Summary

The main aspiration of this PhD-project was to establish and test methods for the estimation of annual and monthly river discharge as well as N-leaching and riverine nitrogen loadings from Danish catchments to help solving tasks resulting from NERI's national and international obligations. The work was focused on three different partial aims. The first was to develop a modelling framework for computing annual and monthly runoff and nitrogen loadings from the whole Danish land mass by combining river discharge and nutrient load estimations and point source measurements from unmonitored areas with runoff and nutrient load measurements from monitored areas at the catchment level. The second partial aim was to suggest a procedure for assessing the long-term impacts of a potential future climatic change on runoff at catchment level, and a third specific goal was to establish frames to simulate N-leaching at catchment scale.

The prototype procedure to calculate runoff and nitrogen loadings to the Danish coastal waters has comprised derivation of a regression model for calculating the contributions from ungauged catchments. GIS databases have been established to i.) procure all information required for the establishment of the runoff regression model and parameterisation of a monthly water balance model (MWB) used to calculate of monthly runoff, and ii.) to calculate annual runoff and nitrogen loadings from ungauged and gauged catchments for the whole country.

An important restriction hampering the development and test of the different models involved was the fact that in many catchments river discharge is smaller than the difference between precipitation and evapotranspiration when using the climatic data provided operationally by the Danish Meteorological institute (DMI). The parameterisation of the monthly water balance model MWB was exclusively based on catchments where the long-term observed river discharge is larger than the difference between precipitation and potential evapotranspiration. Application of the MWB model in areas not fulfilling this requirement will lead to an overestimation in river discharge. However, even if the input data remain unchanged, the model needs to be extended allowing for the description of water imports to and exports from the catchment to adjacent areas. Moreover, though MWB performed well in most of the calibration and test catchments, the parameterisation studies revealed some conceptual weaknesses calling for development and test of new model components. Although, the root mean square error of the current multiple regression model for annual river discharge is still too high for operational use of the scheme at the national scale, its main advantage is that the number of catchments, to be omitted for the model establishment, was limited. Hence, it represents to a large extent average properties based on almost all catchments larger than 10 km^2 and smaller than 300 km^2 for which input data are available. However, The regression equations derived will need to be modified if the input data to run the model have not been correct. Some of the surrogate explanatory variables considered for the annual river discharge approach should be replaced in future.

The fact that the parameterisation of the MWB model required omission of all catchments not fulfilling the requirements of closed simple water balances means that the current model cannot be applied in areas where runoff could not be explained from simple water balance equations. However, the main advantages of the conceptual water balance model, MWB, are, apart from the higher temporal resolution, its capability to calculate different components of the hydrological cycle not considered explicitly in the current regression model, such as fast-flow, slow-flow and actual evapotranspiration.

The second specific objective has involved the establishment of an approach to perform spatially distributed climatic change studies on the catchment scale, involving statistical downscaling of climate data used as input to the conceptual semi-distributed hydrological model ARC/EGMO. The established approach was tested for the period 1860 to 2100 on the upper Stör catchment (1157 km^2) located in northern Germany. The modelling approach seems to provide a good basis for similar future studies to be performed in Danish catchments.

Finally, methods were established supporting the calculation of N-leaching based particularly on nationally available data sets on climate, soil types and agricultural practices. Most importantly, techniques for deriving input data to the two leaching models used, as well as to a groundwater model applied as part of the first leaching study, were tested. Both methods were applied in catchments located in central and eastern Jutland, respectively, but may be used for larger areas as well, even at national scale.

However, it is generally important to keep in mind that any parameterisation is dependent on the reliability of the input data. Independent estimations of actual evapotranspiration, in particular, should be derived and tested as soon as the problems related to the calculation of potential evapotranspiration are solved.