1. PUBLISHABLE SUMMARY

Summary of the context and overall objectives of the project (For the final period, include the conclusions of the action)

Forests are major carbon pools, thus an end to deforestation and a turn to forest recovery can contribute significantly to mitigating global climate change. Forest transitions, i.e. shifts from deforestation to reforestation, have occurred in many countries of the Global North, and recently also in several tropical countries of the Global South, and aims exist to end deforestation globally. However, forest transitions are not necessarily sustainable. Ensuring that forest recovery complies with both ecological and social sustainability criteria remains a vital challenge in forest conservation strategies. The HEFT project therefore set out to understand to which extent forest transitions in the past were connected to shifts towards unsustainable resource use, and what we can infer for sustainable forest recovery today. Focusing on the climate impacts of changes in land and resource use, the project additionally addressed broader social and ecological sustainability implications of forest change.
In case studies in Europe since c. 1850, North America since c.1880, and Southeast Asia since 1980, as well as globally, the project investigated processes such as substitution of fuelwood by modern energy sources, intensification of agriculture, and land displacement, in terms of their climate impacts. We integrated sources and analytical methods from environmental and social sciences as well as the humanities to analyze context-specific trajectories and general interlinkages of forest transitions and resource use in various socio-political contexts. The sound understanding of the links between forest change and resource use was used to identify options for sustainable forest recovery, and to draw lessons for land-based climate-change mitigation policies that are both physically effective and socio-politically viable.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far (For the final period please include an overview of the results and their exploitation and dissemination)

After laying the conceptual and methodological grounds to investigate forest transitions and their climate impacts, the HEFT project compiled a large body of empirical evidence for analyzing forest transitions, changes in resource use and associated GHG fluxes in local, national and regional case studies as well as at the global scale. In addition, qualitative information on the socio-political context of forest transitions was collected in systematic literature queries, document analyses and through expert interviews. We empirically investigated local and national case studies in Europe from the 19th through 21st centuries, Southeast Asia, late 20th century to present, and North America, late 19th century to present.
Major quantitative and qualitative efforts were conducted to analyze trajectories of forest transitions and their connections to resource use and socio-political dynamics in diverse geographical and historical contexts. Counterfactual scenario approaches, decomposition analyses, and regression analyses were applied to quantitatively assess and compare the relative contributions of changes in specific trends of resource use to forest change, as well as their emissions impacts. Combining quantitative methods of environmental accounting with qualitative methods from political ecology and environmental history, we investigated similarities and differences of these processes across case studies in terms of both their biophysical and socio-political dimensions.
We also explored options for sustainable forest conservation, investigating how the use of wood products and biomass more generally could reconcile meeting societal needs while respecting ecological boundaries including, but not limited to, carbon sequestration.

Progress beyond the state of the art and expected results until the end of the project

The project introduced the concept "Hidden emissions of forest transitions", proposing that forest recovery in the context of industrialization is enabled by processes outside of forests which cause additional emissions. Further, we advanced reflexions on what sustainable land use actually means. We advocated for a nuanced perspective that does not focus exclusively on either ecological restoration or social justice, but instead integrates the conflicting aims of both safeguarding ecosystem health while providing biomass to meet human needs. HEFT also contributed to better conceptualizing how international trade of biomass affects climate impacts and sustainability more generally, shedding light on coexisting but diverging methodological approaches, and reflecting on those conditions that make international trade in biomass sustainable - and those that don't.
The project developed accounting methods and models to reconstruct national and global-level forest and ecosystem carbon dynamics and greenhouse gas emissions from agriculture in time periods of 100 to 200 years. This allowed to quantify the climate impact of long-term forest recovery, but also to assess the factors that drove these changes. A particularly innovative approach developed in the project was the historical counterfactual analysis. This way, we were able to show, for example, that globally since 1990, forest recovery resulted from increased average tree growth rates, rather than from forest area expansion.
The project also made major methodological contributions in conntecting biophysical reconstructions of forest and land-use change with assessments of social and political dynamics that shaped them. We found that the reduction of agricultural practices in forests (e.g., forest grazing in temperate regions and shifting cultivation in the tropics) was an important factor accompanying forest transitions across case studies, resulting in ecological (i.e., enhanced tree growth) and social effects (i.e., reduced access to forests). In addition, we found that efficiency gains in land and resource use were important, but overcompensated by increases in consumption (e.g., more energy use, more livestock product consumption), resulting in growing emissions in the long run.
We identified land sharing strategies, e.g. through agroforestry, as potentially viable land-use options that integrate socially just forest use with reduced climate impacts. Furthermore, we found that changes in the entire supply chain, from production to consumption, are required to allow for ecologically sustainable biomass production to meet human needs. Important levers include reductions in livestock production and consumption and a shift in wood use from bioenergy towards long-lived products.

Address (URL) of the project's public website

https://boku.ac.at/hidden-emissions-of-forest-transitions-ghg-effects-of-socio-metabolic-processes-reducing-pressures-on-forests-heft

Biomass C density in global production forests, according to FRA