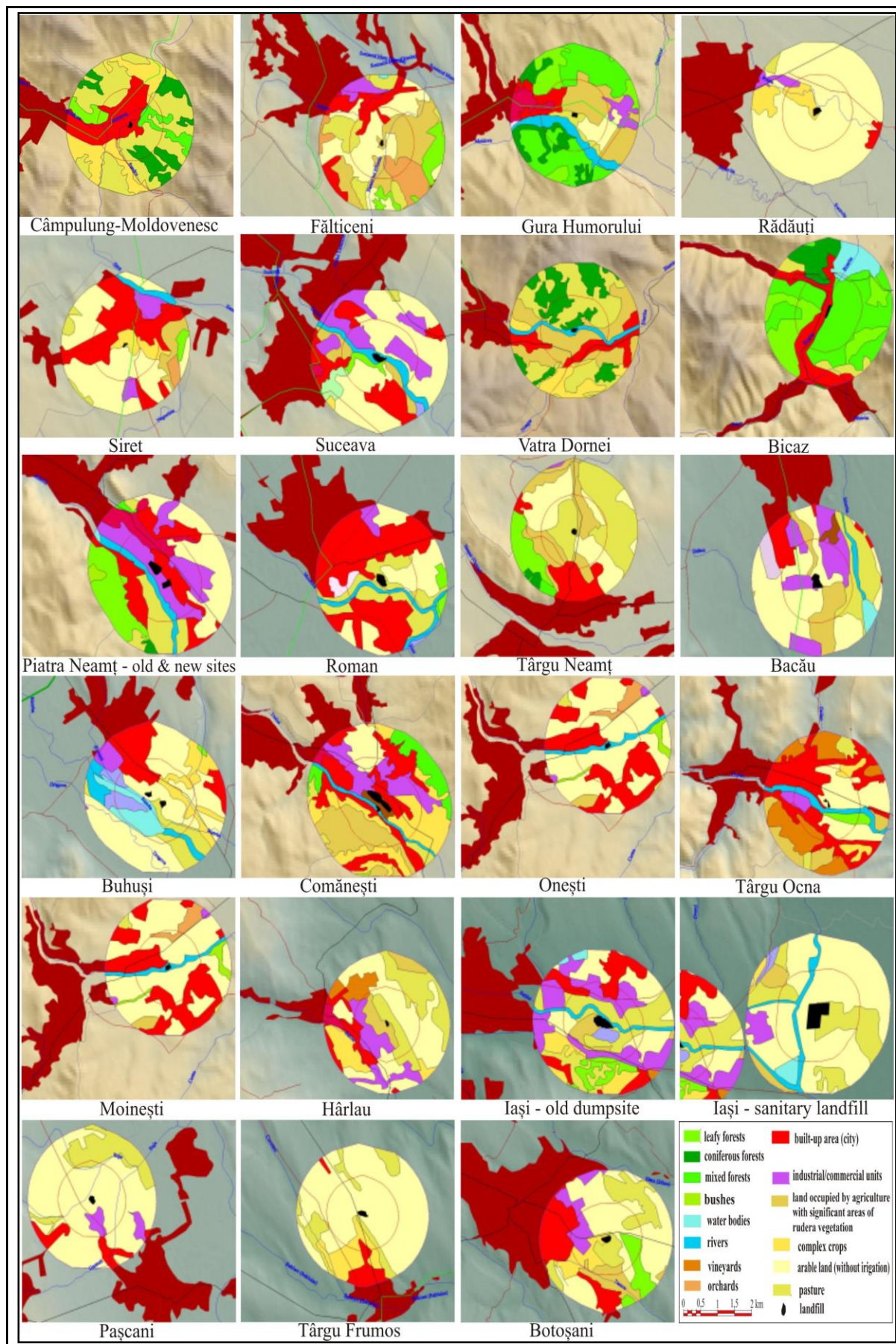


Figure 4: Urban landfills at local scale – buffer areas



**Table 2: Assessment of urban landfills location in the study area**

Landfill	CF1	CF2	CF3	CF4	CF5	Total	Rank
Vatra Dornei	3	3	1	0	0	4	bad
Campulung Mold.	0	1	0	0	0	1	bad
Gura Humorului	0	3	0	0	0	3	bad
Suceava	0	0	0	0	5	5	bad
Siret	0	3	0	3	5	11	<b>acceptable</b>
Radauti	5	3	0	0	5	13	<b>acceptable</b>
Falticeni	0	3	0	0	5	8	improper
Average (SV)	6.42					<b>45</b>	
Bicaz	0	0	3	0	0	3	bad
P.Neamt (old site)	0	0	1	0	3	4	bad
P.Neamt - sanitary	0	0	1	0	3	4	bad
Roman	0	3	0	0	3	6	improper
Tg Neamt	3	5	0	0	3	11	<b>acceptable</b>
Total county (NT)	5.6					<b>28</b>	
Bacau	3	0	0	3	5	12	<b>acceptable</b>
Buhusi	0	3	0	0	5	8	improper
Moinesti	0	3	0	0	3	6	improper
Tg. Ocna	0	0	0	0	0	0	bad
Comanesti	0	0	0	0	3	3	bad
Onesti	3	3	0	5	0	11	<b>acceptable</b>
Average (BC)	<b>6.6</b>					<b>40</b>	
Botosani	3	1	0	3	0	7	improper
Darabani	0	1	0	0	3	4	bad
Dorohoi – old (N)	0	3	0	0	5	8	improper
Dorohoi - new (S)	0	5	0	3	0	8	improper
Saveni	0	5	0	0	5	10	<b>acceptable</b>
Average (BT)	<b>7.4</b>					<b>37</b>	
Iasi – old site	0	1	1	0	5	7	improper
Iasi- sanitary	5	3	0	0	5	13	<b>acceptable</b>
Pascani	0	0	0	0	5	5	improper
Harlau	3	0	0	5	5	13	<b>acceptable</b>
Tg.Frumos	0	5	0	3	5	13	<b>acceptable</b>
Average (IS)	<b>10.2</b>					<b>51</b>	
Vaslui	5	0	0	0	0	5	bad
Barlad	0	0	0	0	0	0	bad
Negresti	0	3	0	0	5	8	improper
Husi	3	0	0	0	5	8	improper
Average (VS)	<b>5.25</b>					<b>21</b>	

By average (no. of points / no. of landfills per county) classification, Iași county still ranks first (10.2), followed by Botoșani (7.4), Bacău (6.6), Suceava (6.42), Neamț (5.6) and Vaslui (5.25). Homogenous landscape of eastern counties (Botoșani, Iași and Vaslui) offers more suitable options for landfill sites than the western region (Suceava, Bacău, Neamț).

It is noted that urban areas are facing various challenges for determining a proper location for a new landfill site according to the current legislation. Urban municipalities need to have several options for the location of waste management facilities.

Three critical factors (residential area, rivers & lakes, forest & protected areas) must be avoided in the 1 km buffer area. Furthermore, agricultural land (arable land, crops, vineyards) and industrial and

commerce facilities should be avoided at least in 0.5 km perimeter. New landfills should be more properly located than these old sites due to EU regulations. Decision-makers, local community, NGOs, academic researchers should get involved in this process. Transparency for all waste management projects should also be provided. NIMBY policy is emerging among EU countries concerning the location of landfills or incineration plants (Wolsink, 2010; Davies, 2008).

The location of new sanitary landfills which will serve an entire county should take into consideration the NIMBY scenario. Often, these landfills are planned to be built in rural areas (eg. Girov commune – Neamț County) to avoid well-populated urban areas and to have a strategic position at county scale. But they should not be

placed in the proximity of built-up areas or agricultural land in order to be accepted by the local community. An improper site may have a significant

impact on local economy. Urban and rural localities from region will be served in the future by transfer stations and regional landfills.

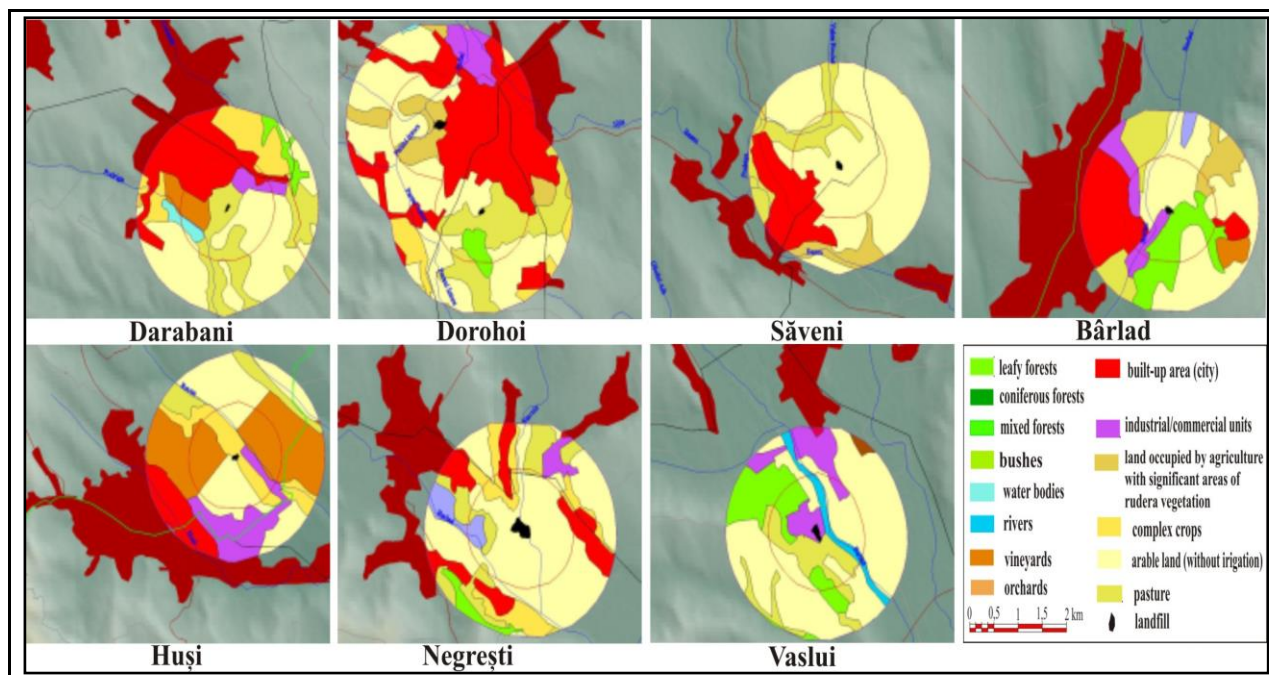


Figure 5: Urban landfills at local scale – buffer areas

These systems will be optimal in the context of full population access to separate waste collection services and high rates of recycling and composting.

### Conclusion

The paper proposed a new assessment method of landfills locations at regional scale taking into account, on the one hand, the proximity of critical factors to such sites based on the buffer analysis through GIS techniques and, on the other hand, the score of landfill sites according to the assessment grid. The results revealed that improper location of old landfills is widespread at regional scale and only Iași county has an acceptable average within the study area. Critical factors are often found inside the buffer area of 1 km which determined the low scores of landfills (< 10 points). Buffer analysis outlined that rivers, agricultural lands and residential areas are most exposed to pollution, despite the fact that these areas must be avoided in the proximity of these sites. Cities have ignored this environmental issue and the new landfill sites should be more proper located under EU regulations. Romania is facing the transition period from a traditional waste management system where landfilling and mixed waste collection prevails to a sustainable system based on the 3R policy (reduce, reuse and recycle). This goal is still far to be achieved but new waste management facilities are already operational in some urban areas. New integrated urban waste management systems from Piatra Neamt, Bacău and

Iași towns may be guidelines of good practices for North-Est Region and Romania. These non-compliant landfills are the legacy of poor waste management facilities. Separate collection, sorting and composting stations, regional sanitary landfills are key elements for the future integrated solid waste management systems in Romania.

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