Policy making is increasingly confronted with the need to evaluate complex alternatives ex ante whilst external pressures from media and stakeholders demand transparency as well as high quality information as a basis. Integrated environmental assessments provide a way to meet these demands and are thus useful tools for modern policy making. An integrated environmental assessment aims to describe the advantages and disadvantages of possible policy measures by assessing their potential impacts. Integrated environmental assessments typically either focus on local detail or on broad, macro-scale trends. As a complicated myriad of local and global processes drives global change, tools supporting policy-making should ideally incorporate both local and global processes and their interlinkages. By focusing on a single scale, integrated environmental assessments often do not give sufficient attention to all interacting processes. Despite some successes in coupling global and local processes in integrated environmental assessments, all currently available approaches have disadvantages and a standard methodology is lacking. The aim of this thesis is, to find out whether a preferred methodology can be identified for linking local and global processes in integrated environmental assessment. For this purpose, various multi-scale methodologies have been applied in this dissertation, notably in studies on the impacts of biofuel production incentives and water management. The advantages and disadvantages of the different multi-scale methodologies have been studied, and more generic observations on model selection and cross-scale interactions in integrated environmental assessments have been made.

The integrated environmental assessments in chapters 2-4 all used a similar methodology. Chapter 2 shows the potential impact of different land use change trajectories on the hydrology in a number of EU river catchments. Chapters 3 and 4 assess the impact of large-scale biofuel crop cultivation on land use and biodiversity under different (policy) scenarios. In all these studies, a set of hierarchically nested models was applied in which global socio-economic and climatic changes were progressively downscaled to produce land use changes within the EU25 at 1 km² scale. Based on these land use maps, predictions were made on the potential impact of these scenarios on landscape and biodiversity (chapters 3 and 4) or on hydrology (chapter 2). Due to the hierarchical set-up, only top-down processes operating at the global and continental level were included and bottom-up forces that influence the aggregate results were absent. Moreover, many processes were not modelled mechanistically but based on empirically established associations or expert-based rules. As a result, the output of these models is only meaningful at the scale of larger regions (e.g. districts or provinces) and not at the local level (i.e., individual pixels), even though the spatial resolution of these studies was quite high (i.e., 1 km²).
The integrated environmental assessments described in chapters 5 and 6 paid much more attention to the representation of local processes. In chapter 5 various water quality and quantity processes were modelled for two existing peatland polders. These results were scaled up by applying a model suite to an imaginary polder having the average characteristics of a range of real polders (which was assumed to be representative for other polders). In chapter 6 carbon emissions were determined by field measurements in a range of land use types in a fen meadow polder. These emissions were then scaled up by linking emissions to vegetation and land use maps for a larger set of polders. In both chapters, local processes were modelled in detail for a few localities and then applied at a higher regional scale by applying the model to a case study representative for the entire region. Global processes were integrated in the analysis by downscaling global scenarios to determine relevant boundary conditions for the study area, and the effects of these new boundary conditions were then calculated. Although these studies had a thorough description of local processes (i.e., high process resolution and high local specificity), they covered only a relatively small geographical extent and additional uncertainty was introduced during the upscaling.

The nested modelling approach applied in chapters 2-4 of this thesis uses a top-down linkage of integrating local and global processes. Only large-scale, top-down processes could be included in these studies. Although these studies attempted to downscale the processes represented in top-down models to a finer local level by increasing the model spatial resolution (i.e. by including high resolution spatial input data and downscaling algorithms), the low process resolution nonetheless prevented any meaningful analyses at the local level. As a result, the conclusion can be made that increasing process resolution would be a more preferred approach to increase the usefulness of these nested modelling approaches for local analyses. However, chapters 5 and 6 of this thesis show that the scaling up of model results with high process resolution also has considerable constraints. These include not only limited data availability and (data and time) problems with model parameterization, but also additional uncertainty during upscaling.

In spite of these limitations, the chapters in this thesis show a variety of methodologies to link local and global processes in integrated assessments. All presented methodologies have their strengths and weaknesses and some methodologies are better suited to certain research than others. It still remains important that researchers make a conscious trade-off between which scales need to be addressed, the type and complexity of their models and the required local specificity. This thesis shows that there is no ‘one-size-fits-all’ methodology and that the different
questions, processes and stakeholders addressed require tailored solutions rather than a uniform generic approach. At the same time, it shows that such solutions are practically feasible and that these modelling studies can offer meaningful, applicable insights.

Integrated environmental assessment can provide important input to policy makers during all different stages of the policy cycle. Although integrated environmental assessments typically provide support to policy makers during the ex-ante and ex-post assessment phase of the policy cycle, all studies in this thesis were directed to support policy makers in other phases of the policy cycle as well (e.g. scientific warning and awareness creation, problem definition, monitoring). By proper model selection and a tailored combination of global and local processes, integrated environmental assessments can thus provide policy makers with important tools in all phases of policy development.