Environmental Science

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Environmental Geoinformatics

Monitoring and Management

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Foreword

The title and subtitle of this textbook convey a distinct message. Monitoring—the passive part in the subtitle—refers to *observation* and *data acquisition*, whereas management—the active component—stands for *operation* and *performance*. The topic is our environment, which is intimately related to geoinformatics. The overall message is: all the mentioned elements do interact and must not be separated.

There are still other aspects which must not be separated: *theory* and *practice* of geoinformatics. The book presents an excellent balance of both fields. Technology is introduced from the Geodesist's view including; Reference Systems, Positioning Systems, Remote Sensing, Photogrammetry, and Geographic Information Systems. Applications range from Climate, Water, and Land Management to Vegetation, Disaster, and Pollution. Today, many textbooks are written by specialists from these particular fields. However, in the applications there are many common technical elements in space and time, like impact from scale, regionalization, time series, data fusion, visualization, etc.—just to mention but a few. An advanced prospect for environmental management requires system-based thinking and interdisciplinary approaches. Furthermore, technology may be a common denominator for better understanding our environment.

Finally, geoinformatics is a modern tool for location-based decision making. Most decisions in public administration and economy are directly or indirectly related to space. Today, advanced models and digital spatial data may make decisions more transparent than ever before. Very often, in geoprojects a lot of money is involved, and the risk of manipulation in decision making inevitably increases. Quantitative analysis and restitution of the results may, however, reduce this risk.

Both authors, Joseph L. Awange and John B. Kyalo Kiema, are experienced researchers and lecturers with a strong international background acquired from different parts of the world. During research fellowships in Germany, they got the picture that "geodesy" is a global concept beyond measuring just the figure of the Earth.

Germany, January 2013

Prof. Dr.-Ing. Dr.h.c.,
Hans-Peter Bähr
Karlsruhe Institute of Technology

Preface

There is no doubt that today, perhaps more than ever before, humanity faces a myriad of complex and demanding challenges. This has been propelled by the ever increasing global population and intense pressure being exerted on the Earth's resources. The resulting consequences are severe changes in land cover (e.g., forests giving way to settlements), diminishing biodiversity and natural habitats, dwindling fresh water supplies, and the degradation in the quality of the little that is available, and changing weather and climatic patterns, especially global warming with its associated predicted catastrophes such as rising sea level and increased numbers of extreme weather events.

These *human-induced* and *natural impacts* on the environment need to be well understood in order to develop *informed policies*, *decisions*, and *remedial measures* to mitigate current and future negative impacts. This can be achieved through continuous monitoring of the environment to acquire data that can be soundly and rigorously analyzed to provide information about the current state of the environment and its changing patterns, and to enable predictions of possible future impacts. Environmental monitoring techniques that may provide such information are under scrutiny from an increasingly environmentally conscious society that demands the efficient delivery of such information at a minimal cost. In addition, it is the nature of environmental changes that they vary both spatially and temporally, thereby putting pressure on traditional methods of data acquisition, some of which are very labor intensive, such as tracking animals for conservation purposes. With these challenges, conventional monitoring techniques, particularly those that record spatial changes, call for more sophisticated approaches that deliver the necessary information at an affordable cost.

Developing pragmatic and sustainable solutions to address these and many other similar challenges requires the use of geodata and the application of geoinformatics. Geoinformatics, defined by Ehlers (2003) as "the art, science or technology dealing with the acquisition, storage, processing, production, presentation and dissemination of geoinformation", is a multidisciplinary field. It has at its core different technologies that support the acquisition, analysis, and visualization of geodata. The geodata is usually acquired from Earth observation sensors as remotely sensed images, analyzed by geographic information systems (GIS), and visualized on paper or on computer screens. Furthermore, it combines

geospatial analysis and modeling, development of geospatial databases, information systems design, human–computer interaction, and both wired and wireless networking technologies. Geoinformatics uses geocomputation and geovisualization for analyzing geoinformation. Typical branches of geoinformatics include: *cartography*, *geodesy*, *geographic information systems*, *global navigation satellite systems* (*GNSS*), *photogrammetry*, *remote sensing*, *and web mapping*.

For example, a typical application of geoinformatics to environmental monitoring and management is the *GNSS-based radio telemetry*, which is a modern method for observing animal movements. This method moves the burden of making observations from the observer (i.e., researcher) to the observed (i.e., animal), and in so doing alleviates the difficulties associated with personal bias, animal reactions to human presence, and animal habits that make most of them secretive and unseen (Cagnacci et al. 2010). The method provides large, continuous, high-frequency data about animal movement, data which, if complemented by other information dealing with animal behavior, physiology, and the environment itself, contributes significantly to our knowledge of the behavior and ecological effects of animals, allowing the promotion of quantitative and mechanistic analysis (Cagnacci et al. 2010).

This book presents the concepts and applications of geoinformatics in environmental monitoring and management. We depart from the 4D to the 5D data paradigm, which defines geodata accurately, consistently, rapidly, and completely, in order to be useful without any restrictions in space, time, or scale to represent a truly global dimension of the digital Earth. The book also features the state-of-the-art discussion of Web GIS and mapping, an invited chapter written by Prof. Bert Veenendaal of the Department of Spatial Sciences, Curtin University (Australia).

The concepts and applications of geoinformatics presented in this book will be of benefit to decision makers across a wide range of fields, including those working in environmental management agencies, in the emergency services, public health and epidemiology, crime mapping, tourism industry, market analysis and e-commerce, or mineral exploration, among many others.

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