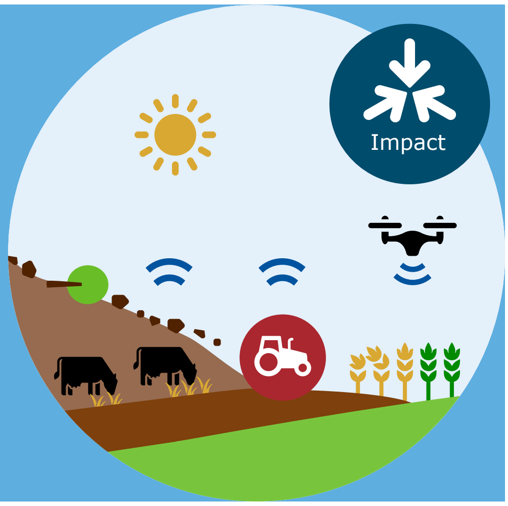
Enhancing drought resilience in Africa through large-scale tree planting

Emerging DS/AI methods



WAGENINGEN
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Data Driven Discoveries in a changing climate (D3C2)

Objective: The aim of this project is to assess the potential of large-scale tree planting to offset rainfall reductions in Africa due to climate change.

Activities and results

In this project, we developed a data-driven model, which we call DeepRainForest-Africa. With this continent-wide, spatiotemporal model, we want to assess changes in rainfall patterns in response to changes in tree cover. Our model architecture builds upon well-established scientific knowledge on pathways through which tree planting affects moisture recycling and consequently rainfall. Using the DeepRainForest-Africa model, we

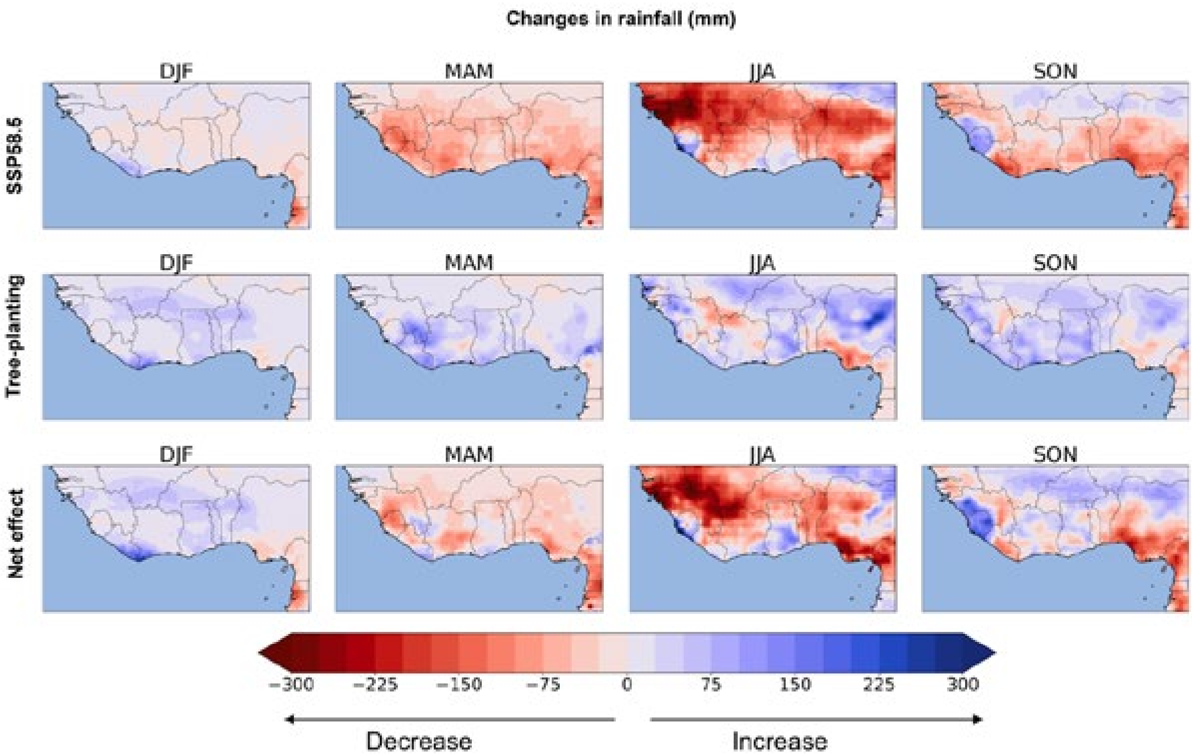

Figure 1 Climate change-induced changes in rainfall (mm) in the period 2081 – 2100 relative to the 2001 – 2020 period in West Africa (Upper panel). Tree-planting induced changes in rainfall (mm) relative to 2001 – 2020 period in West Africa (Middle panel). The net effect or sum of climate-change and tree-planting induced rainfall changes (Lower panel). For all figures, negative values indicate reductions in rainfall and positive values indicate increase in rainfall.

simulated the potential of large-scale tree planting in several ecoregions to offset projected climate change-induced rainfall reductions.

We also wrote a follow-up proposal which was awarded. In this follow-up project, we will couple the DeepRainForest-Africa model to a spatially distributed hydrological model we are developing. This will provide a complete picture of water resources responses to large-scale tree planting. Examples of responses include water for rainfed agriculture, irrigation, hydropower, environmental flow requirements

Achievement

We are proud of a couple of things. First of all, the DeepRainForest-Africa model has potential for wide applicability especially in water resources and food systems. Secondly, we are very proud of the results. Through our research, we have shown that in West Africa in particular, large-scale tree planting can substantially offset projected climate change-induced rainfall reductions. This is especially the case in the critical growing periods from June to November. We also have shown that unlike in West Africa, large-scale tree planting in Southern Africa has minimal effect on rainfall.

Despite the achievements, not everything went according to plan. The initial research plan was to quantify the effects of reforestation through enhanced rainfall on productivity in nutrient-sensitive agriculture. Essentially, we hoped to understand how enhanced rainfall benefits provided by tree planting translates into productivity of nutrient-sensitive agriculture. However, due to methodological limitations which we could not resolve given the time and resources available, we had to shelf this part of the project.

Outlook

This research theme is topical and we have already started working on a follow-up project. The new project seeks to contribute tools and knowledge to minimise unintended maladaptation outcomes of large-scale tree planting on water resources. In terms of water resources, tree planting does not only affect rainfall patterns, it also affects local surface hydrology, sometimes negatively. Failure to consider the full range of water resource effects can lead to maladaptation outcomes. We want to understand this better, especially in the context of climate change. Therefore, we are developing a spatially distributed machine learning hydrological model which we will couple to the DeepRainForest-Africa model.

We also hope to revisit the ‘failed’ part of our research in the near future. Through a future project, we hope to understand how the enhanced rainfall benefits provided by large-scale tree planting translates into crop productivity of nutrient-sensitive agriculture.

Deliverables

We are working to finalize the manuscript and submit it this year. We also wrote a follow-up proposal, which has already been awarded.

Lessons learned

A key lesson we learnt is that for complex problems such as this, a modular machine learning approach guided by well-established domain knowledge can enhance interpretability, avoid erroneous learning outcomes and improve scalability. This does not apply to the traditional monolithic machine learning approaches that attempt to solve a complex problem in a single model.

Contact

Confidence Duku
Researcher climate change (impact) assessment (project manager)
confidence.duku@wur.nl

Project members
Xuezhen Guo
Lars Hein

Wageningen University & Research
P.O. Box 47
6700 AB Wageningen
The netherlands
T +31 317 48 07 00
www.wur.eu