Chapter 34
Urban Environmental Applications of GIScience:
Challenges and New Trends

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ABSTRACT

Geographic Information Systems (GIS) are computer-based systems used to store and manipulate geographical data, and perform spatial analysis. These systems serve to reveal the patterns, relationships, and anomalies, or sometimes invisible characteristics of the geographical data in various applications. While the term "GIS" indicates an object or tool, GIScience, the acronym for Geographic Information Science, covers a broader context of methodologies behind spatial data analysis. Among different application areas of GIS, "environmental monitoring and modeling" plays a significant role in the development of the very first GIS in the world-The Canada Geographic Information Systems (CGIS) in the mid-1960s. After almost 40 years of history, significant changes and challenges took place in the geographic information research agenda. This chapter will point out some of the vital tools and methods used in GIScience (including GIS, remote sensing and 3D modeling) to grasp issues of our urban environments. With recent technological advances that facilitate our understanding of the environment; it is more evident that the vision of more "livable" cities is not too far but not easy as well.

INTRODUCTION

In identifying major causes of environmental problems, one should keep in mind that life on planet Earth involves complex interrelationships between living things: land, ocean water and fresh water, and the atmosphere. The effects of human activity on Earth are now so extensive that global (not just local) environmental change is under way and no one is entirely sure how these interrelationships will evolve. What is certain, however, is that because human actions are changing the environment at the global level, new ways of thinking about and understanding the Earth and its systems with a global perspective are strongly needed. Furthermore, the livability

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and quality of the urban world, and the balance between economic development and urbanization will be important foci in future sustainable urban environments. Although the application and operational tools of sustainability to the cities have been questionable since the last decades (Newman, 1999), there are also technological advances which helps to re-count on the measurement of urban environmental sustainability.

To understand and quantify urban sustainability, researchers including ecologists, environmentalists and urban planners have used Geographic Information Science (GIScience) since the late 1960s. Michael Goodchild was the first to use the term *GIScience* in a paper where he argued that geographic problems were important and different than other questions and hence required a systematic study in a science in its own (Goodchild, 1992). According to him, fundamental issues raised by the use of Geographic Information Systems (GIS) and related technologies, Remote Sensing (RS) and Geomatics should be covered by a geographic scientific approach. Within this approach, the tools of GIScience cope with the issues related to the geo-spatial information where spatial relations need to be analyzed and interpreted. According to Goodchild (2008), GIScience is defined at the core of a triangle through three major concepts: the individual, the computer and the society. The main reason of labeling this approach as "science" is based on the interaction between these three corners of the triangle. Being dominated by the cognitive science, the concern for understanding the individual's spatial relations and learning and reasoning about geographic data could be handled with computers. While research about the computer would be carried out through the issues of representation, the invention of new technologies and adaptation; the research about society would deal with the concepts of impacts and societal context. For these reasons, it is clear that the research agenda of GIScience is a complex and diverse approach that wraps the issues of society, technology and human cognition. Since it is recognized as "science," some of the key characteristics of many spatial sciences are also observed for GIScience. As Longley *et all*. (2005) discusses, there are three bases for classifying geographic problems: first is the nature of the geographic data – *scale* or *geographic detail*. For example, Hungary declared a state of emergency in three counties on the 5th of October 2010 after a torrent of toxic sludge from an alumina plant tore through three villages 160 km (100 miles) west of Budapest. As the effects of the pollution could be observed through European drainage system, this problem should be analyzed at a much broader and coarser regional scale. On the other hand, in case of an emergency analysis in a building, requires local information such as parcel size and shape, entrances, height and age of the building etc.

Second, the *intent* or *purpose* of the problems differentiates the geographic problems from others. In case of environmental actions, some problems should be solved as soon as possible to eliminate all types of costs, cope with emergency or achieve practical objectives. For the flood risky areas, an updated monitoring model of the illegal settlements is an immediate action type of geographic problem solving. In such cases, the intent is to *operate* before and after the environmental risk happens.

Third, as in other scientific problems, *tools* and *methods* are essential in practical problem solving. A significant characteristics of GIS as a tool for geographic problem solving lies in its capacity to integrate general scientific knowledge with specific information and results in practical values.

This chapter is devoted to analyze recent trends in urban environmental applications of GIS and to point out some challenges and future research. To this end, some case studies will be examined through different tools and methods used in GIScience such as remote sensing, spatial analysis and 3D modeling. The goals of applied problem solving in most of the cases will attempt to cover but not limited to: