A Spatial-Dynamic Agent-based Model of Energy Crop Introduction in Jiangsu province, China

Kesheng Shu, Uwe A. Schneider, Jürgen Scheffran

Bioenergy, as one promising option to replace a fraction of conventional fossil fuels and lower net greenhouse gas emissions, has gained many countries, in particular developing ones attention. Their focus is mainly on the design of efficient bioenergy utilization pathways which adapt to both local geographic features and economic conditions. The establishment of a biomass production sector would be the first and pivotal component in the whole industrial chain.

Several existing studies have estimated the global biomass for energy potential but arrived at very different results. One reason for the large uncertainty of biomass potential may be ascribed to the diverse nature of biomass leading to different estimates in different circumstances. Therefore, specific research at the local level is essential. Following this thought, our research conducted in the Jiangsu province, a representative region in China, will explore the spatial distribution of biomass production. The employed methodology can also be applied to other locations both in China and similar developing countries if model parameters are adequately adjusted.

In this study, we analyze the local situation in the Jiangsu province focusing on the selection of new energy crops, since the cultivation of dedicated crop for energy use is still in experimental phase. We also examine the land use conflict which is especially relevant to China with more than 1.3 billion people and a severe burden on food supply. We develop an agent-based model to find the optimal spatial distribution of biomass (SDA-SDB) in Jiangsu province. Compromising data accessibility and heterogeneity of environmental factors across the province, we resolve our model at county level and consider the aggregated farming community in one county as a single agent. The aim of SDA-SDB is to simulate farmers' decision process of allocating land to either food or energy crops facing limited resources and political targets for bioenergy development. Different to previous engineering assessments of biomass potential, SDA-SDB depicts the price of dry matter, the biomass from dedicated energy crop, as an endogenous variable. Thus, the price of dry matter will be decided by the intersection between demand and supply. The demand of biomass is established by the official development plan for bioenergy. Several alternative plans will be assessed. On the supply side, the marginal costs of bioenergy production are controlled by the aggregated behavior of all farmers. In other words, each agent's decision is influenced by other agents' decisions and will influence the final result which will continue to affect other agents' decision in a closed information feedback loop. Furthermore, SDA-SDB introduces coastal mudflat in Jiangsu province as a possible novel resource for energy crop cultivation which is believed to alleviate the conflict between food and bioenergy demand. We also introduce a carbon tax (which is, at the same time, a green-energy subsidy for bioenergy)

in our model to specifically explore its effect on the penetration of biomass. Finally, we summarize our findings for efficient bioenergy utilization pathway in Jiangsu province based on our simulation results and a sensitivity analysis over the key parameters.