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Territorial disparities in municipal waste management. Case Study: Neamț County

PhD Thesis Summary

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Introduction

The thesis enroll in the research of environmental geography and from the viewpoint of the proposed theme it is intended a systemic, territorial and multiscale approach (***EU-27-Romania - Neamț County –cities & communes***) in order to complement the mainly technical or economical studies on municipal waste management issue.

The topic chosen has obviously an interdisciplinary character and geography, by its specific research methods, can bring many contributions in this area, outlining a new direction in scientific literature such as ***geography of waste***.

The paper is structured in five chapters, as set out below, together with the main subsections:

Key words: geography of waste, municipal waste, disparities, multiscale analysis, spatio-temporal analysis, quantitative assessment method of illegal dumping **(QAMID)**

1. The theoretical and methodological framework

This chapter of the thesis is dedicated to the analysis of national and international literature on waste management issue emphasizing the geographical approach manifested by two lines of research :

- ***quantitative approach*** - spatial analysis of waste management infrastructure (collection, transport, recovery and disposal facilities) and its implications on territorial planning and environment by using thematic cartography, GIS, satellite imagery (remote sensing) spatial analysis at national, regional and local level of waste management indicators (multiscale analysis), spatio-temporal anaysis, achievement of statistical database for various geographical regions (administrative territorial units –ATU),
- ***qualitative and social approach*** - which analysis the behaviour of urban and rural communities to waste management options (NIMBY policy for example), the transition from a traditionally system (sometimes rudimentary) based on non-compliant landfills to an integrated waste management systems which aims prevention, recycling and waste recovery.
- In this context, *geography as a science of the interface between natural and social systems may contribute to improving waste management systems by taking into account the natural, socio-economic and demographic features of the territory concerned*

2. Municipal waste management - an environmental issue within the EU

Waste management has become a priority environmental policies at the global level through international conferences in the field of environmental protection and also within the EEC and later the EU through six action programs on the environment (1973, 1977, 1983, 1987, 1992, 2001) which provide a sectorial and vertical approach of environmental issues at first, then it passses to an integrated approach in the context of sustainable development.

As regards the waste management sector, it has been adopted and continuously readjusted the EU acquis such as: definitions, concepts, objectives, priorities and means of implementation for environmental policies.

Disparities between North and South or East and West are determined by a different evolution of the socio-economic as well as waste management policies adopted in recent decades.

3. Waste management in transition. Changes and trends in Romania

In order to join EU, Romania was obliged by the Treaty of Accession to implement the environmental policies concerning the municipal waste management. New regulations in this sector requires the introduction of selective waste collection systems, sorting and composting plants as well as waste disposal in sanitary landfills. Rudimentary infrastructure and partial coverage of population to waste collection services led to various dysfunctions in urban and rural areas.

The geographical distribution of the various parameters of rural dumpsites at ATU level (subchapter 3.3.2.) that are correlated with the coverage rate of population to waste collection services or population density reflects certain spatial patterns at regional and local level such as:

- outer Carpathian counties from Nort-East, South-East and South of Romania (densely populated) had the lowest percentage of rural population served by waste collection services, these regions are also the most vulnerable to waste pollution
- number and surfaces of dumpsites is much higher than counties within Carpathian arch, or those with predominantly mountainous landscape, but, in these cases, watercourses in the vicinity of households are most predisposed to illegal dumping
- In North-East Region, in case of counties that overlap Moldavian Plateau (Botosani, Iasi, Vaslui) geographical distribution of the number and surfaces of dumpsites are not so obvious within the same county because of more homogeneous landscape
- natural landscape transition within Suceava, Neamț & Bacău counties is reflected in the distribution of dumpsites surfaces. Thus, low values prevailed in mountainous western half of these counties (sparsely populated and waste disposal occurs mainly in streams and rivers in the vicinity of households) and increase in the Subcarpathian sector (especially depression areas), corridor valleys (Moldova and Siret rivers), Moldavian Plateau and significantly lower in sparsely populated settlements (often aged) which are isolated from urban centers and/or major thoroughfares.
- at local scale, waste disposal sites varies even within a commune based on the distance between urban and vulnerable factors in the proximity (rivers / streams, degraded lands, local roads, pastures, loams etc)

4 Waste management at local scale. Analysis of disparities in Neamț County

Performance assessment method of waste management in urban areas (PAM - U)

The evaluation grid contains 5 significant indicators for waste management in a new member state of the EU-27 as follows: population access to waste collection services (%), separate collection (% - including five recyclable fractions such as paper/cardboard, plastic, metal, glass, wood and biodegradable fraction),v reuse & recycle (2R -%), landfilling (%) , amounts of waste uncollected (Q_{wu}-%) from total household & similar waste collected.

Values of these indicators are calculated in are calculated in percentages for following years: 2004 (pre-accesion period), 2007 (year of EU accession), 2010 (post-accession). Each indicator according to its percentage values will get a score which will be added to the total amount of points accumulated by an urban waste management system, corresponding to a certain category.

Based on total score, each municipal waste management system corresponds to a certain category such as : **excelent** (45-50 max.), **good or efficiently** (35-45), **moderate or proper** (25-35), **inefficiently** (20-25), **poor** (10-20)**, rudimentary or lacking** (<10).

Traditional municipal waste management purely based on mixed waste collection and landfilling prevailed for all cities in the county, no city have more than 10 points acumulated according to assessment grid. Romania's EU accession year (2007) has not brought major changes to municipal waste management system for Roman, Târgu Neamț, Bicaz and Roznov cities prevailing the same rudimentary performance (under 10 points.).. After three years the same rudimentary performance of municipal waste management systems prevail in Roman, Târgu Neamț, Bicaz and Roznov cities.

Dysfunctions in rural areas

Development of waste management services has been slow during 2003-2009 în Neamt County (compared with other regions from Romania) and this fact was outlined by the uncontrolled waste disposal issue (supported by field observations). This sector has experienced a strong dynamic in 2009-2012 reflected in spatial extension of waste collection services from suburban communes to remote localities within the county; waste management from rural territory is in full process of changing:

- waste collection systems are mostly mixed and rudimentary (*door to door* or *collection points*), waste collected are disposed in urban landfills
- The pre-accession programs (PHARE CES) have developed local separate collection systems and transfer stations (including sorting plant) being recently operational (2011), serving the cities of Târgu Neamț, Bicaz, Roznov and neighboring villages.
- Separate collection still has a low share, often under 10% of total household and similar waste, recyclables collected (mainly PET bottles / plastics) are sold to specialized units.
- Per capita waste generation knows values ranging from one commune to another, 0.01 to 0.7 kg / inhab./day (Săbăoani commune), however, the data (owned by local municipalities or waste operators) are only volumetric estimations and their correct interpretation is difficult to achieve
- local waste collection systems have seen many changes in a short period of time (2009-2012), these changes will be continued by the implementation of the new integrated waste management in the county funded by the SOP Environment programme that will serve all areas of the county.

5. QAMID

5.1 QAMID –ATU

Based on estimating the amounts of waste generated and uncollected (Q_{wu}) are introduced new indicators in the quantitative analysis taking into account the household waste composition, individual composting of biodegradable waste or recyclable from households.

This indicator is calculated for the communes without sanitation services and for those who have implemented such services, in this case, the collection efficiency (C_{ef}) is taking into account according to the age of waste collection services (A_{WCS}) from a commune.

Thus, the Q_{wu} is calulated for 2010 based on 3 cases :

1(a) Q_{wu} t/yr = P_t * I_g*365/1000 *for communes without WCS* , **Q_{wu}** –amount of waste uncollected by a rural locality, **P_t** – population of locality, **I_g** – average waste generation indicator in rural areas (0.3 kg/ inhab.day in 2003)

1(b) Q_{wu} t/yr = P_u * I_g*365/1000 if *coverage rate of WCS equals or <60%*

P_u = pop. unserved byWCS

1 (c) Q_{wu} t/yr = P_t * I_g *365/1000 * C_{ef} , *if coverage rate > 60% , C_{ef} varies according to the Awcs.* In 2003, for localities which have certain waste collection facilities, this indicator was calculated with the following formula:
Q_{wu} t/yr = P_t * I_g *365/1000 *0,3 (C_{ef}).

In this context, to estimate the quantities of waste to be uncontrolled disposed (Q_{ud}) from amount of waste generated and uncollected (Q_{wu}) it should be take into account the organic and recyclable fractions of waste that can be individually reused in households (Q_{rh} indicator) such as:
(2) Q_{bw} (t/yr) = Q_{wu} (t/yr.)* S_{BW}(%), S_{bw} – share of biodegradable waste (%) in waste composition for 2003 and 2010
(3) Q_r (t/yr) = Q_{wu} * S_r (%), S_r – share (%) of recyclables (paper/cardboard, glass, metal, wood, plastic) in waste composition for year 2003 and 2010;
Potential reuse and recovery of waste in individual households (Q_{rh}) is considered to be 70% for biodegradable waste (food waste) used mainly as food for pets and partially for obtaining a compost and 10% for the recyclables fractions:
(4) Q_{rh} = 0.7 * Q_{bw} + 0.1 * Q_r

Finally, Qud can be calculated : **(5) Q_{ud} = Q_{wu} – Q_{rh}.** Uncontrolled disposal of waste (Q_{ud}) takes place either in open dumps in various sites (river banks, roadsides, the back of gardens, forest areas) or by uncontrolled burning.

Comparative analysis between 2003-2010 shows that on the one hand the extension of sanitation services limits the illegal dumping, and on the other hand, Q_{ud} indicator keeps the same values with a slight upward trend in 2010 for settlements without sanitation services.

5.2 QAMID–R

Starting from Q_{ud} indicator based on the proximity of human settlements towards rivers can be calculated Q_{wr} indicator for each village in the study area:
Q_{wr} = Q_{ud} (t/yr). S_{ad} ,

Q_{wr} – waste estimated to be disposed on river banks /into rivers or streams by a locality (village) **Q_{ud}** = amounts of waste uncontrolled disposed by a locality (waste dumping or burning), **S_{ad}** – share of indicator according to the average distance between the built-up area of a locality and the river/stream in the proximity. Rivers exposed to illegal dumping are those that cross the village (residential area) or pas to its proximity (<1km).

Depending on the average distance calculated for each village, it is performed a weighting of Q_{ud} indicator .

The assessment of this vulnerability is based on the pressure of a locality (village) on the river section by household waste dumping of local population:

$L_{wr} = Q_{wr} / L_r$, L_{wr} = locality pressure by waste dumping on river/stream

L_r = the lenght of rivers/stream section (m) vulnerable to waste dumping (that passes the built-areas of village or its proximity < 1 km).

Localities pressure on rivers by waste dumping are assessed according to the following values of L_{wr} (kg/m/yr): **0.1 -2 low; >2-5 moderate; 5-10 significant; >10 high**

In the mountainous region, often villages are crossed by rivers and their tributaries, these streams *being vulnerable to waste pollution*.

High and significant vulnerability to waste dumping for many sectors of rivers and its tributaries in 2003 (as well until 2009), outlining the priority to develop waste collection facilities in this region of county

5.3 QAMID-F

It is calculated Q_{df} indicator (a substitute for the Q_{wr} in the previous section) based on the average distance between a village (outer limit of built-up area) to the river floodplain in the proximity for each village in the area of study using following formula: **$Q_{df} = Q_{ud}$ (t/yr). S_{ad}** ,

Q_{df} – estimated amounts of waste uncontrolled disposed on floodplain / alluvial plain of a river by a village

Q_{ud} = amount of waste uncontrolled disposed (dumping or burning)

S_{ad} – weighted of Q_{ud} based on the average distance according to the table Q_{df} indicator (amounts of household waste disposed on floodplains),

Floodplains exposed to illegal dumping of waste are those located in the proximity of a locality (average distance <1.5 km).

Floodplains of Siret and Moldova rivers are susceptible to uncontrolled waste disposal. Values of Q_{df} indicator for 2003 and 2010 are relatively constant (473.77/471.73 t/yr) reflecting the *lack of overall investments* in waste management sector form this region (Siret corridor valley)

5.4 (**QAMID_sr**)

This method aims to quantify the amounts (estimates) of waste uncontrolled disposed in small rivers that cross the built-up areas of villages .

Thus, the amounts of waste disposed in creeks (Q_{wsr}) is calculated as follows: **Q_{wsr} (t/yr) = Q_{ud} * S_{Ad}**.

In this context, for the most accurate estimation is taken into consideration only those water courses that meet the following conditions: are located in extra-Carpathian region of county, the creeks longitudinally cross the built-up areas of localities, these built-up areas must not be crossed by several water courses (except for small tributaries within the built-up areas), average distance of the last households (outer limit of the built-up area) from the creek must not exceed 600m.

Small rivers which crosses the Subcarpathian hills are mostly vulnerable to waste dumping in the proximity of villages or within built-up areas.

5.5 **QAM-FW**

This method is closely with **QAMID** methods particularly with **QAMID** – R and **QAMID-FR** being analyzed in the same geographic area, basically represent a continuation of uncontrolled waste disposal analysis.

Q_{df} and Q_{wr} indicators (calculated at the village scale in the previous sections) are essential in calculating the amounts of flood waste (Q_{fw}) according to the relation: $\mathbf{Q_{fw} = Q_{wr\ tot} * A_P}$ sau $\mathbf{Q_{fw} = Q_{df\ tot} * A_P}$

$Q_{fw\ tot}$- amounts of waste taken over by floods from several localities (Q_{wr1}+..+$Q_{wr\ n+1}$),

A_P - the accumulation (storage) period of the waste, expressed in number of days (frequently the period between two floods, especially in the extra-Carpathian sector)

This period varies according to geographical region analyzed due to a specific climatic and hydrological context and values of Q_{wr} & Q_{df} must be expressed în t/day or kg/day.

$Q_{wr\ tot}$ – total waste disposed by selected localities along a riverbed or/ creek bank (in the proximity of built-up area)

$Q_{df\ tot}$ – total waste disposed (by selected localities) in the alluvial plain of a river in the Subcarpathian sector (Ozana /Cracău /Bistrița) and corridor valley (Moldova / Siret)

Determination of PET amounts uncontrolled disposed is achieved by following relation: $\mathbf{Q_{fwPET} = Q_{wr/day} * Sp(\%)* A_p}$, Sp – share of plastics (%) in waste composition,

5.6 Determination of areas vulnerable to illegal dumping using GIS techniques in extra-Carpathian region (DAVID –GIS)

The main factors (in the proximity of villages) susceptible to waste dumping are: rivers /creeks; floodplains, pastures, degraded lands (landslides, gully erosion), old geological sites (ex. loam), local roads, forest areas (less common).

Thus, most of these factors (without forests areas) were extracted inside buffer areas of 1km for every village from study area, based on *general vector layers*. Restrictive factors such as altitudine, slope and buffer areas (1 /0,5/0,25 km) must be taking into account for the classification and assessment process of vulnerability to illegal dumping

The vulnerability gradient is determined on one part, by the sum of total classes /notes (restrictive & susceptible factors) and to the other part by weighting each factor.

The resulting values (5-39) are divided into 7 classes (ecart 5 points) as follows: *very low* (5-10) no such areas are determined within buffer areas, *low* (10-15), *insignificant* (15-20), *moderate* (20-25), *significant* (25-30), *high* (30-35) and *very high* (>35).

The method is validated by rural dumpsites or illegal dumping points indentified during field observations from 2009 (September) – 2011

Therefore, from 163 of such sites located on the map, only 4 were not validated by this method being located outside buffer of 1km towards built-up areas of villages. Also, no such sites were found in very low or low areas of vulnerability. Most of these illegal dumps were found for *high class* (64), *significant* (45), *very high* (25), *moderate* (22) and more less for insignificant (3)

Conclusions

Geographical approach is overall performed in this work by:

- multiscale analysis (EU-27- Romania-Neamț County- cities-communes),
- spatial analysis at A.T.U level (administrative territorial units)
- spatio-temporal analysis of various waste management indicators

Uncontrolled waste disposal issue is complex and this *thesis* proposes several new methods and indicators related to the geographical context of the study area therefore:

- *This geographical approach of waste management issue (in terms of environmental geography) reflect new research directions and completes the methodological aspects existing in scientific literature through the publication of several papers*
- *The methods proposed can be valued in environment impact assessments (EIA) studies by academia and environmental authorities or environmental compartments of other institutions*
- *The thesis is the first national work on a new field such as geography of waste, this subdomain of environmental geography follows a progressive trend abroad because of the more obvious local and systemic implications of this sector in the implementation of EU environmental policies*
- *The work opens new opportunities for research on the geographical implications of waste management issue*

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