

Why Trees Outside of Forests (TOF) in Africa are Important to Livelihoods and Global Climate Change.

Deforestation and forest degradation, particularly in closed tropical forests, has been a predominant measurement focus for the remote sensing global change research community. Now, even while forests are losing carbon and are a source of emissions, there is growing evidence that landscapes around the world are increasing tree biomass and are important potential sinks for carbon (Zomer et al. 2016). The most important hotspots for this phenomenon are systems of trees outside of forests (TOF) in agricultural landscapes in semi-arid zones. Africa is a particularly important region, as recent studies have identified the occurrence of farmer-mediated and promoted increases in biomass in savanna and woodland landscapes in rural areas. For example, in West Africa Brandt et al. (2018) observe elevated tree biomass around village areas compared to stocks in natural savannas. A mechanism has been postulated for this: while changing climatic patterns is influencing increased tree productivity, farmers are also promoting enhanced tree biomass to capture the direct and indirect benefits of tree-based ecosystem services, especially from agroforestry. If this pattern is widespread or could be further enabled through policy and management interventions, it could have important implications for climate change mitigation and adaptation by carbon sequestration actions. In the context of international climate policy, it is gaining widespread interest under the concept of *natural climate solutions*. However, this land use and cover change has yet to be fully quantified and mapped.

This proposed project will deploy a remote sensing method that combines pixel mixture modeling using Landsat-class data with digital image analysis using very high-resolution satellite (VHR) data to map important TOF landscapes in Africa. The aim is to estimate the area today, as well as examine its trend and future potential. The question is important because of the potential scale and magnitude of land area in African semi-arid lands that currently support TOF, and which could be increased through policy and economic development interventions. The question is also important because TOF systems can have significant benefits to local communities through agroforestry and other tree-based production systems that bring higher economic returns to local livelihoods, and enhanced environmental benefits for land rehabilitation. The project focuses on two land covers -- forest and agriculture -- and examines the relative importance of TOF-mediated carbon sequestration compared to forest emissions in woodlands and savannas. Using standard methods at our disposal we shall quantify the carbon in the detected TOFs to evaluate their importance. To better evaluate the forest component for comparative assessments, it will also be important to measure the degree to which forest degradation is occurring.

The results of this study will be important to the international climate change mitigation policy community as they are actively seeking quantitative information on TOF as natural climate solutions, specifically as an example in emerging programs for Forest Landscape Restoration (FLR) such as AFR100 – the African-wide contribution to the Bonn Challenge. These results also support the emerging REDD+ agenda and new thinking about expanding the framework to include Agriculture, Forestry and Other Land Use (AFoLU), thereby taking a landscape approach. Lastly, the work shall support international development communities and SDGs through its impact on agroforestry livelihoods.