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*PLANNING AND ENVIRONMENTAL POLICY*

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# A Spatial Econometric Analysis of Well-being using a Geographical Information Systems Approach

**Finbarr Brereton, J. Peter Clinch, and Susana Ferreira**[1]

Planning and Environmental Policy

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## Abstract

In recent years, economists have being using socio-economic and socio-demographic characteristics to explain self-reported individual happiness or satisfaction with life. Using Geographical Information Systems (GIS), we employ data disaggregated at the individual and local level to show that while these variables are important, consideration of amenities such as climate, environmental and urban conditions is critical when analyzing subjective well-being. Location-specific factors are shown to have a direct impact on life satisfaction. Most importantly, however, the explanatory power of our happiness function substantially increases when the spatial variables are included, highlighting the importance of the role of the spatial dimension in determining well-being. This may have potentially important implications for setting priorities for public policy as, in essence, improving well-being could be considered to be the ultimate goal of public policy.

**Keywords:** subjective well-being; spatial amenities; geography; environment; Geographical Information Systems.

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## I. Introduction

The economics of happiness literature developed in the early nineteen seventies with the pioneering work of such researchers as Richard Easterlin. Easterlin and subsequent authors, such as Daniel Kahneman, believe that individual utility, traditionally thought by economists to be immeasurable and hence proxied by income, can be measured directly. One method is to employ happiness data from surveys as empirical approximations of individual utility. The specific question asked varies throughout the literature in terms of subject matter (questions on happiness and life satisfaction are frequently employed) and range of scale (three-point to ten-point scales have been employed in the literature). These questions elicit happiness or life satisfaction from individuals and measures such as these have been found to have a high scientific standard in terms of internal consistency, reliability and validity (Diener *et al.,* 1999)[2] and have been used extensively in the economics literature in recent decades (see, e.g., Easterlin, 1974; 1995; 2001, or Frey and Stutzer, 2000; 2002a; 2002b; 2004).

This literature has examined the role of socio-economic and socio-demographic variables on individual well-being. Established findings within the field include that characteristics of the individual's themselves i.e., their socio-demographic characteristics, such as their age, gender and marital status, influence their happiness. Similarly for micro-economic characteristics, such as income, household tenure and employment status, with unemployment having a profound negative influence on well-being. At the macro-economic level, contributions have focused on the impact of national inflation (Di Tella *et al.,* 2001) and unemployment (Clark and Oswald, 1994) rates and also the type of governance present in the person's area (Frey and Stutzer, 2000). Happiness is found to be inversely related to the inflation and unemployment rates, but to increase with the level of direct democracy.

Prior literature in the economics field has demonstrated that the area or location where an individual lives affects quality of life. This is especially evident in the hedonic pricing literature where there is a long tradition of constructing quality of life indices as the weighted averages of amenities in a particular area, usually a city region (see Rosen, 1974; Roback, 1982 or Blomquist, *et al.,* 1988, for seminal contributions, and Chay and Greenstone, 2005, for a recent state-of-the-art valuation exercise).[3]

[2] Firstly, measures of life satisfaction show temporal reliability, even over a period of several years; secondly, they covary with ratings made by family and friends, with interviewer ratings and with amount of smiling in an interview; and finally, when self-reports of well-being are correlated with other methods of measurement, they show adequate convergent validity (Diener and Suh, 1999).

[3] Roback (1982) found that the average person in her sample would be willing to pay $69.55 per year for an additional clear day, $78.25 per year to avoid an additional cloudy day, and $5.55 per year to avoid an increase of 1 microgram per cubic meter in particulate matter. Blomquist *et al*. (1988) found that the difference in compensation between the most and least desirable U.S. counties in terms of the same bundle of local amenities comprising climate, urban conditions and environmental quality was $5,146. More recently, Berger *et al*. (2003) have shown that one standard deviation changes in climate attributes (heating degree days), air quality and crime produce annual compensation in the Russian housing and labor markets of 7,839, 8,050 and 8,602 rubles respectively, compared to a mean monthly salary of 1,928 rubles.

However, it wasn't until the 1990s that researchers began to examine this spatial aspect of well-being in the economic psychology literature. These more recent papers found that characteristics of people's immediate surroundings (their locality) influenced their well-being, but also that the wider environment had an important role to play in explaining what makes us happy. Environmental variables such as aircraft noise (Van Praag and Baarsma, 2005), air pollution (Welsch, 2006) and the prevailing climate (Frijters and Van Praag, 1998 and Rehdanz and Maddison, 2005) are found to influence welfare, as are environmental attitudes (Ferrer-i-Carbonell and Gowdy, 2007). Findings indicate that excess noise levels adversely affect well-being, as does air pollution and the influence of climate depends on the variable in question, indicating the potential importance of spatial factors in determining well-being.

In terms of examining the geography of well-being, previous studies were hindered by a lack of adequately disaggregrated data (Welsch, 2006; Rehdanz and Maddison, 2002). By the authors own admission, data constraints at the local and regional levels restricted their analysis to aggregated data at the national level, or to focusing on a particular localised area where richer data was available. Hence, thus far, the current literature has stopped short of carrying out a holistic study of the spatial element of well-being, due in no small part to these data constrains, but also to the lack of availability of appropriate tools to carry out such analysis. For example, Rehdanz and Maddison (2005) examine the influence on well-being of climatic conditions, but including too many of their climate variables in the model at once leads to problems of multicollinearity as some of their climate variables did not vary at the national level (i.e., one record per country). They state that their analysis was restricted to the country level and that it would be interesting to see how climate would affect people's happiness in different regions of a country. Ferrer-i-Carbonell and Gowdy (2007) include a set of dummy variables indicating the region where the individual lives to capture the (natural) environment, proxying, for example, London and Manchester as polluted areas. However, in the case of major cities in developed countries, pollution is, generally, a localised phenomenon and categorising an entire cities population under one pollution level may severely under or overestimate their exposure. Welsch (2006) uses life satisfaction scores to value air pollution in European countries, but includes no within country variation in his estimation. Due to a lack of data, Welsch's study was concerned with countries as the cross-sectional units and he states that "future research may address the question how regional or local happiness profiles are affected by the corresponding environmental conditions. It is conceivable that at a more disaggregated level the linkage between environment and happiness is even more articulate than it is with respect to national data". Van Praag and Baarsma (2005) examine a localised problem and use postcodes to link their respondents to objective noise burden, but due to issues of anonymity, this application may only be available at city level where populations are aggregated.

In this paper, we explicitly endeavour to examine the importance of space in the determination of well-being, using a more holistic approach. Firstly, we measure amenities at the level of disaggregation at which individuals actually experience their surroundings, i.e. local level. This is facilitated through the use of Geographical Information Systems (GIS), a system for the visual display of spatial data. Using GIS, 1) the level of disaggregation at which individuals are linked to their surroundings is greatly improved; 2) the vector of spatial variables included in the happiness function is expanded to include variables with a potential influence on well-being, but which have not been examined to date; and 3) distance measures are introduced, as one could hypothesis that the intensity at which individuals experience their surroundings is a function of proximity (as in the case of air pollution and noise). The findings in the paper highlight the critical importance of the role of the spatial dimension in determining well-being, i.e., spatial variables are found to be highly significant with large coefficients. We also find that the impact of spatial amenities on life satisfaction is a function of distance, with the most notable example being that of proximity to coast. This has a large positive effect, which diminishes as one moves further from the coast. Most importantly, the explanatory power of our happiness function substantially increases when the spatial variables are included, resulting in three-times the variation in well-being being explained than has been achieved in any previous cross-sectional study. This indicates that geography and the environment have a much larger influence on well-being than previously thought.

The paper proceeds as follows. Section 2 describes the methodology (data, GIS requirements and the estimation strategy) used in the paper, section 3 presents the results and section 4 concludes.

## II. Methodology

In this paper, we assume that the level of well-being attained by an individual $i$ in location *k* can be represented by the following indirect utility function:

$$u_{i,k} = \alpha + \beta' \mathbf{x}_{i,k} + \gamma' \mathbf{a}_{i,k} + \varepsilon_{i,k} \qquad i = 1....I,\ k = 1,...,K \tag{1}$$

where *u* denotes utility of individual $i$ in location *k*, **a** is a vector of spatial factors, some of which (e.g., commuting time, proximity to a coast) may vary at an individual level and $x$ is a vector of socio-economic and demographic characteristics (age, gender etc.) that are typically included in the literature (see, e.g., Clark and Oswald, 1994; Di Tella *et al*., 2001 or Stutzer, 2004). In the micro-econometric function, the individual's true utility is unobservable, hence we use self-reported well-being as a proxy.

The well-being indicator (or proxy for individual utility) used in this paper is based on the answers to the following question (which was preceded by a range of questions regarding various aspects of the respondent's life): 'Thinking about the good and bad things in your life, which of these answers best describes your life as a whole?'. Respondents could choose a category on a scale of one to seven ('As bad as can be'; 'very bad'; 'bad'; 'alright'; 'good'; 'very good'; 'as good as can be').[4] The use of self-reported well-being introduces measurement error as the respondents may be unable to communicate accurately their underlying utility level. However, as Blanchflower and Oswald (2004a) point out, it is measurement error in the independent variables that would be more problematic in the econometric estimation, and there is a broad consensus among previous studies that self-reported well-being is a satisfactory empirical proxy of individual utility (see, e.g., Stutzer, 2004; Blanchflower and Oswald, 2004b; Ferrer-i-Carbonell and Frijters, 2004).

Data on well-being and on the socio-demographic and socio-economic characteristics used in the analysis come from a survey[5] of a representative sample of 1,500[6] men and women, aged 18 and over and living in Ireland. The survey found a high well-being, in general, in Ireland with an average of 5.5 on the seven-point scale. What makes this data set particularly well suited for this paper is that it can be merged with detailed geographical information as we know the area in which the respondent lives. This information allows us to match the survey data spatially to a national map of Ireland using GIS (Appendix I) and hence it is possible to combine subjective data at the individual level with a vector of spatial amenities (**a**).[7] These two datasets are combined at the local (electoral division[8]) level. However, to assess properly the impact on individual well-being from changes in spatial amenities, ideally, one would want to be able to match climate and environmental factors to a particular individual rather than a particular area. At present, however, the data do not allow this and anonymity may preclude this in any case. Descriptions of the variables and descriptive statistics are outlined in Appendix II.

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[4] Some studies treat self-reported life satisfaction data and happiness data interchangeably. Veenhoven (1997) states that "the word life-satisfaction denotes the same meaning and is often used interchangeably with happiness." Di Tella *et al.* (2001) report a correlation coefficient of 0.56. However, Peiro (2006) points to happiness and satisfaction as two distinct spheres of well-being. He concludes that the first would be relatively independent of economic factors while the second would be strongly dependent.

[5] Urban Institute Ireland National Survey on Quality of Life (2001)

[6] Due to missing observations the final sample consists of approximately (depending on the model specification) 1,467 observations. The effective response rate is 66.6 percent. The margin of error using the entire sample is ± 2.5 percent at a 95 percent confidence level. The 2000 Register of Electors was used as the sampling frame.

[7] GIS works well when applied to static data, and less well when applied to time series analysis (Goodchild and Haining, 2004) and hence is well-suited to the cross-sectional data employed in this paper.

[8] There are around 3440 electoral divisions in Ireland which represent the smallest enumeration area used by the Irish Central Statistics Office in the collection of Census data. These areas are relatively small, particularly in the city regions and those represented in our sample range in size from 18 hectares (in cities) to 6189 hectares (open countryside) (mean = 1767, standard deviation = 1538), with total populations ranging from 47 individuals to 8595 (mean = 2040, standard deviation = 2073).

The use of data collected in Ireland is interesting in its own right. In the last decade, the 'Celtic Tiger' economy grew at a record rate for a developed country (this and other trends are documented in, for example, Clinch *et al.*, 2002). Meanwhile, the Economist Intelligence Unit (2004) has ranked Ireland as first in its quality of life league table for 2005. Nevertheless, there has been much concern regarding the implications of the pace of economic growth for localized environmental quality and life satisfaction generally (EPA, 2004a). This makes Ireland an appropriate subject for the analysis of the influence of spatial amenities on subjective well-being. Furthermore, issues surrounding heterogeneity of preferences may not be as problematic in a small (approximately 70,000 $km^2$) and relatively homogenous country like Ireland, compared to other nations. Also, by examining one country, issues of translation and cultural bias in the well-being question should not arise.[9]

As elements of the vector of spatial factors, the dataset contains climate (from Collins and Cummins, 1996), environmental (from EPA, 2005) and other spatial data (UII, 2006). Several climate variables were considered but following the advice of a climatologist, mean annual precipitation, January mean daily minimum air temperature, July mean daily maximum air temperature, mean annual duration of bright sunshine and mean annual wind speed were chosen (similar to those included in Frijters and van Praag, 1998).

As in Blomquist *et al.* (1988), variables capturing whether the respondent lives near the coast, the violent crime rate and presence of waste facilities in the respondent's area were included. There is evidence suggesting that noise, smell and other negative externalities from waste facilities may impact negatively on well-being or quality of life (DG Environment, 2000). Air pollution and water quality were considered as indicators of environmental quality but regional variation is minimal (EPA, 2004). Additionally, population density (total population divided by total area in $km^2$ (CSO, 2003)), traffic congestion and average commuting time in each area were included to capture crowding and congestion effects. Also, a variable capturing voter turnout in the Irish general election in 2002 (Kavanagh, Mills and Sinnott, 2004) is included as an indicator for social capital (as in Putnam, 2000). Due to data constraints, traffic congestion (number of vehicles (DELG, 2002a) divided by the total length of primary roads per local authority[10] area (NRA, 2003)) and the homicide rate (number of homicides per 100,000 of population (Garda Siochana, 2002)) are measured at the local authority level.

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[9] However, the extent to which these biases are problematic is a matter of debate (Diener and Suh, 1999)

[10] For governance purposes, Ireland is divided into 34 different regions called Local Authority areas. These generally equate to one body per county and one for the three major urban areas of Galway City, Limerick City and Cork City. Dublin is divided into four areas and Tipperary is divided into two local authority areas. These areas are relatively large and range in size from 2035 hectares to 746797 hectares (mean = 229060, standard deviation = 226508), with total populations ranging from 25799 individuals to 495781 (mean = 177377, standard deviation = 135990).

As in van Praag and Baarsma (2005), we include proximity to airports.[11] However, we also include more detailed transport data consisting of proximity to: major roads (national primary and national secondary) (NRA, 2003); international, national and regional airports; railway stations and seaports (UII, 2003). Access to transport routes could potentially enter the micro-econometric function in two ways, positively through accessibility and negatively through pollution and noise. The latter was shown to be the case by van Praag and Baarsma (2005) in relation to airport noise in Amsterdam.

As for the socio-economic and demographic variables, the dataset includes an employment-status variable divided into ten separate categories which follow the International Labour Organisation (ILO) classification: employed (self-employed, full-time employed and part-time employed), inactive (student, working on home duties, disabled, retired, those not working and not seeking work, and those on a government training scheme) or unemployed (CSO, 2006). Unemployment is further divided into two categories of those unemployed having lost or given up their job combined with those not working but seeking work, and those seeking work for the first time. Additional individual characteristics contained in the dataset and typically employed in the literature are age, gender, educational attainment (primary, lower secondary/junior high school, upper secondary/senior high school and university degree), marital status (single, married, cohabiting, widowed and separated/divorced), log of gross household income,[12] whether the respondent is caring for a disabled member of the family and the number of dependent children in the household (1, 2, 3+). As an indicator of individual health we use the number of times the respondent has visited the doctor in the past year (never or once, two to five times and six or more times a year). We also include household tenure (owned outright, mortgaged, renting, or in public housing).

### *II.I. Geographical Information Systems Methodology*

GIS is a powerful computing tool that allows the visual representation of spatially referenced data. It has advanced the technical ability to handle such data as countable numbers of points, lines and polygons[13] in two-dimensional space (Goodchild and Haining, 2004) and link various datasets using spatial identifiers (Bond and Devine, 1991). It represents a solid base for spatial data analysis and provides a range of techniques for analysis and visualisation of spatial data. It provides effective decision support through its database management capabilities, graphical user interfaces and cartographic visualisation (Wu *et al.,* 2001).

[11] All the proximity criteria are based on guidelines in Irish Government policy documents (see, DELG, 2002b).

[12] Income is expressed in thousands of euro. Missing values, 23.7 percent of those interviewed, were imputed based on the respondent's socio-demographic characteristics including age, gender, marital status, education level, area inhabited and employment status. The original income variable was divided in 10 categories, so mid-points were used (as in Stutzer, 2004). The survey was carried out when Ireland was still using the Irish Pound, so we converted to euros using the fixed rate of IR£1= €1.26974.

[13] A polygon is the GIS term for any multi sided figure.

### *II.I.I. GIS in the Economics Literature*

Research using GIS in the economics field has tended to be in the area of environmental valuation through hedonic pricing and a new generation of hedonic studies is using GIS to create larger databases and define new explicative variables in combination with spatial econometric methods (see Bateman, Jones *et al*., 2002; Lake *et al.,* 1998). These hedonic models use a GIS programme to develop neighbourhood characteristics that are unique to each of their included observations (i.e. house or property). GIS has enhanced the ability of these hedonic models to explain variation in sale prices by considering both proximity to, and extent of, environmental attributes (Paterson and Boyle, 2002).

Baranzini and Ramirez (2005) use GIS to value the impact of noise in Geneva, while Lynch and Rasmussen (2001) use GIS to estimate the impact of crime on house prices in Jacksonville, Florida, USA. Paterson and Boyle (2002) use GIS data to develop variables representing the physical extent and visibility of surrounding land use in a hedonic model of a rural/suburban residential housing market. Bastian *et al.* (2002) use GIS data to measure recreational and scenic amenities associated with rural land, while Geoghegan *et al*. (1997) developed GIS data for two landscape indices and incorporated them in a hedonic model for Washington D.C, USA.

### *II.I.I. Creating variables using GIS*

To capture accurately the influence of environmental and location specific variables on individual well-being requires variables to be measured at a high level of disaggregation i.e. at the level at which individuals experience their environment. Therefore they must be captured in a manner that reflects individuals' perceptions of the amenity or disamenity in question. Many facets of an amenity, such as intensity, frequency, duration, variability, time of occurrence during the day etc. (Bateman *et al*., 2001 p4-22) will affect how an individual perceives the amenity. GIS allows variables to be related spatially and hence individuals can be linked to the geographic characteristics of their surroundings. Hence, GIS could, in principle, provide a full quantitative description of overall area quality if all relevant data layers, for example concerning road networks and public services, were available and were transformed in a convenient way into spatial attributes (Din *et al.,* 2001).

However, when specific household or property GeoCodes (X, Y corrdinates) are unknown, as in the case of the household survey data used in this paper, neighbourhood areas must be used as the reference point when creating environmental variables. The typical method of doing this is to use the mathematically-created centre or 'centroid' of the area in question[14] (as was the case in Craglia *et al.*, 2001, who study high intensity crime areas in England) and

[14] A "centroid" is the mathematical term for the centre of an area, region, or polygon, calculated from points on its perimeter. In the case of irregularly shaped polygons, the centroid is derived mathematically and is weighted to approximate a "centre of gravity." These discrete X-Y locations are often used to index or reference the polygon within which they are located and sometimes attribute information is "attached," "hung," or "hooked" to the centroid location.

in this paper we use the centroid of the respondents' electoral division. This introduces a maximum measurement error equal to the greatest distance between the centroid and the boarder of the electoral division in question which will be greatest in rural areas and smallest in the city regions.

The GIS requirements for this paper included the collection, assimilation and pre-processing of digital, spatial datasets, development of methods for spatio-temporal analysis and production of summary statistics and cartographic representations. This process produced layers of data which were 'mapped' into ArcView GIS. The data were entered into GIS as points (e.g. the location of waste facilities), lines (e.g. roads), or polygons (e.g. airports) within the categories of: meteorological; environmental; transport; and administrative boundary data layers. Different variables were entered in different ways. Some were entered directly as the spatial coordinates for this data were known, such as the airport co-ordinates. Others, such as the climate layers were entered as raster maps and these were converted to polygons for analysis purposes, as it was then possible to link individuals to characteristics of their areas. All data were converted to Irish National Grid co-ordinates.

Once the data layers were entered into the ArcView system, variables were created to allow statistical analysis to take place. For example, proximity to coast is measured as three dummy variables; less than two kilometres from the coast, between two and five kilometres and more than five kilometres. This allows us to examine if the amenity/ disamenity value of the variables are functions of distance. We can also disaggregate between different types of similar amenities e.g. landfill and hazardous waste sites (EPA, 2005). Using proximity tools within ArcMap, distance 'buffers' were created from the centroid (as in Craglia *et al*., 2001) of each specific electoral division to a specified distance. Buffer analysis allows the researcher to take a point or line feature and generate a polygon containing all the area within a certain distance of the feature (Bond and Devine, 1991). A tool called 'select by location', was then used to identify the area where a particular environmental condition is satisfied. The variables created were either entered as columns of 0s and 1s, i.e. where the dummy equalled 1 for a particular electoral division if the condition was satisfied and 0 otherwise (e.g., 1 if an electoral division was within a 50 kilometre radius of an airport and 0 otherwise) or as continuous variables (as in the case of the climate variables). These variables were then exported to the statistical software package STATA so econometric analysis could be carried out.

### *II.II. Estimation Strategy*

The stated aim of this paper is to examine the influence of space and place on individual well-being. As a first step towards capturing this influence, a micro-econometric happiness function is specified (Model 1) in which we distinguish between two distinct geographical areas of Ireland, i.e., between those respondents living in Dublin and those living in the rest of the country. This split was considered appropriate in a small (approximately 70,000 km$^2$) and relatively homogenous country like Ireland where the Dublin area comprises 28 percent of the population in only 1.3 percent of the land area, accounts for 39 percent of the national total of Gross Value Added and, with a population of 1.122 million, is the only urban area with a population in excess of 150,000. In Model 1, which also controls for a broad range of socio-economic and socio-demographic characteristics of the individuals in question (age, age-squared, gender, employment status, educational attainment, health, marital status, income and income squared, number of dependent children and household tenure), a dummy for Dublin might be seen as a rough summary measure of the amenities in that area. However, it does not provide much information regarding which specific amenities are most valued by the individuals. Therefore, in order to determine which site-specific factors are most relevant to well-being, a subsequent model is estimated (Model 2), corresponding to the estimation of equation (1) in Section 2, where the spatial variables equate to the amenities contained in vector **a.** This model contains the spatial amenities created using GIS and other data at the electoral division level.

Finally, because the regressions combine data at different levels of disaggregation (individual, electoral division and local authority levels), the standard errors in all the regressions are corrected for clustering (Moulton, 1990).

## III. Results - Assessing the importance of location

### *III.I. Model 1*

Table 1 shows the results from the estimation of our models. Following the recent literature (e.g., Ferrer-i-Carbonell and Gowdy, 2007) and given the ordered nature of our dependent variable, it contains results from ordered-probit regressions.[15] The reference groups for the independent variables are in parentheses.

***- Table 1 about here -***

The results on the socio-economic and socio-demographic characteristics in Model 1 are, broadly speaking, in line with previous findings in the economic psychology literature. For example, the coefficient on being unemployed is negative and significant and, everything else being equal, reduces life satisfaction substantially (see e.g., Blanchflower and Oswald, 2004a for similar results). Gender is significant and negative, indicating that males are less satisfied with their lives than females. Except for the study of Alesina *et al.,* (2004) that finds gender to be significantly related to life satisfaction in the USA, in previous studies gender tends to

[15] We also estimate OLS regressions (Table 2) and the results are comparable.

emerge as insignificant in life satisfaction regressions (Stutzer, 2004; Frey and Stutzer, 2000; Di Tella *et al.,* 2001). We find that those with lower (junior high school) or higher (senior high school) education are more satisfied with life than those with a primary education level (similar to Frey and Stutzer, 2000). As in Clark and Oswald (1994) and Blanchflower and Oswald (2004b), being separated or divorced is negative and significant. However, we find no difference between married and single respondents. Having three or more children is negative and significant at the 5 percent level (similar to Clark and Oswald, 1994). Respondents visiting their doctor two or more times a year are found to be less satisfied with life than those not attending or attending only once. Living in public housing is significant and negatively related to life satisfaction at the 1 percent level with a large coefficient. Perhaps surprisingly, being the carer of a disabled family member emerges as positive and significant in the regression. In line with the standard textbook prediction of utility as an increasing function of income, our proxy for utility (life satisfaction) is an increasing function of (log) income, which emerges significant at the 1% level. Age emerges insignificant in the regression. This is in contrast to the international literature which, generally, finds a U-shaped association between life satisfaction and age.

Examining the influence of location on well-being, we find the coefficient on the dummy variable for Dublin to be highly significant and large; only the coefficients for being unemployed and a discouraged worker are larger in magnitude (see below). Everything else being equal, those living in all areas outside Dublin have a higher life satisfaction. This result is similar to that in Ferrer-i-Carbonell and Gowdy (2007), who find individuals living in Inner London to be less happy, everything else given.

Having controlled for a large number of socio-economic and socio-demographic characteristics, a reasonable hypothesis is that factors related to the size of the settlement and other location-specific factors may be responsible for lower life-satisfaction levels in Dublin. For example, compared to any other area in the country, unparalleled growth rates have resulted in the capital having a much higher population density than other areas and a significant traffic congestion problem (DELG, 2002b). To test this hypothesis, Model 2 examines the importance of spatial amenities.

### *III.II. Model 2*

Model 2, the results of which are reported in the fourth column of Table 1, corresponds to Equation (1). It builds on Model 1 by including the variables with a spatial influence on well-being. These include population density, congestion, commuting time and the climatic and environmental variables. In this model, the dummy for Dublin loses its significance. This result suggests that the spatial variables explain an important part of the difference between living in Dublin and other regions of Ireland in terms of well-being.[16]

The pseudo-$R^2$ of Model 2, at 0.16, (adjusted-$R^2$ equals 0.33) exceeds all those obtained to date in the international literature using a cross-sectional dataset. For example, Ferrer-i-Carbonell and Gowdy (2007) in their study of subjective well-being and environmental attitudes, obtain a pseudo-$R^2$ of 0.088, while Stutzer (2004), in his analysis of Swiss cantons, obtains an $R^2$ of 0.11. Since we control for similar socio-economic and demographic characteristics of the individual as in those studies, we believe this high $R^2$ highlights the substantial influence of spatial amenities as determinants of well-being.[17]

Of the climate variables, the coefficient on mean annual precipitation is positive indicating that, for Irish people, increased rainfall slightly increases life satisfaction. This result may, however, be driven by a positive correlation between rain and scenic beauty.[18] The most spectacular landscapes in Ireland are found in the wettest counties in the West of Ireland. Rehdanz and Maddison (2005) find very scarce precipitation reduces happiness, which they hypothesize might reflect the fact that climate could have an indirect effect on happiness through landscape effects. However, in our case the coefficient emerges insignificant at conventional levels. Increases in the January minimum and July maximum temperatures emerge as amenities and increase life satisfaction. Wind speed emerges negative and significant in our regression, while surprisingly, we find that total annual sunshine is negatively related to life satisfaction. However, it is highly likely that this result is driven by the correlation between higher rainfall and less sunshine.

As in the hedonic literature (e.g., Blomquist *et al.*, 1988), we find the presence of waste facilities in an individual's area to be a disamenity. However, the type of, and distance from, the waste facility in question matters. The coefficient on the variable capturing if a landfill site is in operation in the respondent's electoral division emerges negative and significant compared to those who live in electoral divisions more than ten kilometres away. There is evidence suggesting that noise, smell and other negative externalities from waste facilities of this kind may impact negatively on well-being or quality of life (DG Environment, 2000). Proximity to a hazardous waste facility however, does not seem to have an influence in terms of life satisfaction. It may be that individuals are less aware of the presence of these facilities

[16] We also estimate Model 2 without the Dublin dummy variable and the results are almost identical (results available on request from the authors).

[17] Additional $R^2$ obtained in the literature include Blachflower and Oswald (2004b) at 0.10, Di Tella et al. (2001) at 0.17 and Blanchflower and Oswald (2004a) at 0.084. However, these papers use pooled data over a number of years and hence, may not be directly comparable.

[18] A high correlation coefficient is observed between precipitation and presence of Natural Heritage Areas (0.5874), the latter being EU-designated as areas of outstanding natural beauty.

in their areas. The coefficient on population density is positive and significant at the 5 percent level. This result is similar to that of Roback (1982), who finds population density to be an amenity. Average commuting time and congestion emerge insignificant in the regression as does the crime rate.

Proximity to coast emerges positive and significant with a large coefficient, indicating that individuals living near the coast enjoy higher life satisfaction, other things being equal. Additionally there is evidence that the utility value of coast is a function of distance with respondents living two kilometres or less from the coast more satisfied with their lives, compared to those living more than five kilometres from the coast. Those living between two and five kilometres from the coast are also more satisfied, if insignificantly so, but the coefficient is reduced. Interestingly, proximity to beach emerges insignificant in the regression. It may be that, given Ireland's climate, the amenity value of coastal areas is not a function of the availability of a beach.

We find access to transport emerges as both an amenity and disamenity, depending on the type of, and distance from, the amenity in question. Life satisfaction is highest for those living between thirty and sixty kilometres from an international airport. It may be that those less than thirty kilometres away are affected by the noise disamenity. In relation to regional airports, the amenity value lies at less than thirty kilometres. This result is not unexpected as these are small airports and only deal with smaller, less noisy aircraft and would have significantly fewer arrivals and departures than do the larger airports. Close proximity to a major road (less than five kilometres) emerges as a disamenity, again with distance decay. This may be capturing the noise affects of this transport route. Close proximity to a seaport emerges insignificant in the regression.

## IV. Conclusion

Western governments tend to equate societal welfare with economic measures such as GDP and GNP, prioritising macroeconomic growth in the assumption that this will bring sufficient benefits and revenue to offset any consequent environmental or social costs. However, the use of monetary indicators alone to measure performance runs the risk of leaving governments in the position of having to resolve subsequent social or environmental problems, such as inequality, past pollution or excessive carbon emissions. In this paper, we adopt a holistic approach to the examination of the influence of geography and the environment on happiness with an aim to informing government policy decisions. Using GIS we are able to overcome many of the difficulties that have prevented previous researchers addressing this issue comprehensively. This is achieved by matching individuals to their surroundings at a higher level of disaggregration and by expanding the vector of spatial variables included in the happiness function. We also use proximity measures to examine if the influence of spatial amenities on life satisfaction is a function of distance.

The findings show that climate has a significant influence on well-being, with wind speed negative and significant, but increases in both January minimum temperature and July maximum temperature are positive and significant. Access to major transport routes and proximity to coast and to waste facilities all influence well-being. However, the manner in which they enter the happiness equation differs depending on the amenity in question. Proximity to landfill is found to have a negative affect on well-being. Proximity to coast has a large positive effect, but its influence is a diminishing function of distance. Additionally, the impact of proximity to major transport routes has different effects depending on the type of, and distance to, the amenity in question, e.g., while reasonable proximity to international airports increases well-being, close proximity to major roads decreases it. It may be that, in the former case, the positive effect of access outweighs the negative effect of noise, while the opposite may be true in the latter case.

Our findings highlight the critical importance of the role of the spatial dimension in determining well-being, i.e., spatial variables are found to be highly significant with large coefficients. In fact, the explanatory power of our happiness function substantially increases when the spatial variables are included, resulting in three-times the variation in well-being being explained than has been achieved in any previous cross-sectional study. This indicates that geography and the environment have a much larger influence on well-being than previously thought, as important as the most critical socio-economic and socio-demographic factors, such as unemployment and marital status. This finding has potentially important implications for setting priorities for public policy as, in essence, improving well-being could be considered to be the ultimate goal of public policy.

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**Table 1: Ordered Probit Regressions/ Dependent Variable 'life satisfaction'**

| **Variable Name** | | **Model 1** | **Model 2** |
|---|---|---|---|
| Age | Age | 0.0188 | 0.0100 |
| | | (1.45) | (0.74) |
| | Age-squared | -0.0002 | -0.0001 |
| | | (1.46) | (0.76) |
| Gender | Male | -0.1665** | -0.1719** |
| *(Female)* | | (2.43) | (2.20) |
| Employment status | Retired | 0.0871 | 0.0350 |
| *(Self Employed)* | | (0.54) | (0.25) |
| | Engaged in home duties | -0.3941*** | -0.2817** |
| | | (3.22) | (2.19) |
| | Student | -0.1990 | 0.0251 |
| | | (1.13) | (0.10) |
| | Seeking work for 1st time | -0.2090 | -0.2061 |
| | | (0.59) | (0.55) |
| | Unemployed | -0.9182*** | -0.8674*** |
| | | (4.26) | (3.94) |
| | Not working, not seeking work | -1.4317*** | -1.4863*** |
| | | (3.95) | (3.96) |
| | Working full-time | -0.1280 | -0.0460 |
| | | (1.26) | (0.50) |
| | Working part-time | -0.3695*** | -0.2597* |
| | | (2.80) | (1.82) |
| | Government Scheme | -0.6624*** | -0.9309** |
| | | (2.61) | (2.54) |
| | Permanently unable to work | -0.4888 | -0.6247* |
| | | (1.61) | (1.94) |
| Education | Lower secondary/ Junior high school | 0.4210*** | 0.3023** |
| *(Primary)* | | (3.68) | (2.24) |
| | Upper secondary/ Senior high school | 0.1764* | 0.1940* |
| | | (1.69) | (1.75) |
| | Degree | 0.0617 | 0.1590 |
| | | (0.52) | (1.15) |
| Health | 2 – 5 doctor visits | -0.1555** | -0.2224*** |
| *(Visited the doctor 0 or 1 in the last year)* | | (2.46) | (2.61) |
| | 6 or more doctor visits | -0.3851*** | -0.4252*** |
| | | (3.10) | (3.04) |
| Marital Status | Married | -0.0138 | 0.0720 |
| *(Single)* | | (0.15) | (0.74) |
| | Co-habiting | -0.1239 | -0.2596 |
| | | (0.83) | (1.18) |
| | Widowed | 0.0880 | 0.1124 |
| | | (0.57) | (0.69) |
| | Separated and Divorced | -0.3762** | -0.1981 |
| | | (2.04) | (1.00) |
| Log Income | Income (1000s) | 0.2103*** | 0.2649*** |
| | | (2.90) | (2.95) |
| Number of children in the household | 1 Child | 0.0215 | -0.1197 |
| *(No children)* | | (0.20) | (0.93) |
| | 2 Children | -0.0829 | -0.1111 |
| | | (0.87) | (1.09) |
| | 3 or more children | -0.1772* | -0.1838* |
| | | (1.89) | (1.94) |

**Table 1: Ordered Probit Regressions (cont.)/ Dependent Variable 'life satisfaction'**

| **Variable Name** | | **Model 1** | **Model 2** |
|---|---|---|---|
| Household tenure *(Own Outright)* | Own with a mortgage | -0.0194 (0.27) | 0.0156 (0.20) |
| | Rent privately | 0.0342 (0.27) | -0.0033 (0.02) |
| | Public housing | -0.5125*** (4.69) | -0.4781*** (3.61) |
| Respondent is a carer | | 0.3314* (1.70) | 0.2313 (1.24) |
| Dublin Dummy Variable | | -0.7527*** (11.79) | -0.4430 (1.12) |
| **Spatial Variables** | | **No** | **Yes** |
| Climate Variables | Precipitation | | 0.0005 (1.28) |
| | Wind speed | | -0.3815** (2.36) |
| | January minimum temperature | | 0.8082*** (3.33) |
| | July maximum temperature | | 0.0806*** (3.85) |
| | Average annual sunshine (hours) | | -0.0011 (1.22) |
| Average commuting time | | | 0.0057 (0.48) |
| Population density | | | 0.0061* (1.92) |
| Congestion | | | -0.0001 (1.17) |
| Homicide rate | | | 0.0570 (0.97) |
| Voter turnout | | | 0.0160* (1.84) |
| Proximity to landfill *(More than ten kilometres)* | Contains a landfill | | -0.5145* (1.87) |
| | Within three kilometres | | 0.4332 (1.55) |
| | Between three and five kilometres | | 0.2998 (0.95) |
| | Between five and ten kilometres | | -0.2359 (1.40) |
| Proximity to hazardous waste facility *(More than ten kilometres)* | Contains a hazardous waste facility | | -0.4190 (0.71) |
| | Within three kilometres | | -0.1993 (0.54) |
| | Between three and five kilometres | | -0.3983 (1.01) |
| | Between five and ten kilometres | | -0.2888 (0.89) |

**Table 1: Ordered Probit Regressions *(Cont.)/* Dependent Variable 'life satisfaction'**

| Variable Name | | Model 1 | Model 2 |
|---|---|---|---|
| Proximity to coast *(More than five kilometres)* | Within two kilometres | | 1.1299*** (4.25) |
| | Two to five kilometres | | 0.2761 (1.34) |
| Proximity to beach (*more than ten kilometres*) | Within five kilometres | | -0.2248 (0.73) |
| | Between five and ten kilometres | | -0.1910 (0.62) |
| Proximity to rail station (*more than ten kilometres*) | Within two kilometres | | -0.2868 (1.28) |
| | Between two and five kilometres | | -0.3531 (1.37) |
| | Between five and ten kilometres | | -0.0391 (0.14) |
| Proximity to airport (*more than sixty kilometres*) | | | |
| Regional | Within thirty kilometres | | 1.2726*** (2.63) |
| | Between thirty and sixty kilometres | | 0.0543 (0.27) |
| National | Within thirty kilometres | | 0.1404 (0.40) |
| | Between thirty and sixty kilometres | | 0.5408 (1.55) |
| International | Within thirty kilometres | | 0.4294 (1.56) |
| | Between thirty and sixty kilometres | | 0.5371** (2.16) |
| Proximity to major road (*more than five kilometres*) | Contains a major road | | -0.6040** (1.97) |
| | Within five kilometres | | -0.5816* (1.79) |
| Proximity to sea ports (*more than five kilometres*) | Within three kilometres | | -0.5826 (1.63) |
| | Between three and five kilometres | | 0.0023 (0.01) |
| | Between five and ten kilometres | | 0.2877 (0.85) |
| Number of Observations | | 1467 | 1464 |
| Likelihood Ratio | | -1845.59 | -1692.85 |
| Pseudo $R^2$ | | 0.09 | 0.16 |

*Note 1*: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

*Note 2*: t-statistics in parentheses computed using White's Heteroskedasticity estimator

**Table 2: OLS Regressions/ Dependent Variable 'life satisfaction'**

| **Variable Name** | | **Model 1** | **Model 2** |
|---|---|---|---|
| Age | Age | 0.0155 | 0.0070 |
| | | (1.45) | (0.70) |
| | Age-squared | -0.0002 | -0.0001 |
| | | (1.46) | (0.75) |
| Gender | Male | -0.1369** | -0.1232** |
| *(Female)* | | (2.45) | (2.08) |
| Employment status | Retired | 0.0677 | 0.0407 |
| *(Self Employed)* | | (0.52) | (0.39) |
| | Engaged in home duties | -0.3142*** | -0.1940** |
| | | (3.17) | (2.00) |
| | Student | -0.1520 | 0.0149 |
| | | (1.06) | (0.08) |
| | Seeking work for 1st time | -0.1706 | 0.0491 |
| | | (0.59) | (0.21) |
| | Unemployed | -0.7810*** | -0.6746*** |
| | | (4.17) | (3.56) |
| | Not working, not seeking work | -1.1726*** | -1.0821*** |
| | | (3.85) | (3.60) |
| | Working full-time | -0.0994 | -0.0306 |
| | | (1.23) | (0.44) |
| | Working part-time | -0.3026*** | -0.1628 |
| | | (2.77) | (1.53) |
| | Government Scheme | -0.5330** | -0.6725** |
| | | (2.48) | (2.39) |
| | Permanently unable to work | -0.4181 | -0.4681* |
| | | (1.61) | (1.82) |
| Education | Lower secondary/ Junior high school | 0.3331*** | 0.2038** |
| *(Primary)* | | (3.50) | (2.05) |
| | Upper secondary/ Senior high school | 0.1502* | 0.1284 |
| | | (1.68) | (1.47) |
| | Degree | 0.0582 | 0.0914 |
| | | (0.58) | (0.87) |
| Health | 2 – 5 doctor visits | -0.1348** | -0.1720*** |
| *(Visited the doctor 0 or 1 in the last year)* | | (2.53) | (2.63) |
| | 6 or more doctor visits | -0.3149*** | -0.3249*** |
| | | (3.04) | (3.07) |
| Marital Status | Married | 0.0030 | 0.0671 |
| *(Single)* | | (0.04) | (0.91) |
| | Co-habiting | -0.0696 | -0.1435 |
| | | (0.55) | (0.87) |
| | Widowed | 0.0773 | 0.0945 |
| | | (0.61) | (0.78) |
| | Separated and Divorced | -0.3193* | -0.1537 |
| | | (1.93) | (0.93) |
| Log Income | Income (1000s) | 0.1722*** | 0.2164*** |
| | | (2.93) | (3.49) |
| Number of children in the household | 1 Child | 0.0160 | -0.0920 |
| *(No children)* | | (0.18) | (0.96) |
| | 2 Children | -0.0828 | -0.1204 |
| | | (1.02) | (1.49) |
| | 3 or more children | -0.1620** | -0.1653** |
| | | (2.06) | (2.24) |

**Table 2: OLS Regressions *(Continued)*/ Dependent Variable 'life satisfaction'**

| Variable Name | | Model 1 | Model 2 |
|---|---|---|---|
| Household tenure *(Own Outright)* | Own with a mortgage | -0.0061 (0.10) | 0.0149 (0.25) |
| | Rent privately | 0.0309 (0.30) | 0.0100 (0.08) |
| | Public housing | -0.4379*** (4.81) | -0.3594*** (3.52) |
| Respondent is a carer | | 0.2632* (1.73) | 0.2371* (1.91) |
| Dublin dummy variable | | -0.6222*** (11.43) | -0.2434 (0.78) |
| **Spatial Variables** | | **No** | **Yes** |
| Climate Variables | Precipitation | | -0.0003 (1.05) |
| | Wind speed | | -0.2459** (2.13) |
| | January minimum temperature | | 0.5558*** (3.19) |
| | July maximum temperature | | 0.0543*** (3.77) |
| | Average annual sunshine (hours) | | -0.0011* (1.74) |
| Average commuting time | | | 0.0034 (0.41) |
| Population density | | | 0.0038 (1.63) |
| Congestion | | | -0.0001 (1.36) |
| Homicide rate | | | 0.0501 (1.06) |
| Voter turnout | | | 0.0124** (2.12) |
| Proximity to landfill *(More than ten kilometres)* | Contains a landfill | | -0.3736* (1.90) |
| | Within three kilometres | | 0.2646 (1.32) |
| | Between three and five kilometres | | 0.2564 (1.05) |
| | Between five and ten kilometres | | -0.1346 (1.07) |
| Proximity to hazardous waste facility *(More than ten kilometres)* | Contains a hazardous waste facility | | -0.2068 (0.47) |
| | Within three kilometres | | -0.1715 (0.64) |
| | Between three and five kilometres | | -0.2998 (1.03) |
| | Between five and ten kilometres | | -0.1560 (0.66) |

**Table 2: OLS Regressions *(Continued)*/ Dependent Variable 'life satisfaction'**

| Variable Name | | Model 1 | Model 2 |
|---|---|---|---|
| Proximity to coast *(More than five kilometres)* | Within two kilometres | | 0.8351*** (4.32) |
| | Two to five kilometres | | 0.2271 (1.51) |
| Proximity to beach (*more than ten kilometres*) | Within five kilometres | | -0.1607 (0.73) |
| | Between five and ten kilometres | | -0.0923 (0.42) |
| Proximity to rail station (*more than ten kilometres*) | Within two kilometres | | -0.1705 (1.07) |
| | Between two and five kilometres | | -0.2271 (1.22) |
| | Between five and ten kilometres | | -0.0142 (0.07) |
| Proximity to airport (*more than sixty kilometres*) | | | |
| Regional | Within thirty kilometres | | 0.8329*** (2.78) |
| | Between thirty and sixty kilometres | | 0.0284 (0.21) |
| National | Within thirty kilometres | | 0.0721 (0.28) |
| | Between thirty and sixty kilometres | | 0.3383 (1.44) |
| International | Within thirty kilometres | | 0.2603 (1.30) |
| | Between thirty and sixty kilometres | | 0.3851** (2.18) |
| Proximity to major road (*more than five kilometres*) | Contains a major road | | -0.3703* (1.83) |
| | Within five kilometres | | -0.3543 (1.62) |
| Proximity to sea ports (*more than five kilometres*) | Within three kilometres | | -0.3887 (1.42) |
| | Between three and five kilometres | | 0.0019 (0.01) |
| | Between five and ten kilometres | | 0.2054 (0.75) |
| Number of Observations | | 1467 | 1451 |
| Adjusted $R^2$ | | 0.21 | 0.33 |

*Note 1*: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

*Note 2*: t-statistics in parentheses computed using White's Heteroskedasticity estimator

**Appendix I - GIS mapping**

**Fig 1: Surveyed electoral divisions**

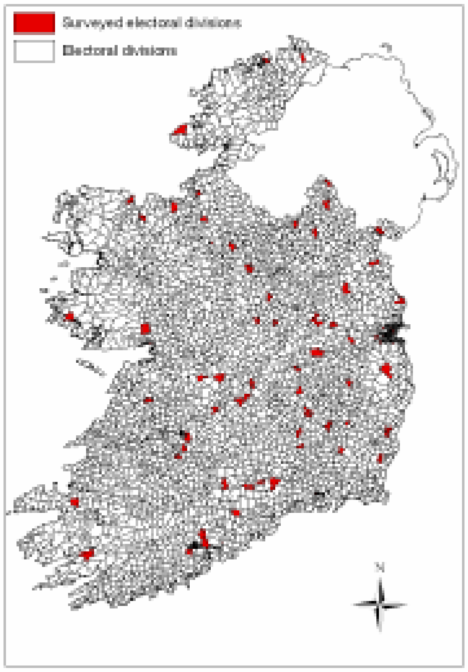



**Fig 2: Surveyed electoral divisions in Dublin City**

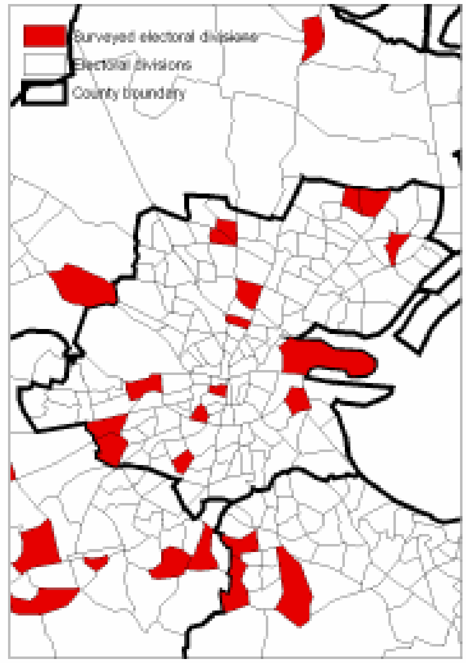



**Fig 3: Average Well-being by Local Authority Area (seven point scale, 1 – 7)**

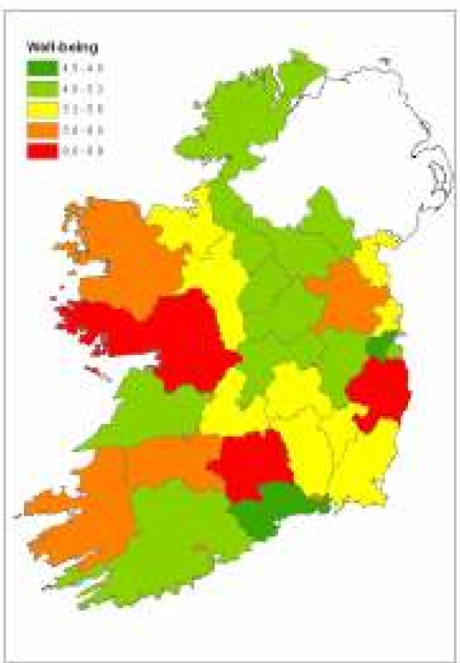



**Fig 4: Transport Infrastructure**

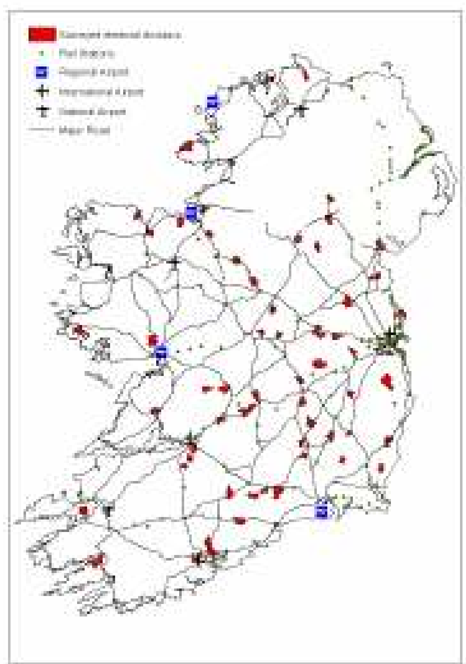


**Fig 5: Location of Waste Facilities**

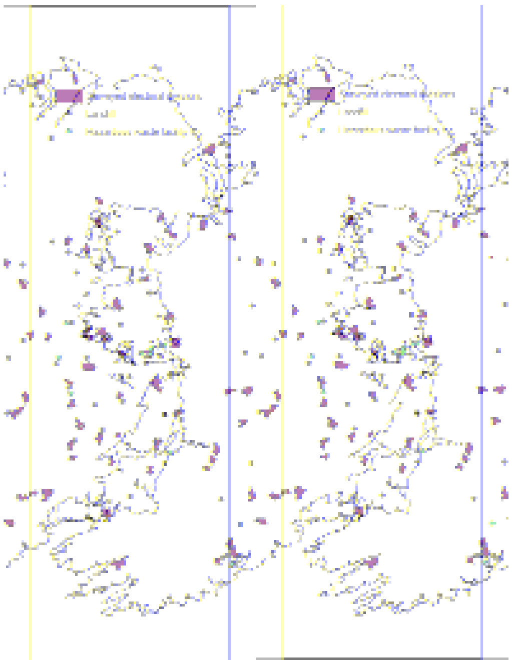


**Fig 6: Blue Flag Beaches and Marinas**

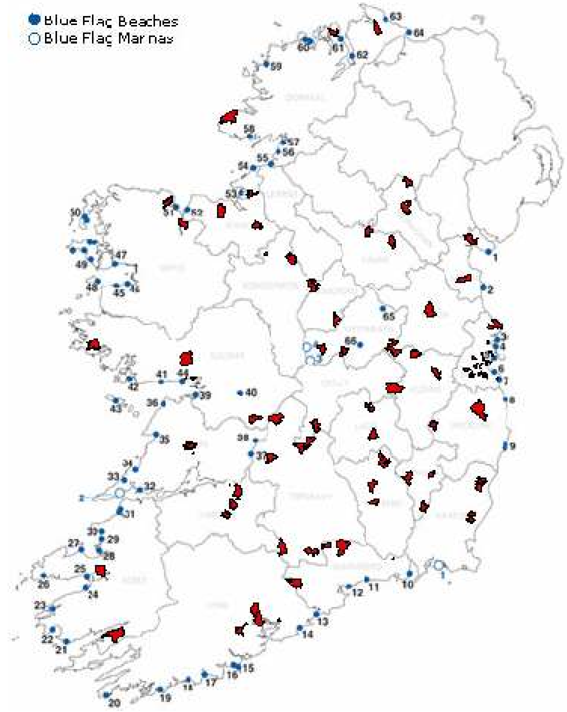



**Fig 7: Average Annual Rainfall**

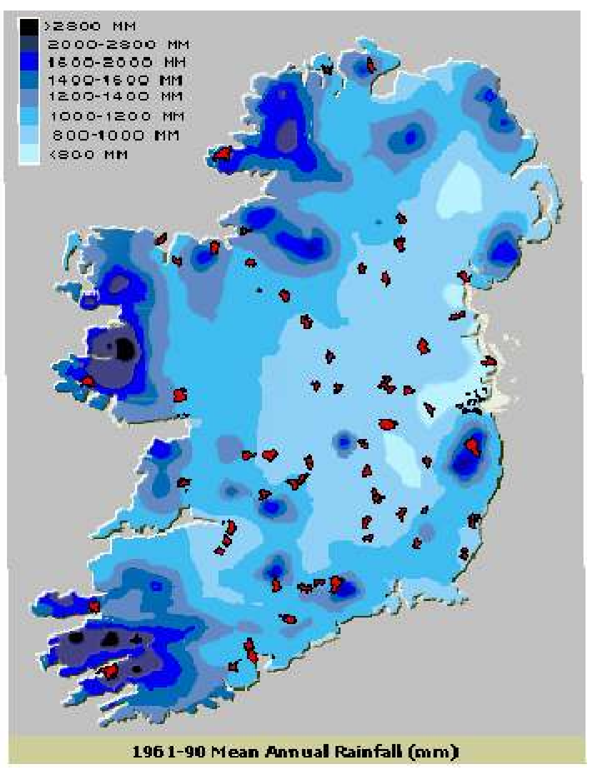



**Fig 8: Average Annual Sunshine**

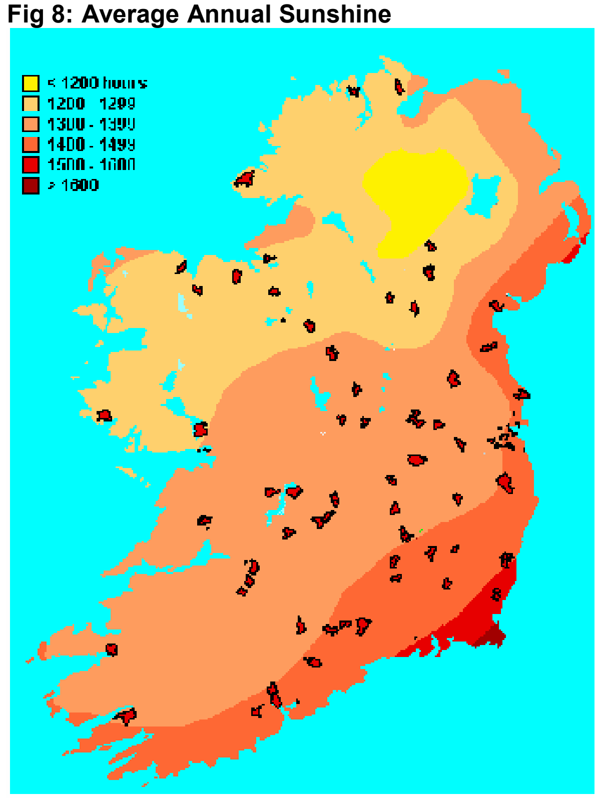


**Fig 9: Mean Daily July Temperature**

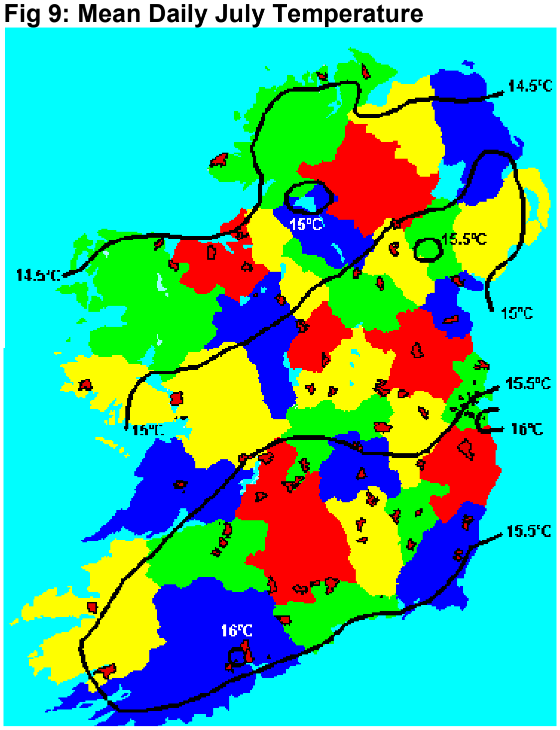



**Fig 10: Mean Daily January Temperature**

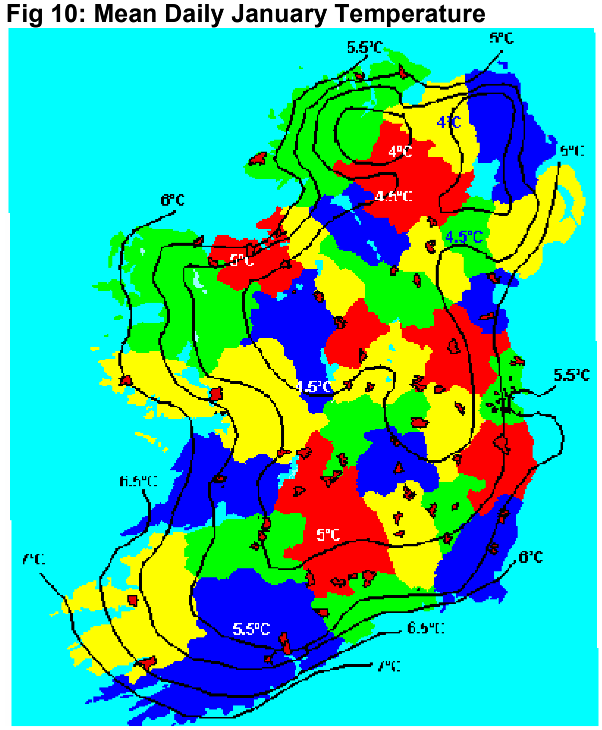
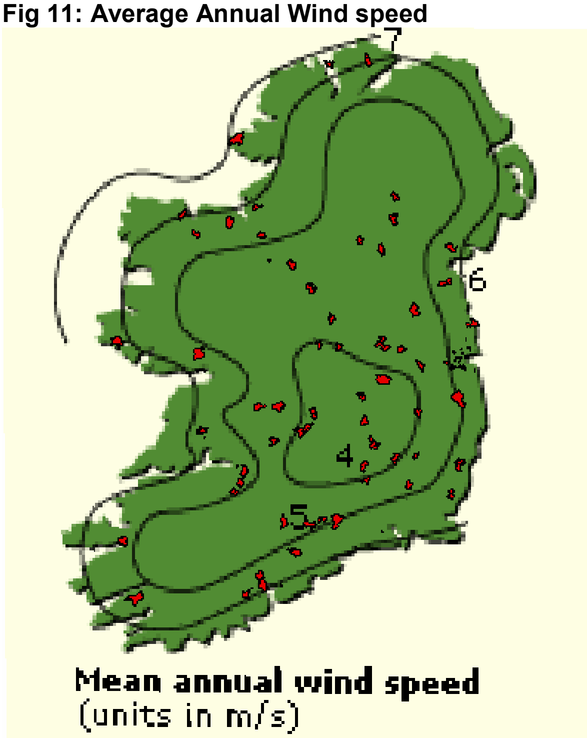



**Fig 11: Average Annual Wind speed**




**Figures 1 to 3**
Data source: Urban Institute Ireland
Base maps: © Ordnance Survey Ireland/ Government of Ireland Copyright Permit No. MP001106

**Figure 4**
Data source: Urban Institute Ireland and National Roads Authority
Base maps: © Ordnance Survey Ireland/ Government of Ireland Copyright Permit No. MP001106

**Figures 5 and 6**
Data source: Urban Institute Ireland and Environmental Protection Agency
Base maps: © Ordnance Survey Ireland/ Government of Ireland Copyright Permit No. MP001106

**Figures 7 to 11**
Data source: Met Eireann
Base maps: © Ordnance Survey Ireland/ Government of Ireland Copyright Permit No. MP001106

## Appendix II

### Variable Listing and Descriptive Statistics

**Table A1: Variable Listing – Socio-economic and socio-demographic variables**

| Variable Name | | Description | Type |
|---|---|---|---|
| Self-reported well-being | | Thinking about the good and bad things in your life, can you say which of these answers best describes your life as a whole? Answers range from 'as good as can be' to 'as bad as can be'. | Discrete (1-7) |
| **Socio economic and demographic variables** | | | |
| Age | | Age of respondent | Continuous |
| Age Squared | | Age of respondent squared | Continuous |
| Gender | | Male/ female | Dummy |
| Employment status | | | |
| | Self-employed | Respondent is self-employed | Dummy |
| | Retired | Respondent is retired | Dummy |
| | Engaged in home duties | Respondent is a homemaker | Dummy |
| | Student | Respondent is in full-time education | Dummy |
| | Seeking work for 1st time | Respondent is seeking work for the 1st time | Dummy |
| | Unemployed | Consists of those not working, seeking work and those unemployed having lost or given up their job | Dummy |
| | Not working, not seeking work | Respondent is not working, not seeking work | Dummy |
| | Working full-time | Respondent works full-time | Dummy |
| | Working part-time | Respondent works part-time | Dummy |
| | Government Scheme | Respondent is on a government training/ education/ employment scheme | Dummy |
| | Permanently unable to work | Respondent is unable to work due to permanently illness or disability | Dummy |
| Education | | | |
| | *Primary* | Respondent has just primary (no secondary) education | Dummy |
| | Lower Secondary | Respondent has a lower secondary education (Junior/ group/inter) | Dummy |
| | Upper Secondary | Respondent has a technical or vocational qualification, or the leaving certificate or both of these. | Dummy |
| | Third level | Consists of non-degree, primary degree, professional qualification, both of these and post graduate degree | Dummy |
| Health | | | |
| | *0-1 doctor visits* | In past year, respondent has visited doctor never or once | Dummy |
| | 2-5 doctor visits | In past year, respondent has visited doctor 2 to 5 times | Dummy |
| | 6 or more doctor visits | In past year, respondent has visited doctor 6 or more times | Dummy |

**Table A1: Variable Listing *(cont.)***

| **Variable Name** | **Description** | **Type** |
|---|---|---|
| Income | | |
| Log Income | Gross household income/ 1000 | Continuous |
| Marital Status | | |
| *Single* | Respondent is single (never married) | Dummy |
| Married | Respondent is married | Dummy |
| Cohabiting | Respondent is cohabiting | Dummy |
| Separated/ Divorced | Respondent is separated/ divorced | Dummy |
| Widowed | Respondent is widowed | Dummy |
| Number of dependent children | | |
| *No Children* | Respondent has no dependent children | Dummy |
| 1 child | Respondent has 1 dependent child | Dummy |
| 2 children | Respondent has 2 dependent children | Dummy |
| 3 or more children | Respondent has 3 or more dependent children | Dummy |
| Caregiver | Respondent is the care giver of a family member with a disability | Dummy |
| Dublin dummy variable | Respondent lives in one of the four Dublin local authority areas | Dummy |

**Table A2: Descriptive Statistics - Dummy variables**

| Variable | n | Percent |
|---|---|---|
| **Well-being** | | |
| As good as can be | 209 | 14 |
| Very good | 547 | 37 |
| Good | 488 | 33 |
| Alright | 197 | 13.3 |
| Bad | 26 | 1.8 |
| Very bad | 4 | 0.3 |
| As bad as can be | 3 | 0.2 |
| **Gender** | | |
| Male | 718 | 47.9 |
| Female | 782 | 52.1 |
| **Marital Status** | | |
| Single (never married) | 518 | 35 |
| Married | 778 | 52 |
| Co-habiting | 36 | 2.5 |
| Separated or divorced | 45 | 3 |
| Widow | 100 | 7 |
| **Children** | | |
| No children | 927 | 62 |
| 1 child (all) | 123 | 8 |
| 3 or more children | 218 | 14.5 |
| **Employment Status** | | |
| Retired | 182 | 12.2 |
| Engaged in home duties | 303 | 20.4 |
| Student | 86 | 5.7 |
| Seeking work for 1st time | 12 | 1 |
| Unemployed | 41 | 2.7 |
| Not working, not seeking work | 7 | 0.5 |
| Full-time employed | 555 | 37.3 |
| Part-time employed | 114 | 7.6 |
| On a government training scheme | 16 | 1 |
| Disabled | 29 | 2 |
| Self employed | 133 | 9 |
| **Education** | | |
| Primary | 204 | 14 |
| Lower secondary | 279 | 18.6 |
| Upper secondary | 704 | 47 |
| Degree | 259 | 17.3 |
| **Health (Doctor visits)** | | |
| Never or once | 855 | 57 |
| Two to five times | 502 | 33 |
| Six or more times | 146 | 10 |
| **Tenure** | | |
| Own outright | 621 | 42 |
| Own with a mortgage | 535 | 36 |
| Rent Privately | 106 | 7 |
| Rent from the local authority | 198 | 13 |
| **Other** | | |
| Caregiver | 36 | 2.5 |

**Geographical and Environmental Variables**

**Table A3: Variable Listing – Environmental variables**

| **Variable Name** | | **Description** | **String** |
|---|---|---|---|
| **Environmental Variables** | | | |
| Climate | Precipitation | Rain fall measured as mm/year | Continuous |
| | Wind | Mean annual wind speed at 10 meters above ground level | Continuous |
| | January Minimum temperature | Air temperature in degrees Celsius | Continuous |
| | January Minimum temperature | Air temperature in degrees Celsius | Continuous |
| | Average Annual Sunshine | Mean annual total duration of bright sunshine, hours/ day | Continuous |
| Waste facilities | | Number of waste facilities in the respondents electoral division area per 100,000 of the population | Continuous |
| Average commuting time | | Measured as the average commuting time in the electoral division area in 2002. | Continuous |
| Respondent lives near the coast | | 1 if respondent lives in an electoral division area which lies on the coast, 0 otherwise | Dummy |
| Population density | | Measured as total population in the electoral division divided by total area in $km^2$ | Continuous |
| Congestion | | Measured as the average number of vehicles in the local authority area divided by the national road length | Continuous |
| Homicide rate | | Number of homicides in the respondents local authority area per 100,000 of the population | Continuous |

**Table A4: Variable Listing – Environmental variables *(cont.)***

| Variable Name | | Description | String |
|---|---|---|---|
| **Disaggregated environmental variables** | | | |
| Proximity to landfill | Contains a landfill | Respondent lives in an electoral division which contains a landfill. | Dummy |
| | Within three kilometres | Respondent lives in an electoral division which is within three kilometres of a landfill. | Dummy |
| | Between three and five kilometres | Respondent lives in an electoral division which is between three and five kilometres from a landfill. | Dummy |
| | Between five and ten kilometres | Respondent lives in an electoral division which is between five and ten kilometres from a landfill. | Dummy |
| | More than ten kilometres | Respondent lives in an electoral division which is more than ten kilometres from a landfill. | Dummy |
| Proximity to hazardous waste facility | Contains a hazardous waste facility | Respondent lives in an electoral division which contains a hazardous waste facility. | Dummy |
| | Within three kilometres | Respondent lives in an electoral division which is within three kilometres of a hazardous waste facility. | Dummy |
| | Between three and five kilometres | Respondent lives in an electoral division which is between three and five kilometres from a hazardous waste facility. | Dummy |
| | Between five and ten kilometres | Respondent lives in an electoral division which is between five and ten kilometres from a hazardous waste facility. | Dummy |
| | More than ten kilometres | Respondent lives in an electoral division which is more than ten kilometres from a hazardous waste facility. | Dummy |
| Proximity to coast | Within two kilometres | Respondent lives in an electoral division which is within two kilometres of the coast. | Dummy |
| | Two to five kilometres | Respondent lives in an electoral division which is between two and five kilometres from the coast. | Dummy |
| | More than five kilometres | Respondent lives in an electoral division which is more than five kilometres from the coast. | Dummy |
| Proximity to beach | Within five kilometres | Respondent lives in an electoral division which is within five kilometres of a beach. | Dummy |
| | Between five and ten kilometres | Respondent lives in an electoral division which is between five and ten kilometres from a beach. | Dummy |
| | More than ten kilometres | Respondent lives in an electoral division which is more than ten kilometres from a beach. | Dummy |
| Proximity to rail station | Within two kilometres | Respondent lives in an electoral division which is within two kilometres of a rail station. | Dummy |
| | Between two and five kilometres | Respondent lives in an electoral division which is between two and five kilometres from a rail station. | Dummy |
| | Between five and ten kilometres | Respondent lives in an electoral division which is between five and ten kilometres from rail station. | Dummy |
| | More than ten kilometres | Respondent lives in an electoral division which is more than ten kilometres from a rail station. | Dummy |
| Proximity to major road | Contains a major road | Respondent lives in an electoral division which contains a major road. | Dummy |
| | Within five kilometres | Respondent lives in an electoral division which is within five kilometres of a major road. | Dummy |
| | More than five kilometres | Respondent lives in an electoral division which is more than five kilometres of a major road. | Dummy |

**Table A5: Variable Listing – Environmental variables *(cont.)***

| Variable Name | | Description | String |
|---|---|---|---|
| **Disaggregated environmental variables** | | | |
| Proximity to Airport | | | |
| International | Within thirty kilometres | Respondent lives in an electoral division which is within thirty kilometres of an international airport. | Dummy |
| | Between thirty and sixty kilometres | Respondent lives in an electoral division which is between thirty and sixty kilometres from an international airport. | Dummy |
| | More than sixty kilometres | Respondent lives in an electoral division which is more than sixty kilometres from an international airport. | Dummy |
| National | Within thirty kilometres | Respondent lives in an electoral division which is within thirty kilometres of a national airport. | Dummy |
| | Between thirty and sixty kilometres | Respondent lives in an electoral division which is between thirty and sixty kilometres from a national airport. | Dummy |
| | More than sixty kilometres | Respondent lives in an electoral division which is more than sixty kilometres from a national airport. | Dummy |
| Regional | Within thirty kilometres | Respondent lives in an electoral division which is within thirty kilometres of a regional airport. | Dummy |
| | Between thirty and sixty kilometres | Respondent lives in an electoral division which is between thirty and sixty kilometres from a regional airport. | Dummy |
| | More than sixty kilometres | Respondent lives in an electoral division which is more than sixty kilometres from a regional airport. | Dummy |
| Proximity to seaport | Within three kilometres | Respondent lives in an electoral division which is within three kilometres of a seaport. | Dummy |
| | Between three and five kilometres | Respondent lives in an electoral division which is more than five kilometres of a seaport. | Dummy |
| | Between five and ten kilometres | Respondent lives in an electoral division which is between five and ten kilometres from a seaport. | Dummy |
| | More than ten kilometres | Respondent lives in an electoral division which is within ten kilometres of a seaport. | Dummy |

**Table A6: Descriptive Statistics - Location-specific and other continuous variables**

| Variable | Observations | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| January minimum temperature (degrees Celsius) | 1480 | 2.35 | 0.5892 | 1.5 | 4 |
| July maximum temperature (degrees Celsius) | 1448 | 19.24 | 0.744 | 17 | 20 |
| Precipitation (mm) | 1480 | 1000.54 | 244.09 | 700 | 2000 |
| Wind speed | 1480 | 5.68 | 0.7479 | 4 | 7 |
| Mean annual sunshine (hours) | 1480 | 1391.55 | 90.76 | 1200 | 1500 |
| Mean daily sunshine (hours) | 1480 | 3.73 | 0.2241 | 3.25 | 4.25 |
| Population density | 1480 | 13.60 | 24.107 | 0.013 | 149.95 |
| Total Population | 1480 | 2039.95 | 2073.69 | 47 | 8595 |
| Average commuting time (minutes) | 1480 | 26.54 | 7.36 | 13.96 | 45.56 |
| Congestion | 1494 | 1260.42 | 1406.59 | 41.42 | 4963.11 |
| Waste facilities (per 100,000 of the population) | 1500 | 3.19 | 1.92 | 0 | 7.07 |
| Homicide rate | 1494 | 1.52 | 1.41 | 0 | 5.42 |
| Age | 1492 | 43.6 | 17.1 | 18 | 90 |
| Income | 1497 | 22986 | 11643 | 1852 | 57138 |

**Correlation coefficients**

**Table A7: Environmental Variables – Correlation Coefficients**

| | Homicide rate | Waste facilities | Total population | Congestion | Population density | Average commuting time | Coast |
|---|---|---|---|---|---|---|---|
| Homicide rate | - | -0.3942 | 0.4294 | 0.2771 | 0.0875 | | -0.1287 |
| Waste facilities | | - | -0.11 71 | -0.4087 | -0.2703 | -0.0092 | -0.0103 |
| Total population | | | - | 0.2726 | 0.3597 | 0.2347 | -0.1882 |
| Congestion | | | | - | 0.4779 | 0.0879 | 0.2260 |
| Population density | | | | | - | 0.0791 | -0.1082 |
| Average commuting time | | | | | | - | -0.1566 |
| Coast | | | | | | | - |

**Table A8: Climatic Variables – Correlation Coefficients**

| | Driving rain | Wind | Mean annual sunshine | Annual Precipitation | July maximum temperature | January minimum temperature | Mean Daily Sunshine |
|---|---|---|---|---|---|---|---|
| Driving rain | - | 0.5505 | 0.1162 | 0.8231 | 0.0560 | 0.5227 | 0.1516 |
| Wind | | - | 0.7046 | 0.3867 | 0.2913 | 0.7132 | 0.7268 |
| Mean annual sunshine | | | - | 0.2146 | 0.5560 | 0.5044 | 0.9699 |
| Annual Precipitation | | | | - | 0.1912 | 0.5519 | 0.2286 |
| July maximum temperature | | | | | - | 0.1695 | 0.5522 |
| January minimum temperature | | | | | | - | 0.5152 |
| Mean Daily sunshine | | | | | | | - |

**Table A9: Environmental/ Climatic Variables Correlations**

| | Total population | Congestion | Population density | Average commuting time | Waste facilities |
|---|---|---|---|---|---|
| Driving rain | -0.3307 | -0.2938 | -0.2889 | 0.1368 | 0.3135 |
| Wind | 0.1215 | 0.2041 | 0.2002 | 0.1821 | -0.0139 |
| Mean sunshine | 0.3201 | 0.2549 | 0.3069 | 0.4449 | -0.0989 |
| Annual Precipitation | -0.2288 | -0.3037 | -0.2533 | -0.0018 | 0.1774 |
| July maximum temperature | 0.1231 | 0.1101 | -0.0290 | 0.3097 | -0.0242 |
| January minimum temperature | -0.0070 | 0.2524 | 0.2243 | 0.0879 | -0.0986 |
| Mean Daily Sunshine | 0.2824 | 0.2106 | 0.2520 | 0.4218 | -0.0482 |