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PREDICTION OF RESIDENTIAL BMW GENERATION ACCORDING TO SOCIO-ECONOMIC AND HOUSEHOLD CHARACTERISTICS FOR THE DUBLIN REGION.

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SUMMARY: Despite the fact that biodegradable wastes account for 72% of the total municipal waste stream in Ireland, less than 6% of collected biodegradable wastes were recovered in 2004. Both planning and design of integrated municipal solid waste management systems require accurate prediction of solid waste generation. This paper discusses the potential household biodegradable municipal waste (BMW) generation for the Dublin Region, Ireland, using statistical data on socio-demographics, particularly household size and social class as the main variables. Historical research was used to assign BMW generation rates. A Geographical Information System (GIS) 'model' of BMW generation was created using ArcMap, a component of ArcGIS 9. BMW generation was predicted within a diverse 'landscape' of residential areas. The results highlight the importance of tailoring waste management strategies to small management areas.

1. INTRODUCTION

Waste management is widely recognised as one of the most problematic areas of Irish environmental management. The rate of waste generation continues to increase proportionally with economic growth. Economic growth during the last decade has stimulated greater consumption throughout Irish society. Ireland is under increased pressure from the European Union to develop its waste management practise to come in line with other European countries. Biodegradable wastes account for 72% (EPA, 2005) of the total municipal waste stream, of which organic waste (i.e. food and garden waste) accounts for almost 40%, and paper, cardboard, textiles, etc. comprise the remainder. Yet, less than 6% of collected biodegradable municipal wastes (BMW) were recovered in 2004 (DEHLG, 2004). It is estimated that 2,007,859 tonnes of BMW was generated in Ireland in 2005, of which 65% was landfilled and the remaining recycled (EPA, 2006). BMW generation has increased by almost 50% in the 9-year period up to 2004. The targets set in the Landfill Directive 1999/31/EC require a progressive reduction in landfilling to 35% of the quantity of biodegradable waste generated in 1995 (451,469 tonnes) going to landfill by 2016 (EPA, 2006).

   The diversion of BMW from landfill has shown little progress. The amount of BMW landfilled in 2005 was 101.4% of the 1995 baseline. It remains a challenge to achieve the landfill diversion targets mandated in the Landfill Directive. The segregation / treatment of

organic waste is therefore considered a top priority for Ireland.

Weight-based household waste collection charges have been introduced in all local authority areas in the Dublin Region, with the charging systems designed to encourage recycling and recovery of household waste. Nevertheless, planning and design of municipal solid waste management systems require accurate prediction of both the quantity and distribution of solid waste generation.

The Greater Dublin Region denotes Dublin City and its suburbs (i.e. Greater Dublin Suburbs) (Figure 1.). Dublin has experienced an increase in the number of households in all areas and in particular, the Fingal local authority area (27.5% increase, 1996-2002). The Dublin Region has 379,372 households, 98% of which are considered urban. The Dublin Region makes up only 1.3% of the total area of Ireland (92,227 ha) but holds 27% of the country's population (1,122,821). While each of the four local authorities comprising the Dublin region are responsible for providing waste management services in its particular area, there is also a significant amount of co-ordination among the four authorities on waste matters, due in no small part to the regional waste management planning strategies adopted in Ireland.

While tactical (day-to-day) and strategic (long term) waste management decisions are made on a very local level (i.e., by a local authority) existing models for waste generation are not able to yield precise enough estimates for diverse areas within a large local authority, or indeed within a larger area such as the Greater Dublin Region. Rather, what is needed is a technique capable of making predictions of waste generation at a "small" scale such that spatial influences can be considered. Spatial representation will allow temporal changes arising from demographic, economic or other influences to be more effectively described. With such a tool, waste management planning can be integrated with, for example, housing strategies or, indeed, with any developments (such as pay-by-weight charging) that will materially affect the generation of solid waste. Waste quantities and spatial distribution of waste must be defined to help Ireland achieve world-class waste management objectives through continuous improvement.

The objective of this research was to develop a Geographical Information System (GIS) model for determining the BMW generation from the residential sector within the Dublin Region. This was achieved by characterizing and defining geographically, the entire residential sector in the Dublin Region. The system application requires demographic and housing statistics and facilitates the visual and spatial distribution of residential BMW to be assessed at the Electoral District level within the region. (The electoral district is the smallest geographic scale for which vital statistics are collected by Ireland's Central Stastics Office, CSO.)

Figure 1. The Location of the Dublin Region in Ireland (left) and Dublin's Electoral Divisions (right), mapped according to Small Area Population Statistics (CSO, 2002).

2. IMPACTS ON WASTE GENERATION

Many factors affect the generation of residential waste. Parameters frequently mentioned (Plöchl *et al*., 2003) as affecting the extent and composition of municipal waste include social factors, structural factors and organisational factors, such as:

- Social
  - Size and family status
  - Age
  - Gender
  - Income
  - Educational level

- Residential structure factors such as
  - Family houses
  - Multi story housees
  - Household size (persons)

- Organisational factors such as
  - Source of waste
  - Bin size
  - Collection system in place
  - Waste fees
  - Seasonal variations.

Household size (on a per person basis) and social class, according to the CSO, were used as the main variables to predict the generation of residential waste for the purpose of this study.

2.1 Household size

BMW from households consists of food and garden waste, paper and cardboard, textile and any other waste capable of undergoing aerobic or anaerobic decomposition. Semi-detached housing units (two houses sharing a common wall) have been found in some studies (Emery et al., 2003) to produce greatest amounts of kitchen waste and associated packaging waste. Bungalows (small single storey houses), semi-detached and detached housing generate more garden waste than flats (i.e., apartments) and terraced housing (several houses sharing common walls and built in a row) (Jones et al., 2006). Dennison (1996) undertook an extensive socio-economically based survey of household waste in Dublin, which, revealed that socio-economic factors, and in particular household size have a significant effect on the generation and composition of the waste stream, findings that were corroborated elsewhere by Jones et al. (2006) and Parizeau et al. (2006). An inverse relationship between specific waste production and household size was also found by Dennison (1996). These findings have important implications for future waste generation in Dublin, which has a low household occupancy rate within a diversity of housing types.
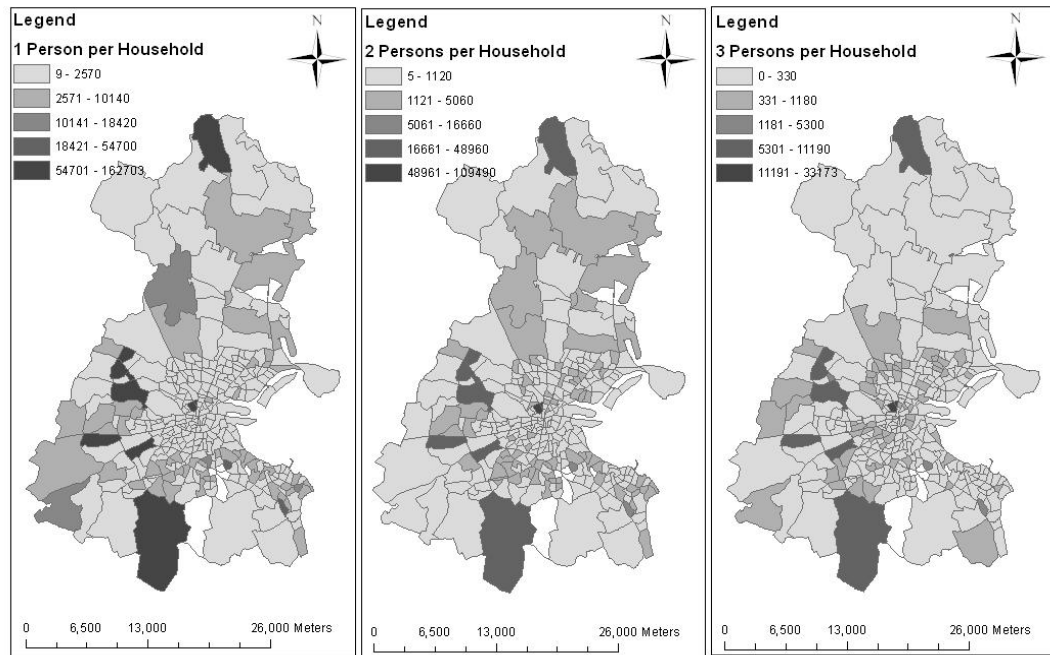
More affluent households are likely to produce larger quantities of waste than the less affluent (DEHLG, 2004). Household characteristics play a major part in the rate of recycling and waste generation.

The residential sector is an important part of the economy. It is also a pressure on the environment through its waste generation rates. The key factors that influence the impact of the residential sector on the environment include:

- Population growth
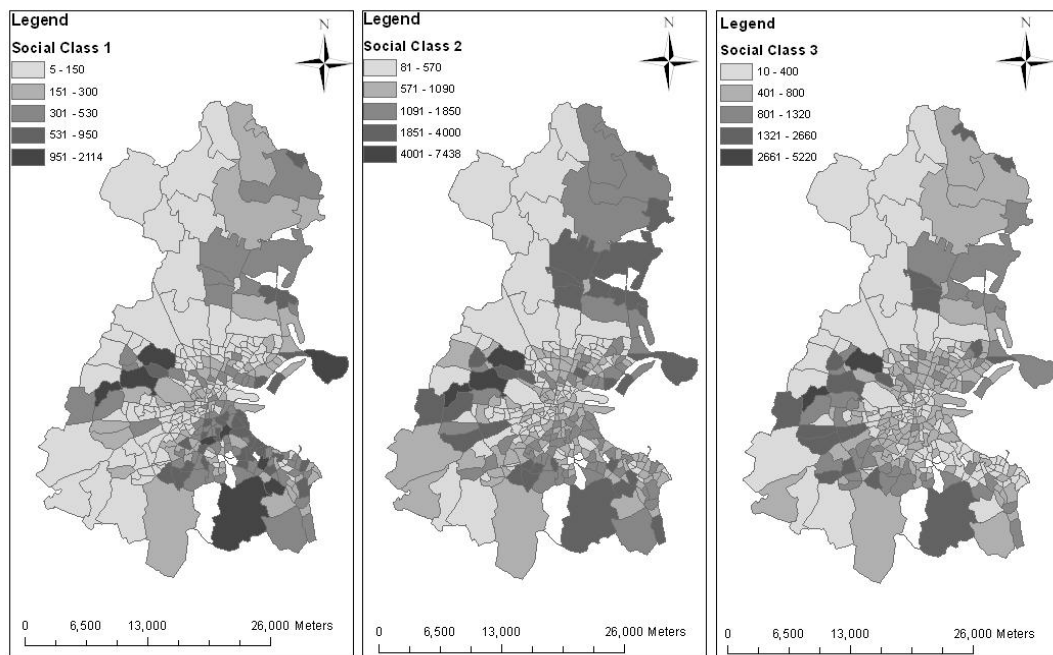- Number of households
- Household size.

Ireland has progressively become a more urbanized society. The expanding population along with smaller household sizes are increasing the demand for residential housing and therefore, also for waste management systems/services.

Figures 2 and 3 are examples of how residential areas were mapped according to household size (Figure 2) and social class (Figure 3). Household sizes were registered for up to 7 persons per household; similarly there were 7 social classes.

Household Size Distribution for 1, 2 and 3 persons per household according to the CSO

Figure 2. Household Size Distributions for the Dublin Region for 1, 2 and 3 persons per Household (Not shown: distributions for 4-7 persons per household).

Social Class 1, 2 and 3 Distributions for the Dublin Region according to the CSO

Figure 3. Social Class Distribution for the Dublin Region for Social Classes 1, 2 and 3. (Not shown: social classes 4 – 7).

2.2 Social Class

Social Class is defined by the CSO in Ireland according to similar levels of occupational skill. Income is correlated with occupational skills. People with higher income would be expected to consume, and therefore dispose of, larger quantities of goods than those of lower income areas. Domestic waste from a single house will vary from week to week and from season to season (Abu Qdais et al., 1997) and within socio economic groups within a country (Kiley, 1997).

Research has found that the average waste generation rate is dependent on income level, with higher income groups generating more (Abu Qdais et al., 1997). Robinson *et al*. (2005) found that there was a wide variation in households claiming to recycle and it was postulated that this corresponded with socio-economic variations between areas as typified by their housing characteristics.

3. EXPERIMENTAL STUDY

3.1 Goal of the study

The main goal of the study was to identify, locate, and quantitatively evaluate the generation of BMW from the residential sector of the Dublin Region and also to map this waste generation to allow visual interpretation.

3.1.1 Scope of the study

The study took into account the entire residential sector in the region. The study area encompassed 92,227 ha, i.e. the Dublin Region (Figure 1). The area studied included all of the Dublin Region comprising of four Local Authority areas, namely Dublin City, Fingal, South Dublin and Dún Laoghaire Rathdown. The scale of the study was conducted at the Electoral District level (smallest administrative area population statistics are published). There are 322 Electoral Districts located throughout the Dublin region, of varying sizes.

3.2 GIS technology

The premise on which this research is based is that municipal waste generation, and particularly BMW, is spatially variable. GIS technology is the ideal tool with which to integrate the variety of factors affecting this waste generation. Spatial representation will allow temporal changes arising from demographic, economic or other influences to be more effectively predicted and monitored.

ArcGIS 9 is an integrated collection of GIS software, which allows users to deploy GIS functionality in desktops, servers or custom applications, both on the web and in the field (ESRI, 2006). Input parameters to the GIS model developed in this research included household type and social class characteristics of residential establishments connected to Electoral District location. The output included maps of the potential residential BMW generation at the Electoral District level for the Dublin Region.

3.3 Central statistics Office Data

The CSO records statistics that describe the demographic profile (e.g., household incomes, house types, family structure, etc.) for the entire residential sector for the Dublin Region, and this profiling facilitated the entire residential sector being included in the research.

3.4 Experimental procedure

The objective of this study was to identify, locate, and map residential waste generation in the Dublin region. The residential sector was envisaged to have significant rate of generation of waste, especially in the urban locations (98% of Dublin is considered urban). This was to be accomplished through carefully selecting the main factors contributing to waste generation in the area, locating them, mapping them and applying a waste generation rate according to the character (household size and social class) of the residential sector. This study presents a geographical information system (GIS) based procedure for the estimation of BMW generation, computed using the populations based on household size and a socio-economics basis.

3.4 Materials and Methods

3.4.1 Overview

The objectives of the study were achieved by identifying, locating, and quantitatively evaluating the BMW generation in the Dublin Region, from the residential sector and also mapping this waste generation for the Region. The ArcMap application, a component of ArcGIS 9 (ESRI, 2004) was used in this study. The input data were readily available from the Irish Central Statistics Office (CSO), Ireland's agency charged with recording the country's vital statistics.

3.4.2 Data collection and generation

The CSO records statistics that describe the demographic profile (e.g., house types, number of occupants, household incomes, etc.) of the entire residential sector for the Dublin Region, so this entire sector was studied in the research. The following procedure was used to analyze the residential sector:
- Map the residential sector and characterize each Electoral District by the demographic profile of the residential sector;
- Apply waste generation rate (obtained from published research);
- Calculate total predicted residential BMW generation rate.

3.4.3 Preparing and analysing residential information

The following data were gathered:
- Household size (persons per household basis, from CSO)
- Social class (according to the CSO)
- Waste generation rates (determined from published literature)

Small Area Population Statistics (SAPS, 2002) (CSO, 2006) were used as the source for the first two data. Waste generation rates were determined from published research pertaining specifically to Dublin (Dennison, 1996, DeBúrca, 1995). Two estimation techniques were utilised for assigning waste generation rates to this sector: household basis and social class basis. Waste generation rates and demographic data were assigned as attributes to the relevant geographic locations and combined give BMW generation rates at the electoral district level.

4. RESULTS

The residential sector was predicted to generate a significant amount of BMW per week whether based on Household size or Social class (Table 2); exactly how much depends on the methodology utilised to estimate household BMW (Household size basis = 8158 t wk^{-1}, Social class basis = 13081 t wk^{-1}). The distribution of household BMW generation predictions is shown in Figure 4. The largest amount of Residential BMW was predicted to be generated in the Electoral Districts Blanchardstown-Blakestown (283.84 t wk^{-1}, social class basis) and Lucan-Esker (243.37 t wk^{-1}, social class basis). In terms of waste generated per hectare Electoral District Cabra West C was estimated to generate potentially 1164 kg wk^{-1} ha^{-1} (household size basis), while Clondalkin-Cappaghmore was seen as a potential waste hot spot, generating 1967.67 kg wk^{-1} ha^{-1} (social class basis).

Table 2. Residential BMW Generation as a Function of Estimation Technique

Estimation Technique	BMW t wk^{-1}	% Difference
Household Size	8158.58	37.6
Social Class	13081.52	

The residential sector was predicted to generate between 2,306 kg wk^{-1} (2 kg wk^{-1} ha^{-1}) in Lucan North (population = 338) to 32,955 kg wk^{-1} (1425 kg wk^{-1} ha^{-1}) in Merchants Key B (population =3449) (Household size basis). On a Social class basis the results predicted were between 3,953 kg wk^{-1} (4.2 kg wk^{-1} ha^{-1}) for Lucan North and 283,238 kg wk^{-1} (399.71 kg wk^{-1} ha^{-1}) in Blanchardstown – Blakestown (population = 24404).
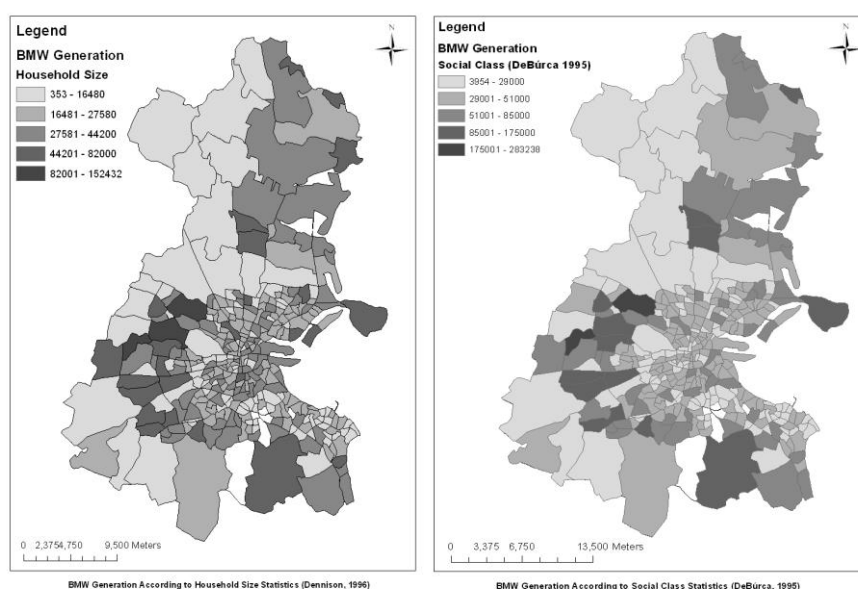

Figure 4. Distribution of Predicted Residential BMW Generation According to Household Size (left) and Social Class Statistics (right).

5. DISCUSSION AND CONCLUSIONS

BMW generation was predicted within a diverse 'landscape' of residential areas. Socio-economic variables and housing types were hypothesised as the key determinants contributing to the spatial variability of BMW generation. A GIS 'model' of BMW generation was created using ArcGIS 9. Using statistical data from the Central Statistics Office (*i.e.*, Small Area Population Statistics, SAPS), social class was mapped on an electoral district basis for the four local authorities in the Dublin region. Historical research was used to assign BMW generation rates to residential areas in districts according the social class of the district. Waste generation rates were also assigned from research based on the distribution of housing types in the region.

The study has identified the geographic patterns of residential BMW generation for the Dublin Region and charactersied the region using socio-demographics. These spatial patterns of predicted BMW distribution appear to confirm the hypothesis about the importance of demographic factors in the generation of BMW.

Results from the study reported here imply that there are large variations in the generation of BMW at the Electoral District level within Local Authority areas. Particularly obvious from large variance in BMW generation rates among district electoral divisions is how population and socio-economic factors combine to affect waste quantity and distribution. The technique is a useful managerial tool to integrate the effect of demographic changes on waste management. The variations in BMW generation highlight the importance of tailoring waste management strategies to small management areas.

Precise estimation of waste generation can lead to a more rational and efficient management of waste for the region. For example, the results from this study identify waste "hot spots" to which special waste reduction efforts might be directed, either in the form of education or perhaps incentives. Likewise, the results may suggest alternative collection strategies the could be used by the local autorities to make more efficient use of existing resources, as well as aid a more functional and economical design of integrated waste management systems.

The GIS based analysis was carried out using up to date small-scale (Electoral District) statistics for optimal precision. In order to verify these predictions, a comparison of results to actual collection data will take place. This will allow for the correlation or validation of the model for more precise predictions. Nevertheless, the system can be easily adapted to suit other regions in Ireland by altering the input statistics for the relevant areas.

REFERENCES

Abu Qdais, H.A., Hamoda, M.F. and Newham, J. (1997) Analysis of residential solid waste generation sites. Waste Management & Research 15 p 395 – 406.

CSO (2006) Small Area Population Statistics, 2002 Central Statistics Office, Cork, Ireland.

DeBúrca, D. (1995) Kerbside recycling schemes as a municipal solid waste management option. M.Eng.Sc. Thesis University College Dublin, Ireland.

DEHLG (2004) Waste Management, Taking Stock and Moving Forward. Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Dennison, G. J. (1996) Integrated solid waste management in large urban communities using the city of Dublin as a case study. Ph.D. thesis University College Dublin, Ireland.

Emery. A.D., Griffiths, A.J. and Williams, K.P. (2003) An in dept study of the effects of socio-economic conditions on household waste recycling practices. Waste Management & Research 21 p 180 – 190.

EPA (2005) National Waste Report 2004. Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland.

EPA (2006) National Waste Report 2005. Environmantal Protection Agency. Johnstown Castle Estate Wexford, Ireland.

ESRI (2004) ArcGIS 9. Environmental Systems Research Institute, Redmond, CA, USA.

ESRI (2006) The complete Geographic Information System. Environmental Systems Research Institute Available at www.esri.com/software/arcgis/index.html. (Accessed December 2006)

Jones, A.E., Nesaratnam, S.T., and Porteous, A. (2006) Working out the factors that affect household waste generation. The Open University Household Waste Study. Factsheet No. 2. Department of Environment, Food and Rural Affairs, U.K.

Kiley, G. (1997) Environmental Engineering. McGraw-Hill London.

Parizeau, K., Maclaren, V., and Chanthy, L. (2006) Waste characterisation as an element of waste management planning: lessons learned from a study in Siem Reap, Cambodia. Resources Conservation and Recycling, Article In Press.

Plöchl, C., Dobson, G. and Buell, U. (2003) Factors influencing municipal waste arising and composition. 8th International Conference on Environmental Science and Technology, Lemons Island, Greece, 8 –10 September 2003 p 682 – 689.

Robinson, G.M. and Read, A.D. (2005) Recycling behaviour in a London Borough: results from large-scale household surveys. Resources, Conservation and Recycling 45 pp 70 – 83.