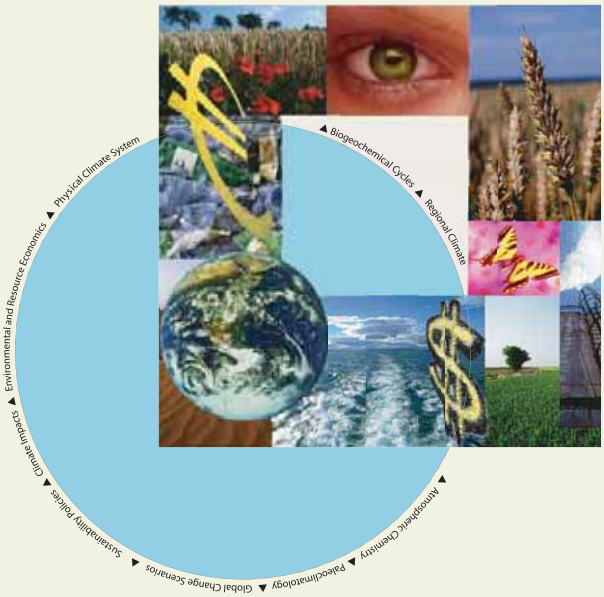
International Max Planck Research School on
EARTH SYSTEM MODELLING

GIS as integrating tool in Sustainability and Global Change

Christine Schleupner

PhD Thesis prepared within the
International Max Planck Research School on
Earth System Modelling



SUMMARY

Rapid land use changes and the impacts of climate change are seen as a major threat to biodiversity preservation and the supply of crucial ecosystem services to humanity. This thesis contributes to actual discussions of the direct and indirect impacts of climate change and climate mitigation politics to land use. It is divided into three parts:

The main topic of **Part one** is the evaluation of impact potentials to the coast of the Caribbean island Martinique caused by extreme weather events and sea level rise. The **first chapter** deals with the development of a GIS-based model for the island that evaluates the sensitivity of the coastal areas to erosion, flooding and inundation. This includes an analysis of the extension of the potential impact area. The results are illustrated in sensitivity and hazard area maps for the Martinique coast that serve as base for further vulnerability studies. In the **second chapter** the Martinique beaches and coastal wetlands are examined to identify the probability of coastal squeeze. In many cases coastal development prevents coasts from adapting to accelerated sea level rise by shifting landward. Also tourism infrastructure augments the probability of beach reduction and mangrove squeeze. On the mountainous island Martinique the majority of settlements and especially tourist hotels are built within the zone at risk to flooding and erosion. Spatial analysis based on a conducted GIS model is carried out that evaluates the tourist destinations most vulnerable to the impacts of sea level rise. If sea level rises and beach reduction becomes an increasing problem the attractiveness of Martinique beaches as tourist destination is likely to decline. **Chapter 3** deals with the evaluation of human vulnerability to accelerated sea level rise on the Martinique coast. In addition, the possible effects of sea level rise on the island are spatially assessed for future regional planning purposes. The actual situation and legislation measures for coastal zone management of the island are described and sea level rise response strategies are discussed. Even if saltwater intrusion and coastal erosion with increasing offshore loss of sediment are locally already a severe problem, potential rises in sea level and its impacts are not addressed in coastal management. This chapter sees itself as recommendation of action not only for Martinique.

Part two deals with the impacts of land use changes for bird populations on the Eiderstedt peninsula in Schleswig-Holstein (Germany). In the past, the landscape has been generally dominated by extensively used grassland. These grassland areas are home to many bird species, and among naturalists Eiderstedt is considered to be one of the prime bird habitats in Schleswig-Holstein. Ongoing changes in the structure of the regional agriculture towards an intensified cattle breeding and the growth of biofuels call for a conversion of large shares of grassland to arable farm land. At the same time a fiercely debate arose to what extent Eiderstedt can be declared as bird conservation area within the Natura 2000 network. In **chapter 4** the drivers and accompanying conflicts of rapid land use changes on Eiderstedt are explored in more detail. Under consideration of

the regional land utilization history three possible scenarios of transformations of agricultural land are developed which can be applied to determine the possible impacts of such conversions. In **chapter 5**, the possible impacts of agricultural land use change on Eiderstedt on breeding bird populations of four key species are determined. The results indicate that an increase of arable farm land to approximately two thirds of the whole agricultural area drastically reduces suitable bird habitat, thus considerably diminishing the number of breeding pairs supported by the environment.

The **third part** evaluates potentials to preserve existing habitats, to restore formerly native habitats, as well as to create non-native managed habitats with respect to freshwater wetlands of the EU. **Chapter 6** deals with the methodological development of a spatial wetland distribution model (SWEDI) and description of its results. Through the GIS-based model the spatial extent of existing wetland distribution within the EU-25 countries is visualised. Additionally, potential convertible sites are modelled for (re-) creation of wetland biotopes. Because the existence of wetlands is driven by site specific natural conditions and the economic environment, **chapter 7** integrates both aspects by linking the GIS-based wetland model with the European Forest and Agricultural Sector Optimization Model (EUFASOM). EUFASOM is a partial equilibrium model which studies simultaneously synergies and tradeoffs between biodiversity conservation efforts, greenhouse gas mitigation options including carbon sinks and bioenergy, as well as traditional agriculture and forestry markets. For different policy scenarios, the optimization model computes the corresponding economic potential of wetlands, its effects on agricultural and forestry markets, and environmental impacts. In **chapter 8** the scenario specific total wetland area per EU-country from EUFASOM is downscaled by a GIS-based site-selection model which uses environmental constraints. The final result is a wetland site-selection model that evaluates optimal distributions for wetland restoration sites levelled after defined restoration goals and dependent on the EUFASOM scenarios. The model is useful to locate sites suitable for renaturational programs and for the effective introduction of faunistic corridors considering the NATURA 2000 network.

In all, the studies show that the inclusion of GIS-based assessment tools is essential to favour effective regional conservation planning and to improve the predictive capacities of coastal zone management plans. Often the illustration of scientific results through maps is indispensable to support public participation. Applying GIS solutions in sustainability and global change helps filling the still existing gap between social sciences and physical geosciences.