



A GIS-based exploration of the relationships between human health, social deprivation and ecosystem services: The case of Wales, UK



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Being able to analyse the relationships between people and nature has always been of key interest to ecosystems conservation, planning decisions and in a number of disciplines of natural and social sciences. In this framework, it is of paramount importance to evaluate possible correlations between factors such as ecosystem services, human health, and social deprivation. The present study aims at exploring relationships between ecosystem services, human health, and social deprivation for the region of Wales in the United Kingdom. Wales is of special interest because as a region it offers many 'green' ecosystems which have already been found to have a positive influence on humans' well-being as well as on socio-economic status. First, a recreational layer showing the size and location of all potential recreational areas in each Welsh local authority was created. Subsequently, correlation/regression analysis and weighted raster analysis were performed which allowed determining quantitatively the degree of correlation between the observed socio-economic factors and recreational areas.

The findings of this exploratory study suggested that the relative size of potential recreational area varies widely within the local authorities comprising Wales. Not all the socio-economic factors which were examined herein found to be correlated with recreational areas. Some variables, such as income and employment deprivation showed high correlations with poor recreation options. Very poor correlation was also reported between recreation options and variables such as life expectancy and long-term illness. Our results, in agreement to previous studies conducted elsewhere, suggested that human health is determined by a complex interplay of more than one of the observed determinants, including for example biology and genetics or living and working conditions. As to our knowledge there are no prior research studies on the topic for our study region, this work provides a key contribution concerning the determination of a "social" value of ecosystems in the context of human health and other socio-economic factors. However, as these are only initial results, further work is required to verify those.

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Introduction

Ecosystems are the basis for human life and human activity on Earth. The goods and services delivered by ecosystems include food, water, fibre, soil formation, plant pollination etc. (European Union, 2011). As the world population continues to grow and is getting wealthier, healthier, and better educated in many parts of the world, the demand for these services has been increasing. In order to live up to this growing need, humans engaged in various activities, some of which resulting to disturbance of biological diversity, an example being the over-exploitation and unsustainable use of natural resources or the invasion of alien species in different ecosystems (World Bank, 2009).

The combination of all these factors is of key importance to understanding the biodiversity loss which stands in direct correlation to the damage of global ecosystem services. In the past the importance of ecosystems had not been sufficiently considered (European Union, 2011). On the contrary, ecosystem services were regarded as public property and therefore their value was not appreciated. As a result, ecosystems have changed during the last 50 years more rapidly and extensively than in any period before. At present, it is estimated that about 60% of ecosystem services are being degraded which includes for example species loss, deforestation, and spreading diseases (Millennium Ecosystem Assessment, 2005). To be informed about their current condition and possible degradation, it is very important to monitor ecosystem services. Such information can lead to better decision making on ecosystem services conservation and their delivery. Furthermore, it can help in identifying services affected by land use management decisions,

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which in turn can potentially help spreading the costs and benefits more fairly among stakeholders (CCI and BirdLife International, 2011).

This ecosystem degradation is influencing business because many economic sectors, such as agriculture, forestry, or fisheries depend on ecosystem services. Consequently, socio-economic factors, such as income or employment status are also linked to ecosystem services and their degradation. However, there are many different ways in which socio-economic data is correlated to ecological systems and the natural environment of people. In general, the integration of socio-economic data into environmental spatial data is always challenging because it involves merging insights from a range of disciplines and types of data sources. Nevertheless, it is very important with regard to policy-making and ecosystem management. Knowing which ecosystem is more 'important' than others for a certain development, helps in identifying appropriate strategies for a sustainable management of the corresponding services (Goldman, 2010).

In general, the spatial information, provided for example by Earth Observation (EO) technology, plays an increasingly important role in monitoring and mapping ecosystem services. In the last thirty years, the advancements in this technology has evolved considerably, which has in turn lead for example to reduction in data cost, an increased resolution and higher storage capacity of satellite imageries. Therefore, remote sensing became to a valuable source of spatial information including ecosystem services data. Current EO-based technologies make it possible to analyse and collect data acquired at different scales of observations with linkages to Geographical Information Systems (GIS) layers and functions (Rogan & Chen, 2004; Gupta & Srivastava, 2010; Patel, Gajjar & Srivastava, 2012). In the context of mapping ecosystem services, GIS can be used for the evaluation of spatial congruence with biodiversity, estimating costs/benefits, or the analysis of synergies and trade-offs between different ecosystem services (Maes et al., 2012). Examining these impacts of ecosystem services on human's well-being, is the basis for the implementation and management of policies to deliver plans, incorporating biodiversity and conservation. There are several studies using remote sensing data as well as GIS in the context of analysing man–environment relationship. For example, Krishna & Doppler (2004) developed within a GIS a methodological concept integrating socio-economic assessment with biophysical environment in order to evaluate both the rural resources and the livelihood development strategies within the study site Nepal. While the biophysical indicators were assessed using remote sensing data, the socio-economic conditions of the people were derived from micro-level surveys with in-depth interviews. So it was possible for the authors to examine the relationship between watershed degradation and the people's socio-economic conditions for their case study Nepal. Another example linking socio-economic data with GIS and remote sensing in the context of ecosystems is the study of Rahman, Netzbund, Singh, and Mallick (2009). Using these geospatial tools, authors were able to assess the demographic profile for their study site Delhi, as well as different kinds of environment related factors, such as the land use and the temperature variations. The authors could combine these factors and determine a spatial pattern of solid waste generation and pollution problems in terms of waste water, air, and noise.

The present exploratory study aims at investigating the spatial relationships of health and social deprivation to ecosystem services for Wales. The objective of this work is two-fold: in one hand, to explore possible relationships between human health, social deprivation and recreational areas using GIS analysis; on the other, to provide possible explanations of the occurrence of those relationships where existed. To our knowledge, there are no prior

research studies focussing in addressing these specific objectives particularly so in the geographical region of Wales.

Wales was chosen as case study within the United Kingdom (UK) because it offers many 'green' ecosystems within its boundaries. This characteristic allows exploring to what degree residents of Wales with a greater exposure to green spaces/recreational areas are more likely to be less deprived than those residents with little exposure to such areas within Wales. From all the set of possible ecosystem services, this study is focused "specifically on "recreation" and "health", belonging to the subgroup "cultural services" of the definition introduced by the Millennium Ecosystem Assessment (MEA, 2005). These variables deemed to be of key special interest, as the increasing number of people, leisure time, and affluence, makes it most likely that the demand for recreation in natural areas and cultivated landscapes will continue to grow. In addition, the socio-economic factors on which this study was focussed lied exclusively on social deprivation and associated issues, such as income and employment status. This decision was made on the basis of former studies conducted in other regions (e.g. Lachman & Weaver, 1998), reporting that health and recreation are in direct correlation to the social status/class of people.

Background

Ecosystem services

According to the Convention for Biological Diversity (Convention on Biological Diversity, 2013) "ecosystem means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit". In doing so, they provide many goods (e.g. food, water, fibre) and services (like carbon sequestration, water purification) for humans and animals. These "benefits people obtain from ecosystems" are called *ecosystem services*. While scientific literature provides a number of different typologies for categorising the numerous types of goods and services (e.g. see recent review by Seppelt, Dormann, Eppink, Lautenbach, & Schmidt, 2011), all classifications have in common that they are defined by human activities and demands. In the present study, the Millennium Ecosystem Assessment (MEA) classification of ecosystem services was decided to be adopted, as that is regarded as one of the most widely accepted classifications of ecosystem services today (Department for Environment, Food, and Rural Affairs, 2007).

In brief, MEA distinguishes between different types of services namely: i) *supporting services* which provide the basic infrastructure for life on Earth, including the formation of soil, and primary production of materials for all other services; ii) *regulating services* that are the benefits accruing to humankind through the regulation of ecological processes by ecosystems. They maintain the environment in a fit condition for human habitation, for example by climate, flood, or disease regulation. Furthermore there is a distinction between iii) *provisioning services* that provide food, water, energy, materials for building and clothing, and plants for medicines and iv) *cultural services*, the "non-material benefits derived from environmental settings".

Human health

According to World Health Organization (WHO) 'health' is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2003). This is still the most cited and accepted definition of 'health', although it should be noted that some critics argue that this definition is unrealistic and inflexible. They base their reasoning on the fact that the word 'complete' indicates a condition of health which is very

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