Development of Statistical Methods for Composite Environmental Quality Indices at Data Zone Resolution.

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Abstract

The principal objective of this thesis is to develop methods for composite indices measuring environmental quality at small spatial scales. Specifically, it is of interest to create a composite environmental quality index at data zone resolution in Greater Glasgow, where data zones are small geographical areas defined by the Scottish Government and used to report various statistics and indicators. The index will consist of various indicators measuring different aspects of environmental quality, being grouped into three 'domains': air quality, soil quality and water quality. Composite indices are multidimensional summaries of data, constructed from a number of one-dimensional indicators measuring one variable each. This is primarily achieved through converting the scales of these individual indicators to a common, unit-less scale and then aggregating the indicators together to form a composite index. Each indicator can be allocated an equal weighting within the composite index or weightings can be allowed to vary. Various subjective choices throughout the construction process can affect a composite index, all of which must be considered when interpreting the final result. Chapter 1 provides background information on environmental issues such as air, soil and water quality in urban areas and the use of composite indices in several contexts, particularly in environmental situations. A literature review of composite index construction methodology is also presented with much of the methodology informing the work of later chapters. Chapter 2 introduces the various data sets that will be used to construct a composite environmental quality index for Greater Glasgow. Exploratory spatial and temporal analyses of these data will also be detailed prior to any formal statistical modelling. Chapter 3 discusses the fitting of geostatistical models to the data. These models will then be used to predict the various environmental processes at a high enough spatial resolution for there to be estimated values for each data zone in the study region. Chapter 4 details how the modelled data from Chapter 3 will be used to construct separate air, soil and water quality indices and then aggregating these domains to create a general, multi-dimensional environmental quality index. A variety of different methods found in the literature will be used and the indices will be reported at data zone resolution. Chapter 5 will assess the composite indices constructed in Chapter 4 by investigating possible methods for determining the robustness and usefulness of the indices. Firstly, an uncertainty analysis of the various indices will be considered to quantify how much statistical variability would be expected for each data zone. Various approaches for assessing how the index can effectively capture changes in environmental quality over time will then be investigated. This will be restricted to a period of five years. Chapter 6 consists of a final discussion of the results presented in this thesis as well as providing suggestions for any further work in this area.