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GeoTree: A Participatory Digital Tool for Forest Landscape Restoration in the Tropics

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Forest landscape restoration (FLR) in the tropics is often undertaken by smallholders and communities whose livelihoods rely on agriculture and forestry. While digital technologies can improve efficiency in FLR efforts, socio-technical barriers often impede the participation of these key actors in the restoration process. The main barriers are lack of technical infrastructure, access to digital tools and services, lack of ease of use for non-tech-savvy farmers, and lack of design targeted for low-literate and marginal groups. Moreover, precisely because of the transformative momentum of digitalization, there is a risk for smallholders to enter the digital divide and power asymmetry gap. The platform has been piloted in Kenya and Cameroon and tracks and monitors activities along the entire restoration chain, from seed collection to on-farm tree planting and monitoring of management activities and payouts to farmers. GeoTree offers participatory functionalities, including interactive forms, polls, geospatial features and maps, and community-driven data collection, which can be integrated into community channels. While other digital tools focus on monitoring tree planting for the purpose of carbon offsetting, GeoTree addresses the digital barriers facing smallholders and communities and enables them to participate fully in FLR efforts. GeoTree leverages blockchain technology to provide an integrated planting management process. The system allows gathering ground-level data with offline encryption and supporting low-internet environments and tracing the restoration process to provide transparency, facilitate real-time monitoring, evaluation, and verification, and support mobilization of sponsors.

Keywords: GeoTree, restoration, tree

Introduction

Forest landscape restoration (FLR) plays a pivotal role in addressing environmental degradation and enhancing livelihoods in the tropics (Ndoli et al., 2021; Kumeh et al., 2023). It encompasses diverse practices such as promoting smallholder forest plantations, expanding agroforestry, encouraging farmer-led natural regeneration, and fostering tree cultivation on farms (Chirwa & Mala, 2016). On-farm tree restoration has proven to be economically feasible, offering cost-effective benefits for farmers. Policymakers are encouraged to invest in and promote these practices to achieve ambitious restoration goals and foster sustainable agroforestry landscapes across Africa (Miller et al., 2020). The success of on-farm tree restoration hinges on various factors, including local ecological conditions, community engagement, and the adoption of sustainable agroforestry practices (Gebirehiwot 2023).

While digital technologies have the potential to enhance FLR efforts, socio-technical barriers often hinder the involvement of key stakeholders in the restoration process (Urzedo et al., 2023). However, the digital transformation journey faces challenges such as the lack of digital literacy and organizational development needs. Smallholder communities are at risk of being left behind in the digital revolution, which could exacerbate the digital divide and power imbalances in agriculture and food systems. Notable risks and challenges include inadequate access to technology, digital illiteracy, gender disparities, perceived usefulness, and exclusion.
This paper introduces GeoTree, a user-centered mobile application, designed to overcome these impediments and establish a digital workflow for community-led landscape restoration on farms.

Material and Methods

Study area
The study encompasses over 5000 hectares of restored land in Cameroon and Kenya, with a goal of planting at least 400,000 trees and benefiting 4,000 smallholder farmers. Six project sites were chosen, three in Cameroon (Mbalmayo, Foumban, and Moutouroua) and three in Kenya (Turkana County, Siaya County, and Mukogodo Forest).

GeoTree Mobile App
We employed GeoFarmer (Eitzinger et al., 2019), an innovative app platform designed to facilitate dynamic engagement and streamlined communication within the farming community. This versatile tool not only enables seamless two-way interaction but also enhances tracking and support mechanisms crucial for sustainable agricultural projects. Researchers and implementers can leverage GeoFarmer to foster continuous collaboration, gather valuable insights, and strengthen the execution of research initiatives.
GeoFarmer provides a cloud-hosted backend environment with an application protocol interface (API) for interaction with the backend through authorized platforms. The backend features basic functionalities for user management, data collection, and a community channel structure that considers specific attributes such as language, geography, topics, and target communities. These channels are adaptable to various use cases, providing tailored solutions for diverse needs. Three primary user roles were employed for the project: Moderators, who oversee channel dynamics, conceptualize activities, and engage in community-led restoration efforts; Facilitators, responsible for data collection, monitoring, and maintaining direct communication with farmers; and Farmers, as subscribed users and channel participants who contribute by filling forms, autonomously monitoring their planted trees, and providing valuable feedback.
GeoTree apps were developed as product flavors of the original GeoFarmer app. This approach allows for the creation of multiple app versions using the same base code, which is more targeted to the users' needs and avoids overwhelming them with unnecessary functionality. The GeoTree suite streamlines the entire tree restoration journey, from seed collection to monitoring tree growth and well-being on farms. By leveraging blockchain technology, the system offers an integrated planting management process. It facilitates ground-level data collection with offline encryption support in low-internet environments, enabling transparent, real-time monitoring, evaluation, verification, and sponsor mobilization.

Results and Discussion

We have devised a comprehensive workflow and a mobile app that empowers farmers to lead the restoration process from seed to tree (Figure 1). The GeoTree suite, comprising MyGeoTree Collector, MyGeoTree Nursery, MyGeoFarm Facilitator, and MyGeoFarm versions, plays various roles throughout the process.

Figure 1. Workflow for tracking restoration from the seed collection to the planted tree.

MyGeoTree Collector
This app empowers seed collectors by providing a powerful tool to record essential data about their seed collections. They can document information such as collected species, location coordinates, and capture images to provide visual evidence of the seed tree and collection site. Each seed collection is assigned a unique QR code, ensuring accurate and efficient seed tracking throughout the process.

MyGeoTree Nursery
When the seed collections reach the nursery, the associated QR codes are scanned for seamless check-ins. Nursery staff can access the app's guided steps and instructions to ensure optimal germination and growth of the seeds, transforming them into healthy seedlings ready for planting.

MyGeoFarm and MyGeoFarm Facilitator
At the appropriate stage, the seedlings are assigned new QR codes and transferred to farms by dedicated facilitators. Beneficiaries are registered within the app to take responsibility for nurturing and caring for the trees, with facilitators overseeing the process. The beneficiary, in collaboration with the facilitator, becomes the guardian of the tree, ensuring its ongoing care and protection. To guarantee regular monitoring of the tree's status, MyGeoTree prompts the facilitator and beneficiary to conduct assessments at recurring intervals, such as twice a year. Through the app, they record vital information such as tree height, health condition, and any necessary maintenance actions. This data facilitates continuous evaluation of the tree's progress and helps identify potential issues that may arise.

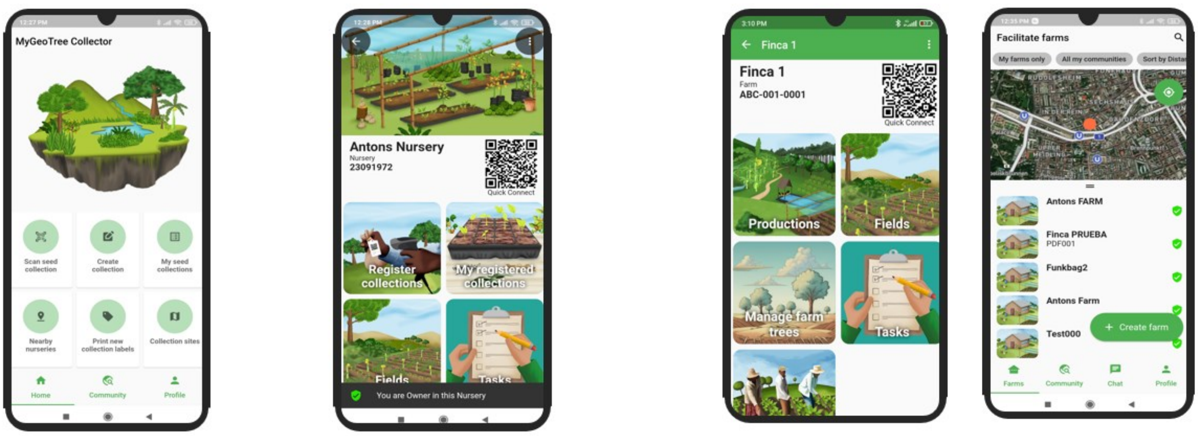

Figure 2. User centered android based mobile applications (from left to right): MyGeoTree Collector, MyGeoTree Nursery, and MyGeofarm (Farmer and Facilitator version) for on-farm tree restoration.

Conclusions and Outlook

The GeoTree applications bring a multitude of benefits to community-led landscape restoration, including improved awareness of restoration opportunities, enhanced capacities among smallholders, and increased transparency regarding seed sources and restoration experiences through engagement and feedback with communities. The potential for scalability through digitalization is substantial.

Following successful pilot programs in Cameroon and Kenya, we plan to expand the GeoTree applications to Ethiopia, India, and Uganda, providing further validation of their effectiveness on a larger scale.

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