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Spatial assessment of construction waste generated by residential buildings in rural areas

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ABSTRACT

The management of construction waste it is at an early stage in urban areas and lacking in rural areas where this fraction is frequently uncontrolled disposed on public lands. Despite the fact some items of construction waste are considered inert for the environment (soil, concrete) it also contains hazardous items (paint additives, cans, and containers) or recyclables (plastics, metals, wood). Potential recovery of this waste stream is high if it is properly managed. The paper estimates the potential amounts of waste resulted from residential constructions across rural municipalities of Neamț County between 2002 and 2010. These statistical values are calculated at commune level (rural territorial administrative unit) in order to outline the disparities between various geographical areas using thematic cartography. This approach is correlated with demographic features in order to reflect such spatial patterns. The map of population density within built-up areas reveals where the construction sector is emerging at the county scale. Field observations highlight the existence of illegal disposal practices of construction waste in the proximity of settlements or water bodies. This waste stream should receive proper attention in following years in order to achieve recycling and recovery targets imposed by EU regulations.

Key words: construction waste, spatial assessment, Neamț County, Romania

INTRODUCTION

Construction and demolition waste (CDW) is a specific waste stream according to the EU regulations. This fraction needs to be separately collected, recycled and treated through proper facilities in order to achieve a minimum recovery rate of 70% (by weight) until 2020. EU challenges the member states to improve their current waste management systems according to "waste hierarchy" concept which promotes the 3R policy (reduce-reuse-recycle). Urban expansion and population growth led to an increased amount of CDW across the world and scientists start to focus on this field [1, 2, 3].

These wastes contain cement, bricks, asphalt, wood and other building materials which are usually inert and they can be used as fillings, a foundation for roads or even as a coating material for urban landfills.

The main measures that can be applied to these waste streams according to the environmental agency [4] are: source separate collection by type of material (hazardous and non-hazardous); to promote recycling and the reuse of construction and demolition waste (CDW); to provide capacity for treatment and sorting; proper disposal site for wastes which cannot be recovered. On the other side, the municipal waste management systems from rural areas are poorly developed and illegal dumping is still an environmental threat because of the low coverage rates of waste collection services [5].

Rural dumpsites often contain mixed fractions such as recyclables (PET/plastics, glass, aluminum cans) textiles, construction, and demolition waste, agricultural waste (straw, branches, sawdust, weeds) polluting the local environment. The paper examines the construction waste generated from residential buildings which are susceptible to be uncontrolled disposed in the proximity of built-up areas.

MATERIALS AND METHODS

Residential constructions increase the population density in built-up areas as an indicator of human pressure on local environment and on the other hand, it leads to increased quantities of construction waste. Firstly, the population density (2010) within built–up areas is calculated and mapped using the color range across rural municipalities (communes) of Neamț County. The data are correlated with a total number of authorizations released for the construction of private residential buildings in the period 2002-2010. These data layers are overlapped (color range and proportional circles) resulting in the first map. Subsequently, it is estimated the potential amount of construction waste (Q_{cw}) resulted during the study period using a waste generation rate (WGR) of 21.38 kg/m^2 per net usable floor areas (A_{ufa}).

Such calculations are performed at commune level based on the total usable floor areas (UFA) derived from authorizations according to following formula:

$$Q_{cw}\ (t) = A_{ufa}\ (m^2) * W_{GR}\ (kg/m^2)/1000$$

Raw data are provided by National Institute of Statistics, Department of Neamț County. The guide for construction and demolition waste of EPA Sibiu (2011) presented as a case study the management of construction waste in a high-income country (HIC) such as Norway [6]. In that case, the waste generation rate per square meter (m^2) per usable floor area is much higher such as 41.6 kg/m^2 for larger buildings than 500 m^2 and 56.1kg/m^2 for smaller ones. These rates are too high considering the socio-economic conditions in Romania. The waste generation rate specific for residential areas 21.28 kg/m^2 used as case study in Thailand [7] is more suitable taking into consideration that Romania and Thailand are classified as upper middle-income countries (UMIC) by World Bank.

The second map reveals, on the one hand, the spatial distribution of net usable floor area (UFA) or net internal area (NIA) per building using Jenks Natural Breaks of statistical data, and on the other hand, the estimated amounts of construction waste during 2002-2010 associated with building permits.

Local disparities are outlined at county scale by comparing these maps. The third map indicates the potential recovery of construction waste streams based on waste composition data specific for rural buildings.

The data are extracted from a case study performed in Buzău County (South-East Region) as shown in figure 1. The data reveal the construction waste composition specific for rural residential areas and these are not compatible with large infrastructure projects or major demolition/construction activities.

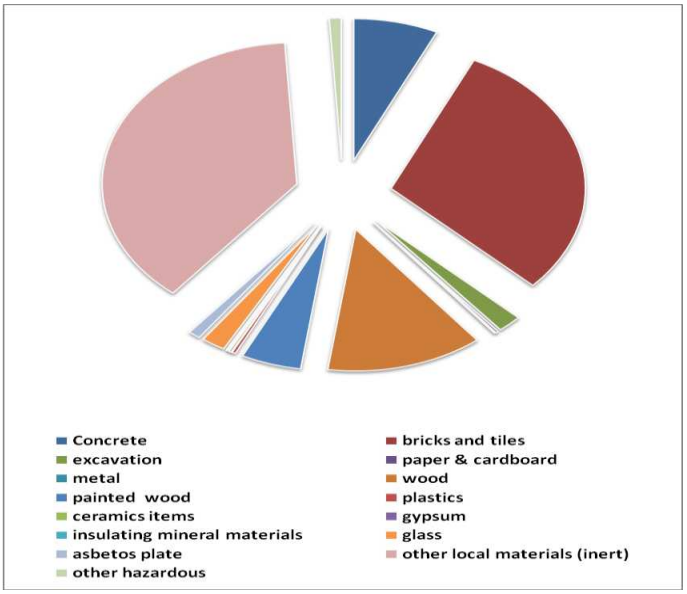

Figure 1. C&D composition (%) in rural residential areas. Source of data [8]

Potential recovery streams include recyclables (paper/cardboard; metals, wood, plastics, glass) almost 15.6 % of total fraction, concrete (7%), bricks and tiles (30%) and other local materials (inert-38%). The recyclables can be processed by the waste operators. The concrete, brick, tiles and other material can be sent to a crush plant or to be reused (if hazardous items are extracted) by local councils.

RESULTS AND DISCUSSION

A proper system for recovery and recycling of C&D waste is lacking in Romanian rural regions and only the reuse or recovery of this fraction at household level is performed. There are no relevant data concerning the streams of this waste fraction across the Neamț County. Furthermore, no such data were available for urban areas until 2004. These wastes were mixed collected and disposed in the non-compliant urban landfills.

Piatra Neamț, the capital city of Neamț County, has a crushing station for CDW waste for following specific fractions: broken bricks, asphalt waste, concrete waste, mixed construction waste. This station is operational since 2007 when a new integrated urban waste management system were implemented through ISPA funds. Also, there are two collection points for this fraction located in Dărmănești and Mărăței neighborhoods. Despite this fact, the uncontrolled waste disposal of CDW fraction on improper sites (riverbanks, local roadsides, public places) was overlooked by local authorities in the study region including urban or rural localities.

Most of the rural buildings permit overlap on localities that have the highest density in built-up areas (> 800 inhab/km^2) in 2010 which are located in the proximity of major rivers such as: terraces of Moldova river or in the proximity of its floodplain (Boteşti, Gherăeşti, Săbăoani, Cordun, Cotu Vameş communes); terraces of Siret river (Tămăşeni, Adjudeni and Sagna communes); terraces of Bistrita river from Subcarpathian sector (Dumbrava Roşie, Săvineşti, Zăneşti and Podoleni communes).

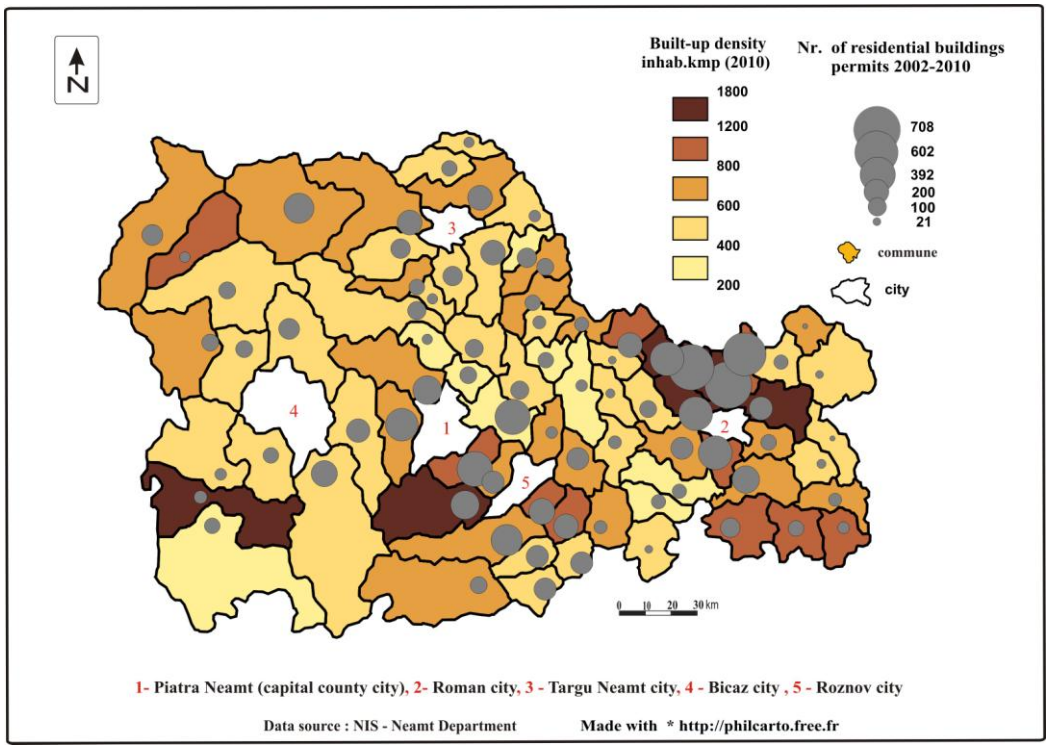

Figure 2. Spatial distribution of built-up density and residential buildings permits

These communes mentioned above are also located on the one hand, in the proximity of two major cities (Piatra Neamț and Roman) which have a regional polarizing role and on the other hand, the localities are passed by major traffic roads or located in their proximity (European and national roads). These geographical regions are most suitable for residential constructions which lead to higher waste generation rates of the main streams (household waste/construction waste). The peri-urban communes (of county capital city) located in the mountain region (Gârcina, Alexandru cel Bun and Pângărați), are well populated areas and attractive areas for construction sector which may generate large amounts of construction waste in as revealed by figure 2.

Neamț Depression is another densely geographical area due to a significant tourism potential in the proximity of Târgu Neamț city (Vânători Neamț, Agapia, Petricani and Grumăzeşti communes). A lower number of building permits (2002-2010) is observed in the subcarpathian hills from central county (Dragomireşti, Bârgăoani communes etc.) and Moldavian Plateau (peripheral municipalities from South-East of the county such as Boghicea, Stănița, Poienari and Pâncești communes) as shown in figure 2.

Such areas are remote from the main urban areas (Piatra Neamț and Roman cities) and the difficult socio-economic conditions reflect the lower amounts of potential waste generated (< 150 t). Furthermore, the usable floor areas per building is lowest in hill regions (southeast of the county) where deprivation index calculated by [9] is higher compared to western half of county (mountain region) with average values above 116 m^2 per building where deprivation index is lower.

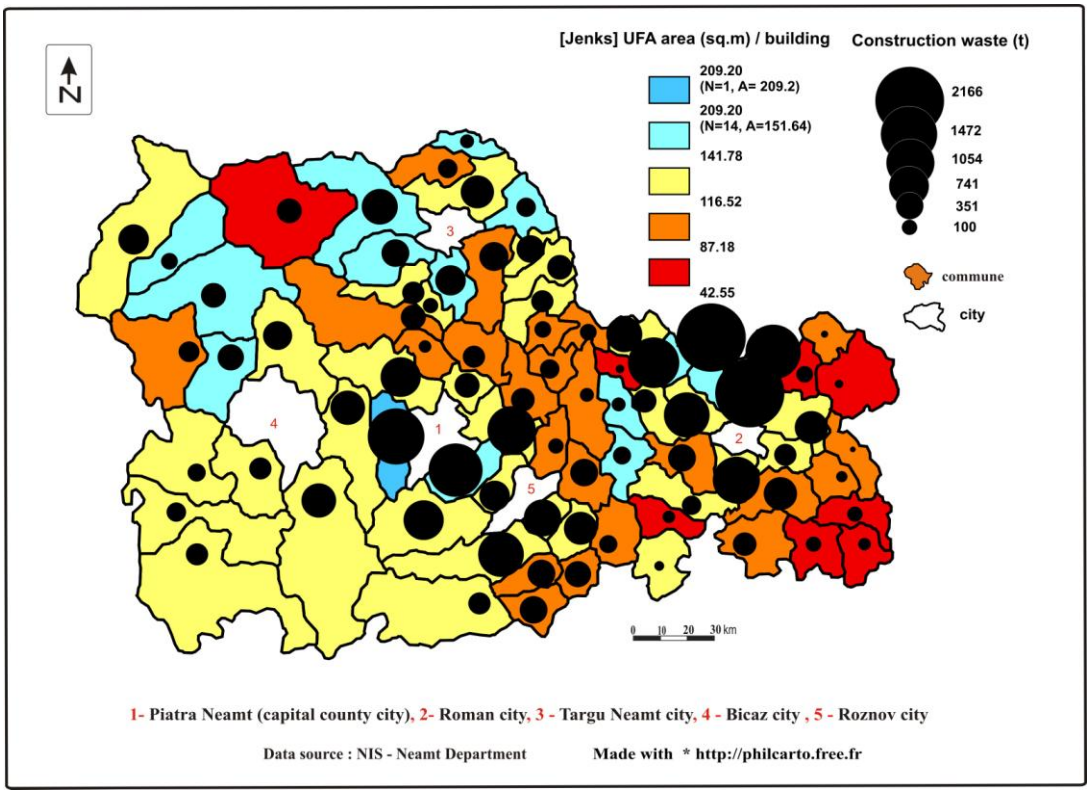

Figure 3. Construction waste generated by the new residential buildings in rural areas

The "Alexandru cel Bun" commune has the largest usable floor area per building (209.2 m^2). This value is explained by a large number of touristic pensions in the proximity of Piatra Neamț city. Peri-urban municipalities are the main construction areas for rural residential areas which may generate over 1000 t of construction waste. The largest amounts of construction waste (> 2000 t) are generated in northern area of the Roman city by Săbăoani and Tămășeni communes followed by Doljești, Gherăești, Girov and Alexandru cel Bun municipalities (1000-1500 t). The Subcarpathian sector of Bistrița river located in downstream of Piatra Neamț city is another peak area for construction waste generation (400 – 1000 t). The same part is revealed in mountain region along the route between Piatra–Neamț and Bicaz cities (Pângărați, Tarcău) where construction sector is supported also by the touristic pensions.

There are significant disparities between such emerging areas and poorest regions of Neamț County where the development construction sector is limited. The construction waste is under 100 t in the center (Bârgăuani commune) and south-eastern part of the county.

In peripheral areas of Neamț County, the construction waste associated with new residential buildings is around 50 t (Poienari commune) or under this threshold such as Stănița commune (36 t). The total amount of construction waste generated by rural buildings during 2002-2010 at the county level is 31393 t of which 4897.3 t are recyclables, 9417.9 t brick, and tiles, 2197 t concrete. Potential recovery of construction waste represents the waste fractions which could be diverted from landfilling or waste dumping on public lands via recycling and recovery operations. This potential varies from one commune to another as shown in figure 4.

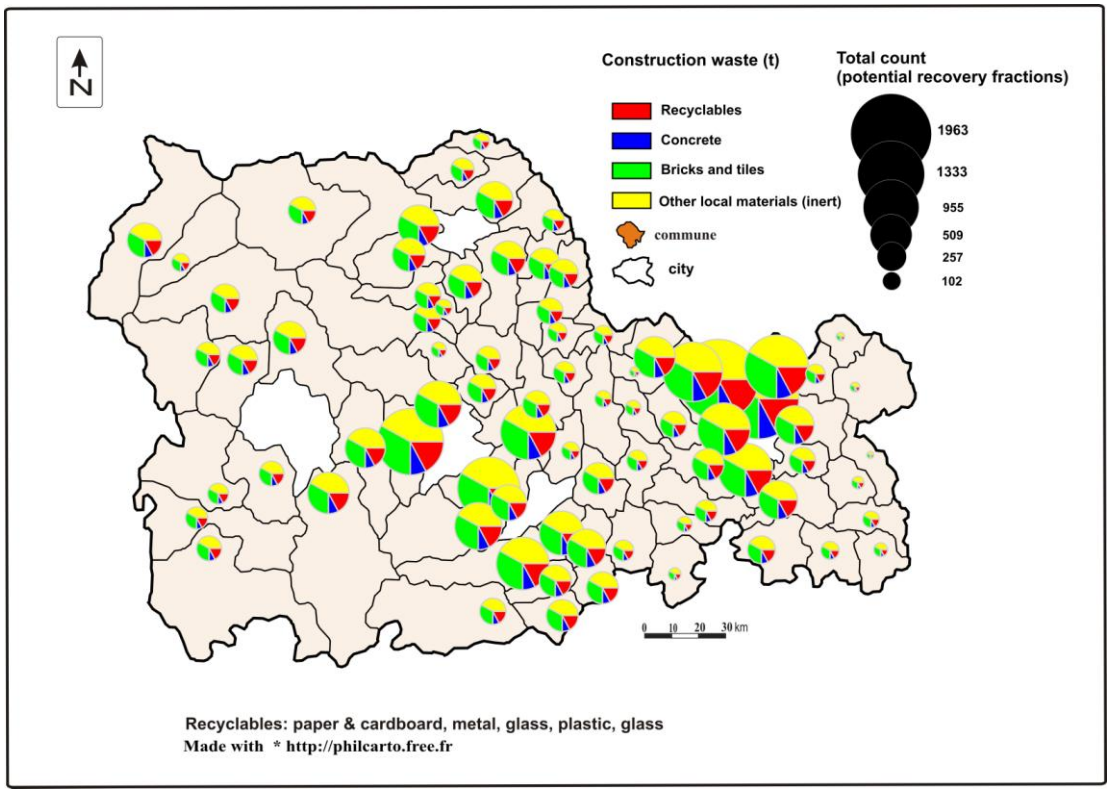

Figure 4. Potential recovery fractions of construction waste in rural areas

The values are ranging between 1963 t to under 50 t in peripheral rural areas. The large amounts of recyclable fractions are generated in the proximity of urban areas. These fractions could be collected by the urban waste operators. However, during 2002-2010 the waste collection services are poorly developed across rural municipalities. Frequently, these fractions were mixed and disposed on improper sites in the proximity of the built-up areas (riverbanks, floodplains, pastures, roadsides) as revealed by field observations during 2009-2011. The largest dumpsites were encountered in the case of localities located on fluvial terraces at a distance more than 1.5 km from river main course [10]. Such areas are also prone for construction sector reflected by a dense population and numerous building permits (Săbăoani, Gherăești, Botești).

The Siret corridor valley is another area where construction sector is expanding with large amounts of waste (Tămășeni commune - 2166 t; Doljești – 1356 t) disposed in wild dumps, frequently located on floodplains due to the lack of appropriate waste management services. On opposite side, the rivers and tributaries in the proximity of households are most vulnerable to illegal dumping, particularly in mountainous western half of the county. These dumpsites, which may also include household and agricultural fractions, are potential threats during the floods for downstream localities (particularly the households in the proximity of rivers and their tributaries) and local bridges.

Household annexes which are frequently built on floodplains of rivers are the most vulnerable to these natural hazards. Rural municipalities were forced to close the rural dumpsites until July 2009, several sites were compacted and covered with construction and demolition waste as shown in figure 5.

Figure 5. Uncontrolled waste disposal of CDW waste in rural areas and reuse of this fraction as coating material for local dumpsites

As regards the waste management sector, the current priority should be the extension of waste collection services and the improvement of the existing ones in densely populated communes of Neamț County. New waste disposal centers for CDW waste is needed (which does not require major investments like the municipal fraction) where these wastes can be collected by sanitation operators or reused by authorities for local infrastructure projects (road foundations, embankments, dikes etc.) in order to avoid the uncontrolled waste disposal practices. The industrial symbiosis between private and public sector could avoid the landfill of CDW fraction. Almost 30,000 t of CDW waste was reused as cover material (instead of virgin soil) in order to rehabilitate a fly ash landfill site of Termica power plant in Suceava County [11].

CONCLUSIONS

The paper reveals spatial implications across Neamț County of rural residential buildings between 2002 and 2010. The quantitative and geographical approaches are necessary to reveal the most attractive rural areas for new residential constructions which also correspond to the *hot spots* of construction waste generation. The local environment is vulnerable to illegal dumping in the proximity of these built-up areas especially if the population is not fully covered by waste collection services.

Construction waste is inert to environment but some fractions are hazardous and improper disposal of these streams may facilitate the pollution of sensitive environmental factors (rivers/groundwater/local biodiversity). Also, these fractions disposed on improper sites favor the waste dumping of other streams (household and agricultural waste, sawdust) including toxic waste such as WEEE, batteries etc.

The new regional approach of the integrated waste management system is under implementation supported by EU funds. This system will change the current waste management infrastructure from urban and rural areas in following years. Rural waste management is a complex issue which Romania is facing in order to provide sustainable waste management facilities.

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