Abstract

The 21st century has brought new challenges for forest management at a time when globalization in world trade is increasing and global climate change is becoming increasingly apparent. In addition to various goods and services like food, feed, timber or biofuels being provided to humans, forest ecosystems are a large store of terrestrial carbon and account for a major part of the carbon exchange between the atmosphere and the land surface. Depending on the stage of the ecosystems and/or management regimes, forests can be either sinks, or sources of carbon. At the global scale, rapid economic development and a growing world population have raised much concern over the use of natural resources, especially forest resources. The challenging question is how can the *global demands* for forest commodities be satisfied in an increasingly *globalised economy, and where could they potentially be produced*? For this purpose, wood demand estimates need to be integrated in a framework, which is able to adequately handle the competition for land between major land-use options such as residential land or agricultural land.

This thesis is organised in accordance with the requirements to integrate the simulation of forest changes based on wood extraction in an existing framework for global land-use modelling called LandSHIFT. Accordingly, the following neuralgic points for research have been identified: (1) a review of existing global-scale economic forest sector models (2) simulation of global wood production under selected scenarios (3) simulation of global vegetation carbon yields and (4) the implementation of a land-use allocation procedure to simulate the impact of wood extraction on forest land-cover.

Modelling the spatial dynamics of forests on the global scale requires two important inputs: (1) simulated long-term wood demand data to determine future roundwood harvests in each country and (2) the changes in the spatial distribution of woody biomass stocks to determine how much of the resource is available to satisfy the simulated wood demands.

First, three global timber market models are reviewed and compared in order to select a suitable economic model to generate wood demand scenario data for the forest sector in LandSHIFT. The comparison indicates that the 'Global Forest Products Model' (GFPM) is most suitable for obtaining projections on future roundwood harvests for further study with the LandSHIFT forest sector. Accordingly, the GFPM is adapted and applied to simulate wood demands for the global forestry sector conditional on selected scenarios from the Millennium Ecosystem Assessment and the Global Environmental Outlook until 2050. Secondly, the Lund-Potsdam-Jena (LPJ) dynamic global vegetation model is utilized to simulate the change in potential vegetation carbon stocks for the forested locations in LandSHIFT. The LPJ data is used in collaboration with spatially explicit forest inventory data on aboveground biomass to allocate the demands for raw forest products and identify locations of deforestation.

Using the previous results as an input, a methodology to simulate the spatial dynamics of forests based on wood extraction is developed within the LandSHIFT framework. The

land-use allocation procedure specified in the module translates the country level demands for forest products into woody biomass requirements for forest areas, and allocates these on a five arc minute grid. In a first version, the model assumes only actual conditions through the entire study period and does not explicitly address forest age structure. Although the module is in a very preliminary stage of development, it already captures the effects of important drivers of land-use change like cropland and urban expansion. As a first plausibility test, the module performance is tested under three forest management scenarios. The module succeeds in responding to changing inputs in an expected and consistent manner. The entire methodology is applied in an exemplary scenario analysis for India. A couple of future research priorities need to be addressed, particularly the incorporation of plantation establishments; issue of age structure dynamics; as well as the implementation of a new technology change factor in the GFPM which can allow the specification of substituting raw wood products (especially fuelwood) by other non-wood products.

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